United States Department of the Interior
FISH AND WILDLIFE SERVICE
Post Office Box 1306
Albuquerque, N.M. 87103

In Reply Refer To:
R2/DTS 042669

Cons. # 22420-2005-F-117

Memorandum

To: Regional Director, Navajo Regional Office, Bureau of Indian Affairs, Gallup, New Mexico

From: Regional Director, U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico

Subject: DRAFT Biological Opinion for the Desert Rock Energy Project, U.S. Bureau of Indian Affairs, Gallup, New Mexico

This transmits the U.S. Fish and Wildlife Service's (Service) draft biological opinion (BO) regarding effects of actions associated with the Bureau of Indian Affairs' proposed Desert Rock Energy Project (DREP) on federally listed species and their designated critical habitats, as defined below, in accordance with section 7(b) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), and implementing regulations at 50 CFR 402. Species affected by the proposed project are the endangered Colorado pikeminnow (*Ptychocheilus lucius*) 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 its designated critical habitat, the threatened Mesa Verde cactus (*Sclerocactus mesae-verdae*), the endangered Mancos milkvetch (*Astragalus humillimus*), the endangered Rio Grande silvery minnow (*Hybognathus amarus*) and its designated critical habitat, and the endangered California condor (*Gymnogyps californianus*). You have determined that the proposed project is likely to adversely affect the Colorado pikeminnow and its designated critical habitat, razorback sucker and its designated critical habitat, flycatcher, Mancos milkvetch, and Mesa Verde cactus. You also determined that the proposed DREP is not likely to adversely affect the California condor, Rio Grande silvery minnow and its designated critical habitat, or critical habitat for the flycatcher.

We concur with your determination in the biological assessment (BA) that the project is not likely to adversely affect the California condor. Our concurrence is based on the lack of suitable nesting habitat in the terrestrial action area, the absence of records of the species in the terrestrial action area, and the proposed conservation measures to reduce the likelihood of birds striking transmission lines. Additionally, we concur with your determination that the project is not likely to adversely affect the Rio Grande silvery minnow and its designated critical habitat. Our concurrence is based on the risk assessment, which indicates that the level of exposure to contaminants is not likely to pose a risk to the species or the primary constituent elements of critical habitat. Finally, we concur with your determination that the project is not likely to adversely affect southwestern willow flycatcher critical habitat. Our concurrence is based on the fact that there are not likely to be any measureable effects to the Rio Grande basin or the primary constituent elements of critical habitat, where flycatcher critical habitat is located.

This concludes consultation under section 7 of the Endangered Species Act, as amended, for the California condor, Rio Grande silvery minnow and its designated critical habitat, and critical habitat for the southwestern willow flycatcher. Please contact the Service if this project changes or new information reveals effects of the action to these species or critical habitat to an extent not covered in the BA.

This draft 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 the relationship of those effects to the function and conservation role of critical habitat for the Colorado pikeminnow and razorback sucker to determine whether the current proposal destroys or adversely modifies critical habitat for these species.

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 represents our draft 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.

A Reasonable and Prudent Alternative (RPA) is not included in this draft BO for the following reasons:

1. The Service cannot at this time formulate an RPA to the proposed action that can be implemented in a manner consistent with the intended purpose of the action, will be consistent with the scope of the action agencies' legal authorities and jurisdictions, and is economically and technologically feasible.

2. The Service and the action agencies are working together to formulate an RPA that the action agencies can accept.

Should the Service and the action agencies agree upon an RPA it will be inserted in future drafts of this BO. If the Service and the action agencies determine that no RPA is available, future drafts will indicate this fact and provide an explanation.

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

Regional Director

Attachment

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

DRAFT

Endangered Species Act – Section 7 Consultation
DRAFT Biological Opinion

Desert Rock Energy Project
New Mexico

Agency:	U.S. Bureau of Indian Affairs
Consultation Conducted By:	U.S. Fish and Wildlife Service, New Mexico Ecological Services Field Office
Date Issued:	October 15, 2009
Approved by:	Santiago Gonzales Deputy Field Supervisor
Biological Opinion Number:	22420-2005-F-117

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TABLE OF ACRONYMS

ACI	activated carbon injection
af/yr	acre-feet per year
BA	biological assessment
BIA	Bureau of Indian Affairs
BLM	U.S. Bureau of Land Management
BMP	best management practice
BNCC	BHP Billiton Navajo Coal Company
BO	biological opinion
C	Celsius
CNAP	Colorado Natural Area Program
CNHP	Colorado Natural Heritage Program
DEIS	draft Environmental Impact Statement
DOI	U.S. Department of the Interior
DREP	Desert Rock Energy Project
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
CCB	coal combustion byproduct
cfs	cubic feet per second
CI	confidence interval
cm	centimeter
COPEC	chemicals of potential environmental concern
CPC	Center for Plant Conservation
DW	dry weight
F	Fahrenheit
FCPP	Four Corners Power Plant
FGD	flue gas desulfurization
ft	feet
g	gram
GWPRF	Ground Water Protection Research Foundation
ha	hectare
in	inch
IPCC	Intergovernmental Panel on Climate Change
kg	kilogram
km	kilometer
kV	kilovolt
LANL	Los Alamos National Laboratories
lb	pound
m	meter
mi	miles
mm	millimeter
MW	megawatt
ng/L	nanograms per liter

NIIP	Navajo Indian Irrigation Project
NMEP	Navajo Mine Extension Project
NNDFW	Navajo Nation Department of Fish and Wildlife
NNEPA	Navajo Nation Environmental Protection Agency
NNHP	Navajo Natural Heritage Program
NOAEL	no adverse affect level
NWR	National Wildlife Refuge
ORV	off road vehicle
OSM	Office of Surface Mining
PAH	polycyclic aromatic hydrocarbon
PCE	primary constituent element
PNM	Public Service Company of New Mexico
POD	plan of development
ppm	parts per million
Reclamation	U.S. Bureau of Reclamation
RM	river mile
ROW	right of way
RPA	reasonable and prudent alternative
Service	U.S. Fish and Wildlife Service
SJGS	San Juan Generating Station
SJRRIP	San Juan River Recovery Implementation Program
SL	standard length
SMCRA	Surface Mining Control and Reclamation Act
SO_2	sulfur dioxide
µg/g	micrograms per gram
µg/L	micrograms per liter
WW	wet weight
YOY	young of the year

INTRODUCTION

This draft biological opinion (BO) is based on our review of the proposed Desert Rock Energy Project (DREP) located in San Juan County, New Mexico, and its effects on the endangered Colorado pikeminnow (*Ptychocheilus lucius*) 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), the threatened Mesa Verde cactus (*Sclerocactus mesae-verdae*), and the endangered Mancos milkvetch (*Astragalus humillimus*) 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 draft BO is based on information provided in the biological assessment (BA) from the Bureau of Indian Affairs (BIA), dated December 22, 2008, electronic mail and telephone conversations between our staffs, data in our files, a review of the literature, and other sources of information. A draft Environmental Impact Statement (DEIS) has been completed and released for public comment (BIA 2007). A complete administrative record of this consultation is on file at the New Mexico Ecological Services Field Office, Albuquerque, New Mexico.

BACKGROUND AND CONSULTATION HISTORY

The BIA proposes to approve a lease for the Navajo Nation to develop the DREP, which includes construction and operation of a 1,500 megawatt (MW) coal-fired power plant, various air emissions, construction of access roads, electrical transmission lines, and a water-well field, as well as construction of various mining facilities and operations at the Navajo Mine on the Navajo Nation in San Juan County, New Mexico, and surrounding area. The BIA is the lead consulting agency for the air and water permits for this project.

On February 18 and November 26, 2004, the U.S. Fish and Wildlife Service (Service) provided technical assistance and a species list to BIA during scoping for the project.

On April 30, 2007, BIA submitted a BA for the proposed DREP. The BA did not provide sufficient information to initiate formal consultation, and the Service requested additional information from BIA in a July 2, 2007 letter. The BIA responded on October 26, 2007 with a revised BA for the DREP. Many of the questions asked by the Service in the July 2, 2007 letter were not addressed and only some of the additional information requested was provided in the revised BA. Consequently, the BA still did not provide sufficient information to complete a thorough analysis of the effects of the action on federally listed species. The key issues of concern were:

- The analysis of the effects of emissions on federally listed species and their habitats is predicated on the chemical composition of the coal. According to the U.S. Geological Survey data on coal from the Colorado Plateau Coal Assessment Area (Affolter 2001), coal from the Navajo Coal Field has, on a whole-coal basis, higher concentrations of mercury, selenium, and other contaminants than reported in the BA. Coal quality is the key to the analysis of effects of the emissions; the chemical composition of the coal determines the volume of pollutants that will be emitted. The difference in coal composition was not reconciled by BIA.

- The risk analysis provided does not take into account bioaccumulation or the heavy metal contributions from the existing two coal-fired power plants in close proximity to the proposed Desert Rock power plant. Bioaccumulation analysis is particularly important for the Colorado pikeminnow, a top predator.

- The cumulative effects of emissions from the three adjacent coal-fired power plants (the proposed DREP, the San Juan Generating Station [SJGS], Four Corners Power Plant [FCPP]), their contribution to greenhouse gas emissions, and the effect of climate change on threatened and endangered species need to be fully analyzed.

On February 2, 2009, the BIA provided a 26 page "errata package" further revising the December 22, 2008 BA provided to the Service.

On February 26, 2009, the Service sent a letter to U.S. Environmental Protection Agency (EPA) Region 9 Air Division requesting additional input on the sources and deposition of mercury and its bioaccumulation in the critical habitat of the endangered species on the Colorado River.

On February 26, 2009, the Service sent a letter to BIA requesting a 60-day extension of the consultation period in accordance with 50 CFR $402.14(e). The final BO would be issued on June 16, 2009.

On March 30, 2009, the Service received a letter from New Mexico Environment Department requesting a meeting to discuss their concerns regarding the BA submitted by the BIA on the DREP.

On April 6, 2009, the Service briefed BIA and EPA on the status of the consultation and issues with the information provided in the BA.

On April 7, 2009, the Service received a letter from the Navajo Nation requesting participation in any meetings with the New Mexico Environment Department discussing the DREP.

On April 15, 2009, the Service, BIA, and EPA had a senior managers' conference call to discuss the consultation.

On April 16, 2009, the Service received a letter from BIA with further discussion on issues raised on the April 15, 2009, senior managers' conference call.

On April 16, 2009, the Service received a letter from BIA requesting a draft of the BO.

On April 28, 2009, the Service met with New Mexico Environment Department, New Mexico

Game and Fish and the Navajo Nation to discuss the consultation.

On May 12, 2009, the applicants and BIA agreed to time a 90-day extension, with all parties agreeing the final BO would be due November 16, 2009.

On July 1, 2009, the Service requested external peer review of the mercury and selenium analysis developed for the draft BO from four external experts. Reviews were received on July 20 (selenium), September 18 (mercury), and September 21, 2009 (selenium). The second peer review of the mercury analysis was not received.

The Service met with BIA and the applicants on June 8, August 4, and September 8, 2009, to discuss the analysis of effects and elements of a potential Reasonable and Prudent Alternative (RPA), and on September 22, 2009, the Service provided BIA and the applicants with a conceptual outline for an RPA via conference call.

On September 29, 2009, the Service met with and provided BIA and the applicants with a draft RPA.

DESCRIPTION OF THE PROPOSED ACTION

ACTION AREA

Following is a summary of the action area, which is described in more detail in the BA.

The action area encompasses the San Juan River watershed and eight sub-basins of the Rio Grande–Elephant Butte watershed (separated by the Continental Divide), including the 300 kilometer (km) radius of the proposed DREP power station. This action area is defined based on infrastructure and modeled atmospheric emissions from the plant. It includes the northwestern portion of New Mexico west of the Rio Grande and north of Elephant Butte Reservoir and extends generally northeast to include portions of southwestern Colorado, southeastern Utah, and northeastern Arizona.

The Rio Grande originates in southwestern Colorado and bisects the eight sub-basins of the Rio Grande–Elephant Butte watershed within the action area. The upper Rio Grande is fed by several streams, including the Rio Chama, Rio Hondo, and El Rito, which all flow into Cochiti Reservoir, located about half way between Santa Fe and Albuquerque. The Rio Chama and Rio Grande originate in the lower San Juan Mountains of southwestern Colorado, which extend into northern New Mexico south to near Chama. This portion of the action area is characterized by the high elevation San Juan Mountains and the Jemez Mountains with elevations ranging from 5,000 to 10,000 feet (ft).

The middle Rio Grande (below Cochiti Reservoir to Elephant Butte) is bounded on the east by the Sandia and Manzano Mountains, which are outside of the action area, and on the northwest by the volcanic steep-walled canyons and mesas of the Jemez Mountains. Topographically, the middle Rio Grande within the action area decreases in relief to the south with lower elevation mesas, cuestas, and buttes located west of the broad river valley.

The San Juan River watershed is within the Navajo Section of the Colorado Plateau physiographic province. Topographically, the area is characterized by broad, rolling plains, sandstone capped cuestas, and high mesas bisected by broad canyons. The San Juan River watershed is the second largest of three sub-basins of the upper Colorado River basin. The San Juan River originates in the San Juan Mountains of southwestern Colorado and flows approximately 50 km (31 miles [mi]) south to the Colorado/New Mexico border, 305 km (190 mi) westward to the New Mexico/Arizona border, and then continues another 219 km (136 mi) into Lake Powell, which is the western extent of the action area. The San Juan River has few perennial tributaries (the Animas River is the largest), and it receives substantial seasonal flows from a number of ephemeral drainages. In 1962, Navajo Dam was constructed just south of the Colorado border in New Mexico to store flows from the San Juan, Los Piños, and Piedra Rivers.

PROPOSED ACTION

Desert Rock Energy, LLC and Dińe Power Authority are proposing to construct and operate a 1,500 MW gross (1,366 MW net) coal-fired power plant. BHP (Broken Hill Proprietary) - Billiton Navajo Coal Company (BNCC) proposes to expand its current surface coal mining operations within the BNCC lease Areas IV South and V, including coal preparation and industrial facilities within Area IV North to provide coal for the proposed power plant.

The proposed coal-fired power plant would include no more than two 750 MW generation units, a plant cooling system, coal handling facilities, power transmission interconnection facilities, a water supply system, access roads to the plant site, and other ancillary facilities. The proposed expansion of the mining operation would include mining approximately 13,000 acres from Area IV South and V of the BNCC lease and construction of a coal conveyor and coal preparation facilities, industrial facilities, and related infrastructure on approximately 670 acres in Area IV North.

The proposed action is summarized below in terms of the required facilities (Table 1). The proposed facilities would be located approximately 30 mi southwest of Farmington in San Juan County, New Mexico, within the boundaries of the Navajo Nation. Detailed information on the proposed action, including project construction, plant operation, maintenance, mining, and decommissioning is provided in the DEIS prepared for the project, dated May 11, 2007 (U.S. Department of the Interior [DOI]/BIA 2007) and incorporated here by reference.

Table 1. Acreage requirements for facilities and infrastructure for the proposed action

Facility	Acres
Power Plant	
Leased Site	592
Power Plant Footprint	149
Infrastructure	
Transmission line (Segments A,C,D)	1,205
Water Well Field B	890
Power Plant Access Road	21
Coal Mining Operations	
BNCC Lease Areas IV South and V	13,006
Area IV North	674

Power plant

Up to 1.2 million tons of earth material is expected to be removed from the site for the construction of the power plant. The cut-and-fill activities would be conducted using scrapers or excavators. These activities would occur in a manner that soil would not need to be imported or exported. The plant site would be surrounded by fencing for security and safety purposes and regular access to the plant would be through a primary gate with security controls. The power plant would have a 50-year design life without major capital improvements.
Facilities included within the power plant site (i.e., administration building/control center, turbine hall, air-emission control equipment and facilities, maintenance shop, etc.) and operation of the plant are described in more detail in the DEIS (BIA 2007).

The power plant is proposed as a mine-mouth operation and would be fueled by sub-bituminous coal provided by the adjacent coal resources of the BNCC lease areas. The coal would be delivered from the BNCC lease areas to the power plant via conveyor. Operation of the power plant would require up to 5.3 million tons per year of pulverized coal.
State-of-the-art emission controls would be used to minimize emissions of potential air pollutants. Air pollution controls for the pulverized coal-fired boilers would consist of the following:

- Low nitrogen oxide burners and selective catalytic reduction to control emissions;

- Low sulfur coal and wet flue gas desulfurization (FGD) to control sulfur dioxide (SO_2) emissions;

- Wet FGD and a wet stack to control acid gas emissions, including sulfuric acid mist;

- Wet FGD to control mercury emissions. Activated carbon and hydrated quicklime injection to be installed before the fabric filter baghouse if needed for additional reductions, with secondary reductions in SO_2 emissions and SO_2 mist;

- A fabric filter to control particulate emissions; and

- High efficiency combustion to control carbon monoxide and volatile organic compound emissions.

Highly efficient supercritical boilers would operate at high temperatures and pressure to create steam to turn a turbine connected to a generator that would produce the electricity. Steam exhausted from the turbine would be cooled by a hybrid cooling system. This type of cooling system uses 80 percent less water than conventional wet cooling systems. No cooling pond would be required.

At the end of its useful life (estimated at over 50 years), the power plant and all associated facilities would be decommissioned. All structures and equipment at the site would be dismantled and removed. All wells would be decommissioned and abandoned or transferred to the Navajo Nation for future use in accordance with Navajo Nation procedures, regulations, and applicable contracts. Following removal and abandonment of facilities, any areas disturbed would be rehabilitated as near as possible to their original condition.

Access road

Although existing access roads and two-tracks are available within the project area and along proposed utility and transmission corridor alignments, a new permanent access road is proposed to provide access to the proposed power plant site. This access road would spur west off of existing BIA 5082, commonly known as the Burnham Road, that currently crosses, in a north-south direction, within Areas IV and V of the BNCC lease area.

Transmission lines

Two single-circuit 500-kilovolt (kV) transmission lines, each with a 250-ft wide right-of-way (ROW), would leave the power plant site and parallel the east side of the Chaco River to the north for approximately 14.9 mi to the FCPP operated by Arizona Public Service Company. From the FCPP, one single-circuit 500-kV transmission line would parallel an existing 230-kV transmission line within a 250-ft wide ROW across the San Juan River to interconnect with the proposed Navajo Transmission Project (NTP) transmission line, a distance of approximately 10.8 mi.

At each structure site, a work area of approximately 200 by 200 ft would be required for the location of structure footings, tower assembly, and equipment maneuvers. The work area would be cleared of vegetation only to the extent needed. After construction, disturbed areas not needed for normal maintenance of the transmission line would be graded to blend as closely as possible with the natural contours and planted with native plant species. Areas would be reseeded prior to the season(s) when precipitation is normally received.

Pilot lines would be strung from structure to structure by helicopter and threaded through the stringing sheaves at each tower. Following the pilot lines, a larger diameter, stronger line would be attached to conductors to pull them through. Conductors and ground wires would be strung using powered pulling equipment at one end and powered tensioning equipment at the other end of a conductor segment. Sites for tensioning equipment and pulling equipment would be approximately 3 mi apart. The tensioning site would be an approximately 40,000-ft^2 area. The pulling site would require approximately half the area of the tension site.

During pre-design project development activities, a series of preexisting roads were field-verified and mapped for access to proposed transmission tower sites resulting in selection of routes that avoided disturbance of culturally and biologically sensitive areas. Existing roads would be used to the greatest extent possible; however, some overland access on undisturbed areas would be required. All biological and cultural resources of importance along or within all roads used for the project would be inventoried and monitored by a professional biologist or archaeologist prior to construction-related activities, and these resources would be avoided during long-term maintenance activities of the project.

Water well field

The average annual water consumption demand of the DREP is estimated to be 4,500 acre-feet per year (af/yr) (or 2,795 gallons per minute) of continuous flow for a period of 50 consecutive years. An additional 450 af/yr would be available to meet Navajo Nation municipal demand for a total of 4,950 af/yr. Although the life of the proposed action is 50 years, the term of the water agreement with the Navajo Nation is 40 years. The project proponents would renegotiate the water agreement at the end of its term. The proposed water source would be groundwater from the Morrison Formation aquifer, located at depths of 1,000 and 6,000 ft. Based on evaluations of the hydrologic characteristics of the Morrison Formation aquifer, it was estimated that 10 to 20 new production wells could meet this anticipated water demand (BIA 2007).

The proposed well field would be located on the 240 hectare (ha) (592 acre) power plant site lease area. Wellheads may be located along the proposed transmission line Segment A if there is not adequate space within the 240 ha parcel for all of the project wellheads. More detail on siting and operation of wells is provided in the DEIS.

Overhead distribution power lines would be constructed to supply electricity to the wells and would be constructed in the same ROW, paralleling the main water utility pipeline and collector pipelines. Access to the production wells would be needed for construction, operation, and maintenance. Access roads would be approximately 4.6 meter (m) (15 ft) wide and would be gravel roads constructed in accordance with BIA and/or Navajo Nation standards.

BNCC mine lease (Navajo Mine Extension Project)

The expansion of coal mining in Areas IV South and V and the addition of coal preparation and industrial facilities in Area IV North are called the Navajo Mine Extension Project (NMEP). The NMEP, which encompasses approximately 13,000 acres, would supply coal to the power plant. Additional detail on the coal conveyor system is located in the DEIS.

BNCC holds New Mexico Office of the State Engineer Permit Number 2838 for surface water usage and associated Groundwater Permit Number SJ-2917. These permits provide BNCC a total diversionary right of 51,600 af/yr, with a consumptive right of 39,000 af/yr, for waters drawn from the San Juan River. The additional consumption associated with the expansion of the surface mining operations at the Navajo Mine required to supply coal to the DREP is estimated to be approximately 600 af annually. The additional consumption is within the existing consumptive right and would cause no depletions to the San Juan River beyond those authorized under the current water right permit. The additional 600 af of water annually required for the proposed NMEP would be used for dust suppression, for irrigation required to re-establish native vegetation on reclamation areas, and to be treated and used as potable and sanitary water.

All mining areas associated within the BNCC lease areas disturbed by mining activities would be reclaimed per the terms and conditions of BNCC's Surface Mining Control and Reclamation Act (SMCRA) permit as administered by Office of Surface Mining (OSM).

Detailed information concerning the construction and operation of the Desert Rock power plant and associated components including the BNCC mine lease are contained within the DEIS (BIA 2007).

Coal combustion byproducts

Up to 1.35 million tons of coal combustion byproducts (CCBs) could potentially be generated annually by the power plant. The CCB generation rate would vary, depending on power plant output and coal quality.

The CCBs produced annually would include up to 1.12 million tons of fly ash, 124.5 thousand tons of bottom ash, and 108.3 thousand tons of synthetic gypsum (calcium sulfate) from FGD. As part of the DREP, CCBs would first be sold for commercial purposes, as possible, and any remaining CCBs would be backfilled into the mined out areas at NMEP. The details of this placement will be discussed in the SMCRA permit for NMEP and would comply with OSM regulations.

CCBs that cannot be marketed for reuse would be mine-filled as a part of required mine reclamation activities by BNCC at NMEP. The CCBs that are planned for placement at the NMEP will be comprised of fly ash, bottom ash, and FGD residuals produced during the combustion of the Navajo and other coals used at the power plant. CCBs from the power plant would be mixed and backfilled in mined-out pits and inactive ramps to restore the natural contour of the land. Mine reclamation activities using CCBs will be conducted and managed in a manner that is environmentally sound and protective of human health and the environment. Additional details on CCB placement and reclamation of the mine are provided in the DEIS.

As discussed above, the DREP is evaluating the use of activated carbon injection (ACI) to reduce mercury in flue gas emissions; however, it is not currently used for mercury emissions controls at local power generation facilities. Thus at this time, the possible effect of ACI on CCB chemistry would be addressed by NMEP through literature studies until actual samples from the DREP facility are available for comprehensive testing. The detailed plans for characterizing CCBs and potential placement locations in mine backfill at the NMEP for the SMCRA permit are described in the "Work Plan for CCB Testing and Evaluation for the Navajo Mine Extension Project." This work plan has been finalized in consultation with the OSM and will be implemented.

CONSERVATION MEASURES

The following conservation measures are part of the proposed action.

General conservation measures

Prior to construction

- An Oil and Hazardous Materials Spill Prevention, Control, and Countermeasure Plan shall be prepared to address hazardous materials storage and spill prevention.

- A Storm Water Pollution Prevention Plan shall be prepared and implemented for construction activities to control surface runoff, reduce erosion, and prevent sedimentation from entering waterbodies during construction.

- An Environmental and/or Biological Resource Compliance Monitoring Plan shall be prepared for all construction projects to ensure implementation of mitigation measures described in pertinent resource sections of the DEIS (USDI/BIA 2007). The plan shall identify the frequency and type of monitoring required by qualified natural/biological resources personnel. The plan shall be submitted for Navajo Nation Department of Fish and Wildlife (NNDFW) approval prior to any construction.

- All construction personnel shall attend an environmental protection briefing prior to working on any construction site in the project area. This briefing is designed to familiarize workers with statutory and contractual environmental requirements and the recognition of and protection measures for sensitive vegetation community and wildlife habitats.

- Protective barriers shall be placed around specified sensitive vegetation community and wildlife habitats as identified by the NNDFW. Barriers shall be installed prior to construction and field inspected by NNDFW personnel to verify proper placement.

- Above ground structures (i.e., transmission towers) shall be sited and designed in order to minimize disturbance to sensitive wildlife habitats and to minimize adverse effects to landscape features such as topography and vegetation.

- Imported soils, fills, or aggregates shall be free of deleterious materials (i.e., trash, construction debris, noxious weeds). Sources of imported materials shall be submitted for Navajo Nation approval prior to construction.

- A Non-Native Species Management Plan shall be prepared prior to the commencement of any ground-disturbing activities that specifies the locations and methods for removing non-native plant species, prescriptions for monitoring activities after construction, and reporting requirements. The plan shall be submitted for NNDFW approval prior to ground-disturbing activities.

- A Revegetation Plan shall be prepared for approval by the NNDFW prior to the commencement of any ground-disturbing activities that prescribes plant salvage, revegetation, and post-construction monitoring activities. 30 CFR 816 requires coalmine permittees to develop a reclamation plan. The OSM is the lead agency for ensuring that mined lands are reclaimed in accordance with SMCRA.

- Preconstruction surveys shall be conducted, as specified by the NNDFW, by a qualified biologist to identify the number, type, and location of special status species that potentially occur within the project area.

- A construction work schedule shall be prepared for all off-site construction projects to minimize noise and human activity effects on wildlife in adjacent habitats.

- A Construction Traffic and Parking Management Plan will be developed that minimizes traffic interference and maintains traffic flow.

- If any grading, clearing, brushing, or construction occurs off site during the migratory bird breeding season (approximately February 15 through August 31), a qualified biologist shall conduct a survey of the habitat to determine whether there are active bird nests in the area, including raptors and ground nesting birds. The survey would begin not more than three days prior to the beginning of work. If an active nest is observed, a minimum 91 m (300 ft) buffer (152 m [500 ft] for raptors) would be established using temporary fencing. The buffer would be in effect as long as work is occurring or until the nest is no longer active.

- From two to five acres of off site wetland/riparian creation and/or enhancement will be completed as applicant committed mitigation to offset impacts to waters of the U.S. This mitigation measure will be implemented as determined in consultation with the U.S. Army Corps of Engineers and the Navajo Nation Environmental Protection Agency (NNEPA) during the Clean Water Act Section 404 permitting process.

<u>During construction</u>

- All construction contractors shall implement and comply with requirements of the Oil and Hazardous Materials Spill Prevention, Control, and Countermeasure Plan prepared for all construction projects.

- All construction contractors shall implement and comply with operational compliance requirements of the Storm Water Pollution Prevention Plan.

- Construction activities shall be monitored by qualified natural resources personnel as outlined in the Environmental and/or Biological Resource Compliance Monitoring Plan.

- All project construction contractors shall implement and comply with the Non-native Species Management Plan prepared for each project component.

- Vegetation salvage, seed collection, and revegetation shall be implemented as defined in the Revegetation Plan. Topsoil shall be salvaged, segregated during storage, and reused in the proper location and depth as specified by the NNDFW.

- No paint or permanent discoloring agents shall be applied to rocks or vegetation to indicate limits of survey or construction activity.
- All construction activities shall be completely confined to the areas of potential ground disturbance for each project component as described in the DREP DEIS under the Preferred Alternative. Clearing of vegetation and ground disturbance shall be minimized to the greatest extent possible.

- Stationary noise sources shall be located as far as possible from sensitive wildlife habitat areas.

- On-site work for transmission corridor construction that generates noise levels above 76 decibels shall be done between 7:00 a.m. and 7:00 p.m.

- Excavation sites shall be monitored or covered to avoid trapping wildlife, and routes of escape for wildlife should be maintained. The construction site shall be inspected daily for appropriate covering and flagging of excavation sites. Each morning the project area shall be inspected for wildlife trapped in excavation pits. A qualified biologist shall be available to inspect excavations before refilling occurs.

- Vehicle speeds shall be restricted and posted within the plant site and on access roads.

- Construction-related trips of workers and equipment, including trucks, shall be reduced by implementation of the Construction Traffic and Parking Management Plan.

- Stabilization of material piles shall be achieved by using chemical palliatives, woven fabrics, or plastic sheeting.

- Earthmoving activity and vehicle travel shall be restricted during periods of high winds (i.e., more than 30 mph).

- Diesel-powered construction equipment shall be properly tuned and maintained and shut off when not in direct use. Periodic, unscheduled inspections shall be employed to limit unnecessary idling and to ensure that construction equipment is properly maintained, tuned, and modified consistent with established specifications.

- Proposed electrical transmission and distribution lines shall be designed and constructed utilizing "raptor-safe" design. The most complete manual on this work is: "Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 2006" (APLIC 2006).

<u>Post-construction</u>

- All tools, equipment, barricades, signs, surplus materials, debris, and rubbish shall be removed from the project work limits upon project completion.

- The success of revegetation efforts shall be monitored. Plant materials used for revegetation shall remain alive and in a healthy, vigorous condition for a period of one year after final acceptance of planting. The project site shall be monitored in accordance with the Non-native Species Management Plan and Revegetation Plan. All plants determined to be in an unhealthy condition shall be replaced.

Conservation measures for the Colorado pikeminnow and razorback sucker

- The Storm Water Pollution Prevention Plan will be implemented for all construction activities with potential to discharge pollutants into the San Juan River. This includes project components that are adjacent to the San Juan River, as well as those components constructed away from the San Juan River but with potential for runoff to flow into the San Juan River.

- A Hazardous Materials Handling and Response Plan will be developed and implemented for all proposed project components.

- Implementation of a Spill Prevention, Control, and Countermeasure Plan for all storage facilities subject to 40 CFR 112.

- Maximum achievable control technology standards will be implemented to minimize air emissions containing hazardous air pollutants and/or mercury compounds.

- The project proponents will participate in funding water quality monitoring and other related studies and potential habitat restoration through the San Juan River Recovery Implementation Program (SJRRIP) in coordination with the Service.

Conservation measures for the southwestern willow flycatcher

- Surveys will be conducted to determine the extent of flycatcher use of the San Juan River basin over the life of the project. These surveys will include the following:

    1. Determining the location, extent, and suitability of flycatcher habitat in the San Juan basin.

    2. Surveying for flycatchers in areas where suitable habitat has been identified. Surveys should be completed every five years (one full survey season using the flycatcher survey protocol). Survey locations would be recommended by the proponent and approved by the Service.

    3. Evaluate current and future restoration projects to determine if flycatcher habitat has been created and survey restored habitats as determined appropriate.

- Timing restrictions for construction of transmission towers and stringing of conduit lines, as well as other construction and maintenance activities within and above the San Juan River floodplain and within 0.25 mi (0.4 km) of the Chaco River will be implemented. Work will not be conducted between May 1 and August 30 to avoid disturbance to migrant or potential breeding flycatchers.

- Because southwestern willow flycatcher habitat along the Chaco River was not subject to protocol surveys in 2006 in all survey periods, the Chaco River will be resurveyed for flycatchers if habitat conditions change over the course of project development and construction.

- Additional conservation measures have been developed and are described in the Riparian Monitoring and Mitigation Plan developed for the proposed project (Appendix H of the BA). These measures include habitat mapping, presence/absence surveys, wetland creation or enhancement, and exotics eradication.

Conservation measures for Mancos milkvetch

- Implementation of a Storm Water Pollution Prevention Plan for all construction activities with potential to discharge pollutants in areas of suitable Mancos milkvetch habitat.

- In areas of potential Mancos milkvetch habitat, pre-construction surveys will be conducted for all potentially disruptive activities and for all ground-disturbing activities. This includes all construction and maintenance activities or any activity requiring human presence outside of developed areas. Surveys should include a minimum of a 200-ft (60 m) buffer around the areas that have potential to be disturbed. The recommended survey period is during the flowering period (April to early May); however, surveys can be conducted by experienced botanists year-round. If individual plants are encountered during surveys, construction plans will be altered to minimize or eliminate disturbance.

- Implementation of a Spill Prevention, Control, and Countermeasure Plan for all storage facilities subject to 40 CFR 112.

- Human activity in portions of the project area where Mancos milkvetch have potential to occur will be minimized. Workers associated with the DREP will limit their activities to established construction and maintenance areas, roads, and walkways.

- Long-term range-wide monitoring and sampling will be conducted for potential effects of particulate deposition and air pollutants of concern. Monitoring will take place annually over a minimum of 10 years, including baseline sampling prior to the actual construction of the power plant. Monitoring soil and plant tissue levels of chemicals of potential environmental concern (COPECs) will occur across their range within the action area. Monitoring should include trend objectives and appropriate management responses should a decline in population number or reproductive potential be noted of more than 10% of baseline data. After 10 years, the monitoring plan should be reevaluated for its effectiveness in meeting the trend objectives.

  Monitoring sites will be established along transmission line Segment D to evaluate potential impacts of increased off-road vehicle (ORV) activities and the potential invasion of exotic species.

Conservation measures for the Mesa Verde cactus

The conservation/mitigation measures described below apply to all areas where Mesa Verde cacti are known to occur and individual plants or populations have been observed. Also included are measures to protect suitable, but unoccupied habitats, for this cactus. Desert Rock Energy, LLC and their contractors would strictly comply with all stipulations of the grant of easement issued by the BIA for the project throughout the term of the grant, as well as the procedures and stipulations identified in the project plan of development (POD).

- If more than ten additional cacti from those recorded in 2006 are found during pre-construction surveys, Desert Rock Energy, LLC will coordinate with NNDFW to review the effectiveness of mitigation and avoidance measures.

- If more than ten cacti cannot be avoided and need to be transplanted, Desert Rock Energy, LLC will coordinate with NNDFW to review the effectiveness of mitigation and avoidance measures.

- If more than two cacti are damaged during construction, Desert Rock Energy, LLC will coordinate with NNDFW to review the effectiveness of mitigation and avoidance measures.

- During the course of monitoring activities described above, annual plant lists will be maintained within each monitoring block to document spatial and temporal changes in species composition and identify other sensitive plant species that may occur, but not have been previously observed in the project area.
- Long-term range-wide monitoring and sampling will be conducted for potential effects of particulate deposition and air pollutants of concern. Monitoring will take place annually over a minimum of 10 years, including baseline sampling prior to the actual construction of the power plant.

- Monitoring soil and plant tissue levels of COPECs will occur across their range within the action area. Monitoring should include trend objectives and appropriate management responses should a decline in population number or reproductive potential be noted of more than 10 percent of baseline data. After 10 years the monitoring plan should be reevaluated for its effectiveness in meeting the trend objectives.

- Monitoring sites will be established along transmission line Segment D to evaluate potential impacts of increased ORV activities and the potential invasion of exotic plant species.

- Project proponents will provide up to 26,400 ft (8,046 m) of wire rope or cable to support efforts by the NNDFW to limit access to currently planned Mesa Verde cactus conservation areas. Specifications of these materials will be determined in coordination with the NNDFW.

- The project proponents will donate $10,000 to the Center for Plant Conservation (CPC) to fund a sponsorship of Mesa Verde cactus. The sponsorship establishes a permanent fund whose proceeds ensure sustained progress for recovery of the species. The CPC would then make an annual payment of $500 to the Denver Botanic Gardens (Mesa Verde cactus sponsor) for a period of approximately 20 years to establish a long-term storage of seeds at the National Center for Genetic Resource Preservation lab.

- Intensive pedestrian surveys for Mesa Verde cacti were performed in May of 2006. All Mesa Verde cacti and associated habitat that could potentially be affected by construction, operation, or maintenance of the transmission line were documented. All areas that may be affected directly or indirectly by construction, operation, or maintenance of the line or access roads within or outside of the 250-ft ROW will be resurveyed prior to construction activities to develop a pre-engineering map, which will include all cacti locations from previous surveys. Unoccupied habitat will be classified in terms of quality based on substrate suitability, the degree to which suitable substrate is fragmented or isolated, previous presence of cacti (based on Navajo Natural Heritage Program [NNHP] records and the 2006 surveys), and proximity to occupied habitat.

- Based on the results of the 2006 surveys and pre-engineering surveys, a detailed *Mesa Verde Cactus Construction Plan* will be developed for the purposes of avoiding cacti and *minimizing disturbance of habitat* to the greatest extent practicable. The construction plan will include a map of all cacti identified through the spring 2006 surveys, pre-engineering surveys, habitat classification by quality, and all construction work areas. The construction plan will be submitted to the Service, NNDFW, and the BIA for review. In order to discourage the illegal harvesting of cacti, the locations of cacti will be kept confidential and no universal transverse mercator coordinates will be included in the final reports. Project Construction Inspectors and biological monitors will be the only individuals with detailed cacti location information. All agency comments will be addressed and incorporated into the plan, as appropriate, prior to construction. The plan, without the maps of specific cacti locations, will be included in the project POD and adherence to the recommendations included therein will be a requirement of the construction contractor.

- Construction areas, including tower sites and spur roads, will be located in coordination with project engineers and resource specialists to avoid individual cacti and habitat identified during the surveys. Wire-pulling and wire-splicing sites and materials staging areas will be evaluated for the presence of individual cacti prior to the clearing of any vegetation necessary in order to store equipment on site. Placement of these areas will be within, or as near as practicable, to existing roadways and/or heavily used areas. The siting of these areas also will take into consideration indirect effects from operation and maintenance (e.g., long-term utilization of access roads in areas where cacti are known to occur) as well as effects related to potential increase of access by off-road/highway vehicles. The pre-engineering surveys will determine the level of impact on cacti or their habitat in areas of conventional access.

- To the extent practicable, the placement of access roads will minimize disturbance to Mesa Verde cactus habitat. The approximate locations of overland spur access roads will be included as part of the detailed maps included in the POD. The locations of access roads will be further refined once final engineering has been completed and the exact locations of the tower sites are determined. The edges of the access roads will be flagged in the field and, to the extent practicable, will take advantage of existing disturbance, slope, and topography. Access roads will not be proposed in any area known to contain individual Mesa Verde cacti based on the results of both the 2006 surveys and pre-construction surveys. To the extent possible, access roads will be sited no closer than 50 ft (15 m) from a known individual cactus location.

- Overland spurs will not be bladed, and construction personnel will be advised to follow existing tire tracks within the designated area and minimize their trips along these spurs to the extent possible in order to reduce disturbance. When construction is complete, all tower sites and spur roads will be hand-raked to remove tire tracks. An emphasis will be placed on obscuring access points at intersections with paved and improved dirt roads and re-creating the topography and natural barriers (e.g., washes). Reclamation techniques will be specifically designed to address site-specific soil properties and the potential for long-term erosion.

- Pre-construction surveys for Mesa Verde cacti will be conducted in the spring of the year preceding the initiation of construction to identify any new areas of cacti. The locations of any additional cacti identified during pre-construction surveys will be added to the project maps developed for the POD. Appropriate mitigation will be developed and reviewed with the BIA and other applicable agencies and included in the POD.

- A worker education and awareness program for Mesa Verde cacti will be developed and presented to all personnel that would be on site during pre-construction surveying and construction. The program will include information on the legal and biological status of Mesa Verde cactus, the importance of habitat, the occurrence of cactus and unoccupied habitat in the study area, conservation measures, fines and penalties for damaging or removing cacti, and reporting procedures to be used if cacti not previously identified are discovered or disturbed cacti are discovered. A simple pamphlet or card summarizing critical information for avoiding cactus and minimizing effects on habitat will be provided to all field personnel.

- Qualified biologists will be on site to monitor avoidance of cacti and habitat during all construction-related activities, including the initial delineation of construction exclusion areas (e.g., fenced and flagged areas). All sites where Mesa Verde cacti are present will be monitored daily. Construction activity within 200 ft (60 m) of a cactus site will be monitored continuously. Any disturbance to cactus or habitat outside the construction zone will be reported immediately by the biological monitor to the Construction Inspection Contractor who will report to the BIA and the NNFWD. A written account including a map, the extent of the disturbance, the number of cacti and/or quantity of habitat disturbed, and the circumstances surrounding the disturbance will be submitted to the BIA within 48 hours. The incident reporting procedures for all construction activity is part of the project POD.

- Access roads and tower sites in areas where Mesa Verde cacti are present will be enclosed with construction fencing. Fencing along access roads will extend 200 ft (60 m) in both directions beyond the limits of areas that contain cacti or suitable habitat. Any cacti located within the ROW will be enclosed with construction fencing including, where possible, a buffer radius of 50 ft (15 m) around the cacti. All project personnel will be instructed that their activities must be confined to the designated construction area. All construction fencing will be inspected daily by the on-site biologist and maintained in a functional capacity by the contractor.

- All traffic will be restricted to the ROW, designated work areas, and authorized access roads.

- Overland spur roads will be used in areas to minimize surface disturbance and will be staked or flagged in the field. Cross-country travel will be strictly prohibited.

- The pneumatic cleaning of construction equipment will be required before it is permitted on the ROW, as well as when equipment is moved from an area where noxious plant species are known to be present. Water shall not be used to clean equipment since it may provide moisture for germination of noxious weed seed that may be present.

- Because of the delicate nature of soil structure in areas that support Mesa Verde cacti, no post-construction reseeding will be implemented. Such soils are typically fine-grained, possess a low cohesion and in-place density, and are highly subject to erosion. Disturbance to soil structure during revegetation efforts conducted in these types of soils can accelerate erosion processes, which are known to be detrimental to Mesa Verde cacti. Reseeding would establish plants in Mesa Verde cactus habitat, in some instances where there is currently minimal vegetation that would compete with the cacti for water and other resources. A restoration plan for all areas of disturbance will be included in the POD.

- Routine post-construction inspections of the line in Mesa Verde cactus habitat will be performed using aircraft. For minor maintenance or repair of structures or line that may be required, access will be accomplished by helicopter. If extensive repairs are required, all stipulations governing the placement and restoration of access routes covered in this document will be required. Surveys for Mesa Verde cactus will be required prior to any ground disturbing activities for maintenance. Surveys performed would be valid for 3 years.

- Individual Mesa Verde cacti that cannot be avoided during the construction process will be transplanted in cooperation with the NNDFW. Transplanted cacti will be monitored for a minimum of five years. Desert Rock Energy, LLC will provide funding for the annual monitoring and monitoring report.
- Desert Rock Energy, LLC will monitor the Mesa Verde cactus population for a five-year period near where the DREP connects to the NTP.

- Locked gates will be installed at strategic locations to restrict unauthorized vehicle access to protect Mesa Verde cacti along the ROW. Strategic locations are those areas where a gate can be placed into a topographic feature that cannot be crossed by vehicles. Signs will be placed at intersections of the access road with other roads to discourage vehicular traffic along the ROW that would alert people to the sensitivity of the area.

- Desert Rock Energy, LLC will develop a comprehensive weed management plan that addresses the management of exotic species for a period of time after construction (preferably at least five years).

As part of the Terms and Conditions of this BO, the Service requires that documentation and reporting on the implementation of the conservation measures will occur within six months after completion of project construction. Thereafter, documentation and reporting will occur annually for five years on the status of transplanted and relocated cacti and on control of noxious weeds within the disturbed sites. After five years of annual monitoring, documentation and reporting will occur every 10 years.

ANALYTICAL FRAMEWORK FOR THE JEOPARDY DETERMINATION

The following analysis relies on four components to support the jeopardy determination for the Colorado pikeminnow and razorback sucker: (1) the *Status of the Species and Critical Habitat*, which evaluates the Colorado pikeminnow and razorback sucker's rangewide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the Colorado pikeminnow and razorback sucker in the action area, the factors responsible for that condition, and the role of the action area in the Colorado pikeminnow and razorback sucker's survival and recovery; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the Colorado pikeminnow and razorback sucker; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the Colorado pikeminnow and razorback sucker.

In accordance with the implementing regulations for section 7 and Service policy, the jeopardy determination is made in the following manner: the effects of the proposed Federal action are evaluated in the context of the aggregate effects of all factors that have contributed to the Colorado pikeminnow and razorback sucker's current status and, for non-Federal activities in the action area, those actions likely to affect the Colorado pikeminnow and razorback sucker in the future, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the Colorado pikeminnow and razorback sucker in the wild.

The following analysis places an emphasis on using the range-wide survival and recovery needs of the Colorado pikeminnow and razorback sucker and the role of the action area in providing for those needs as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

ANALYTICAL FRAMEWORK FOR THE ADVERSE MODIFICATION DETERMINATION

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 statutory provisions of the

Act to complete the following analysis with respect to critical habitat.

The following analysis relies on four components to support the adverse modification determination: (1) the *Status of the Species and Critical Habitat*, which evaluates the range-wide condition of designated critical habitat for the Colorado pikeminnow and razorback sucker in terms of primary constituent elements (PCEs), the factors responsible for that condition, and the intended recovery function of the critical habitat overall, as well as the intended recovery function of discrete critical habitat units; (2) the *Environmental Baseline*, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the PCEs and how that will influence the recovery role of affected critical habitat units; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and how that will influence the recovery role of affected critical habitat units.

In accordance with Service policy and guidance, the adverse modification determination is made in the following manner: the effects of the proposed Federal action on critical habitat are evaluated in the context of the aggregate effects of all factors that have contributed to the current status of the critical habitat range-wide and, for non-Federal activities in the action area, those actions likely to affect the critical habitat in the future, to determine if the critical habitat would remain functional (or retain the current ability for the PCEs to be functionally established in areas of currently unsuitable but capable habitat) to serve the intended recovery role for the species with implementation of the proposed Federal action.

The following analysis places an emphasis on using the intended range-wide recovery function of Colorado pikeminnow and razorback sucker critical habitat and the role of the action area relative to that intended function as the context for evaluating the significance of effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

STATUS OF THE SPECIES AND CRITICAL HABITAT

COLORADO PIKEMINNOW

The Colorado pikeminnow is the largest member of the minnow family native to North America. The top predator in the Colorado River system, it is an elongated pike-like fish that once grew as large as 1.8m (6 ft) in length and weighed nearly 45 kilograms (kg) (100 pounds [lb]) (Behnke and Benson 1983); such fish were estimated to be 45-55 years old (Osmundson *et al.* 1997). Today, fish rarely exceed one m (~ three ft) in length or weigh more than eight kg (18 lbs). The mouth of this species is large and nearly horizontal with long, slender pharyngeal teeth (located in the throat) adapted for grasping and holding prey. The diet of Colorado pikeminnow longer than 80 to 100 millimeters (mm) (three or four 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 Colorado 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). Colorado 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 because of major alterations to the riverine environment. Having lost approximately 75-80 percent of its former range, the Colorado pikeminnow was federally listed as an endangered species in 1967 (Service 1967, Miller 1961, Moyle 1976, Tyus 1991, Osmundson and Burnham 1998).

Critical habitat was designated for the Colorado 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): San Juan County, New Mexico, and San Juan County, Utah, including the San Juan River from the New Mexico 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 PCEs of Colorado pikeminnow critical habitat include:

(1) Water: enough water of sufficient quality delivered to habitats in accordance with a hydrologic regime that is required for the particular life stage for the species;

(2) Physical habitat: areas of the Colorado River system that are inhabited or potentially habitable for spawning and feeding, as a nursery, or as corridors between these areas, including oxbows, backwaters, and other areas in the 100-year floodplain which when inundated provide access to spawning, nursery, feeding, and rearing habitats; and

(3) Biological environment: adequate food supply and ecologically appropriate levels of predation and competition.

Life history

The life history phases that appear to be most limiting for Colorado pikeminnow populations include the first year of life (including egg hatching and development of larvae) and spawning. These phases of Colorado pikeminnow development are tied closely to specific habitat requirements. Natural spawning of Colorado pikeminnow is initiated when water levels are dropping after the spring rise and temperatures approach the range of 16˚ Celsius (C) (60.8˚ Fahrenheit [F]) to 20˚C (68˚F) (Vanicek and Kramer 1969, Hamman 1981, Haynes *et al.* 1984, Tyus 1990, McAda and Kaeding 1991). Water 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); and in the San Juan River, 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 five temperatures, and hatching success was found to be highest at 20˚C (68˚F) and lowest 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 1985) and adult (Bulkley *et al.* 1981) Colorado pikeminnow indicated that 25˚C (77˚F) was the most preferred temperature for both 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 four years of age and females at five years. Of 24 nine-year-old females, average fecundity was 77,400 eggs/female (range, 57,766 – 113,341) or 55,533 eggs/kg, and average fecundity of nine 10-year old females was 66,185 eggs/female (range, 11,977 – 91,040) or 45,451 eggs/kg (Hamman 1986).

Most information on Colorado pikeminnow reproduction has been gathered from spawning sites on the lower 20 mi (12.2 km) of the Yampa River and in Gray Canyon on the Green River (Tyus and McAda 1984, Tyus 1985, Wick *et al.* 1985, Tyus 1990). Colorado 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, unpublished data) indicate a similar association of habitats. The 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 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 Colorado 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, Colorado pikeminnow prefer warm, turbid, relatively deep (averaging 0.4 m [1.3 ft]) backwater areas of zero velocity (Tyus and Haines 1991). After about one 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).

Colorado 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 mainstem 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 mi (1,290 km) upstream in September 1987 (Platania 1990). Ryden and Ahlm (1996) reported that a Colorado pikeminnow captured at river mi (RM) 74.8 (between Bluff and Mexican Hat, Utah) made a 50–60 mi (80–96 km) migration during the spawning season in 1994 before returning to within 0.4 RMs of its original capture location.

Although migratory behavior has been documented for Colorado pikeminnow in the San Juan River (Platania 1990, Ryden and Ahlm 1996), only one of 13 radio-tagged fish tracked from 1991 to 1994 was classified as migratory; 12 were considered sedentary (Ryden and Ahlm 1996). Miller and Ptacek (2000) followed seven radio-tagged wild Colorado 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 Colorado 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 Colorado pikeminnow are also between RM 120 and 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 Colorado pikeminnow on a year-round basis (Holden and Masslich 1997).

In contrast to Colorado pikeminnow in the Green and Yampa Rivers, the majority of Colorado 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 Colorado 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 Colorado pikeminnow in both 1993 and 1994 at the mouth of the Mancos River prior to the spawning period.

Historic spawning areas for the Colorado pikeminnow in the San Juan River are unknown; however, Platania (1990) speculated that spawning likely occurred upstream at least to Rosa, New Mexico (a town near the Colorado-New Mexico border that was abandoned and inundated by the creation of the Navajo Reservoir). Two locations in the San Juan River (RMs 132 and 131.1) 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. 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 Colorado 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 decreasing after a high flow from 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 Colorado pikeminnow during the fall suggests that Colorado 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 Colorado pikeminnow (Osmundson *et al*. 1995).

On the Green River, tributaries are an important habitat component for Colorado pikeminnow (Holden 2000). Both the Yampa and White Rivers were heavily used by Colorado 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, Colorado pikeminnow utilized the Animas River in the late 1800s, and this river could still provide suitable habitat. Five stocked Colorado 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 Colorado pikeminnow have passed upstream, increasing the probability that the Animas River, 15 mi upstream, will once again be used by this species. Colorado 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 Colorado pikeminnow in the Green River preferred backwaters that were also turbid. Bestgen *et al.* (2006) found that in a laboratory setting, turbidity provided some protection to larval Colorado pikeminnow from predation by red shiner (*Cyprinella lutrensis*). 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 frequently turbid historically as it is today. Currently, it is assumed that the endemic fishes evolved under conditions of frequent turbidity. Therefore, the retention of turbid conditions is probably an important factor in maintaining the ability of Colorado pikeminnow to compete with or avoid predation by non-native fish or other predators that may not have evolved under similar conditions.

Population dynamics

Between 1991 and 1995, 19 (17 adult and two juvenile) wild Colorado 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 2000a, 2003b).

Estimates during the seven-year research period between 1991 and 1997 suggested that there were fewer than 50 adult Colorado pikeminnow in a given year (Ryden 2000a). Monitoring for adult Colorado pikeminnow occurs every year on the San Juan River. In 2007, 167 Colorado pikeminnow were collected during the monitoring trip, the fourth consecutive year that more than 100 Colorado pikeminnow were caught (Ryden 2008a). However, only two of these fish were greater than 350 mm (13 in). In addition, 12 Colorado pikeminnow greater than 400 mm (15 in) 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; 28 in) and was stocked in 1996 as an age-0 fish. Because of the low number of Colorado pikeminnow in the San Juan River, population estimates using mark-recapture techniques have not yet been used.

Colorado pikeminnow reproduction was documented in the San Juan River in 1987, 1988, 1992-1996, 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 Colorado 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 Colorado pikeminnow have been collected near the Mancos River confluence, New Mexico, in the vicinity of the Montezuma Creek confluence near Bluff, Utah, and at a fish survey 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 Colorado pikeminnow exists somewhere below the Mixer (Platania 1996). Capture of a larval Colorado 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). Recent studies found catch rates for YOY Colorado 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 Colorado pikeminnow.

Tissue samples from Colorado 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

Colorado 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

Colorado 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 diseases. Backwaters and other low-velocity habitats in the San Juan River are important nursery areas for larval and juvenile Colorado pikeminnow (Holden 1999), and researchers believe that overlap in these habitats with non-native fish species limit the success of Colorado 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 Colorado 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 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 Colorado pikeminnow larvae (Bestgen *et al.* 2006). High spatial overlap in habitat use has been documented among young Colorado 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 Colorado pikeminnow and exhibited antagonistic behaviors to smaller Colorado pikeminnow. They hypothesized that Colorado pikeminnow may be at a competitive disadvantage in an environment that is resource-limited.

Channel catfish (*Ictalurus punctatus*) are a threat to juvenile, subadult, and adult Colorado 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 Colorado 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). Platania (1990) noted that, during three years of study on the San Juan River (1987 - 1989), spring flows and Colorado pikeminnow reproduction were highest in 1987, while catch rates for non-native 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. 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 Colorado pikeminnow (Davis 2003); however, because the Colorado pikeminnow population is so low, documenting a population response would be extremely difficult.

Status and distribution

The Colorado pikeminnow was designated as endangered prior to the ESA (32 FR 4001); therefore, a formal listing package identifying threats was not prepared. Construction and operation of mainstem dams, non-native fish, and local eradication of native minnows and suckers in the early 1960s were recognized as early threats (Miller 1961, Holden 1991). The Colorado 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 Colorado 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 mainstem 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 seven of the ten mainstem fishes as endangered (Mueller 2005).

The map below of wild Colorado pikeminnow distribution in the Colorado River basin was reproduced from the Colorado Pikeminnow Recovery Goals (Service 2002a, Figure 1).

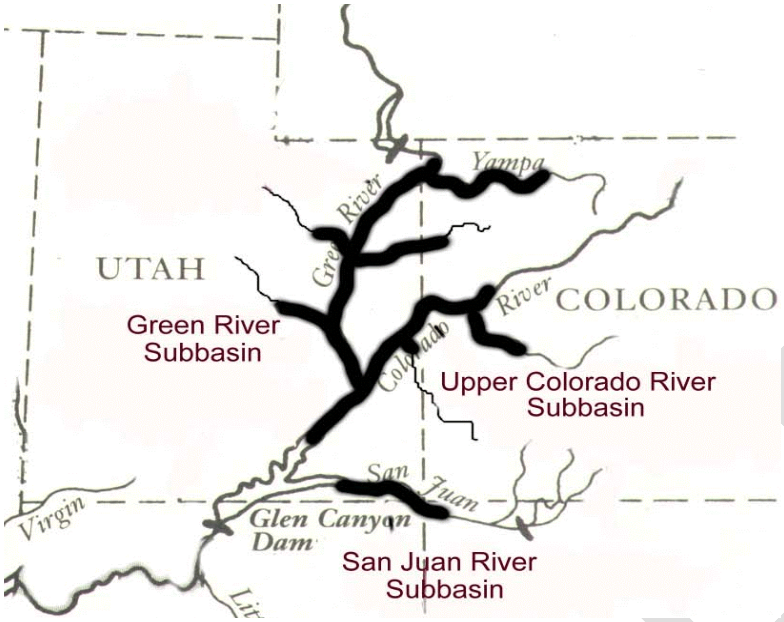

Figure 1. Distribution of Colorado pikeminnow in the Colorado River system.

Estimates of abundance in 2002 summed for the three Colorado pikeminnow populations range from about 6,600 to 8,900 wild adults. Estimates of subadults are not currently available for all populations. Estimates of the number of adults for the three subbasins are: Green River, 6,000–8,000; upper Colorado River, 600–900 [includes some subadults]; and San Juan River, 19–50 (Service 2002a).

In the upper Colorado River basin, declines in Colorado pikeminnow populations occurred primarily after the 1960s coinciding with the construction of a number of dams: Glen Canyon Dam on the mainstem 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 were nearly extirpated. River reaches in which native fish have declined more slowly 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.

RAZORBACK SUCKER

Like all suckers, 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 Colorado pikeminnow, razorback suckers may live over 40 years.

Historically, razorback suckers were found in the mainstem Colorado River and major tributaries in Arizona, California, Colorado, Nevada, New Mexico, Utah, Wyoming, and in Mexico (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 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 mainstem as far upstream as Rosa, New Mexico (now inundated by Navajo Reservoir) (Ryden 1997).

The razorback sucker was designated as endangered under the ESA in 1991 (56 FR 54957), due to little evidence of natural recruitment and declining numbers of adult fish. Threats identified at the time included diversion and depletion of water, introduction of non-native fishes, and construction and operation of dams. 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 areas of the San Juan River basin (59 FR 13374): San Juan County, New Mexico, and San Juan County, Utah, including 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 Colorado pikeminnow, including:

1) Water: enough water of sufficient quality delivered to habitats in accordance with a hydrologic regime that is required for the particular life stage for the species;

2) Physical habitat: areas of the Colorado River system that are inhabited or potentially habitable for spawning and feeding, as a nursery, or as corridors between these areas, including oxbows, backwaters, and other areas in the 100-year floodplain which when inundated provide access to spawning, nursery, feeding, and rearing habitats; and

3) Biological environment: adequate food supply and ecologically appropriate levels of predation and competition.

Life History

McAda and Wydoski (1980) and Tyus (1987) reported springtime aggregations of razorback suckers in off-channel habitats and tributaries; such aggregations are believed to be associated with reproductive activities. Tyus and Karp (1990) and Osmundson and Kaeding (1991) reported off-channel habitats to be much warmer than the mainstem river; 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 floodplain, razorback sucker are likely also 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 during the spring rise 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/female (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 four 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 they are important to the early life stages of most riverine fish. Prior to construction of large mainstem dams and the suppression of spring peak flows, low velocity, off-channel habitats (seasonally flooded bottomlands and shorelines) were commonly available throughout the upper 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.

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 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 habitat 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, Tyus and Karp 1990, Osmundson and Kaeding 1991). Their diet consists primarily of algae, plant debris, and aquatic insect larvae (Sublette *et al.* 1990). McAda and Wydowski (1980) and Bestgen (1990) suggest that the diet of razorback sucker was composed primarily of "ooze," (i.e., plant detritus with associated bacteria, fungus and zooplankton) as well as insect larvae. Papoulias and Minckley (1992) found that razorback sucker larvae exhibited prey-size selection, based on body width. Marsh (1987) examined the stomachs of 34 adult specimens from Lake Mohave and found contents dominated by planktonic crustaceans, diatoms, filamentous algae, and detritus. Jonez and Sumner (1954) reported midge larvae as the dominant food item in their stomach analysis of Lake Mohave razorback suckers. They also reported algae as the most common food item found in razorback sucker stomachs from Lake Mead, followed by plankton, insects, and decaying organic matter. Vanicek (1967) examined eight adult razorback sucker stomachs from the Green River and found them packed with mud or clay containing chironomid larvae, plant stems, and leaves.

Population Dynamics

Because wild razorback sucker are rarely found in the wild and they are a long-lived fish, it is difficult to determine natural population fluctuations. 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 suckers are rare throughout their historic range and extremely rare in the mainstem San Juan River. Until 2003, there was very limited evidence indicating natural recruitment to any population of razorback sucker in the Colorado River system (Tyus 1987, McCarthy and Minckley 1987, Osmundson and Kaeding 1989, Bestgen 1990, Platania 1990, Platania *et al.* 1991, 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 (RMs 35.7 and 4.8) (Ryden 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 dolomeiu*), largemouth bass, bluegill (*Lepomis macrochirus*), green sunfish, and redear sunfish (*L. microlophus*) (Jonez and Sumner 1954, Marsh and Langhorst 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 [TL] 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 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 (*Esox lucius*), 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 (mainly sucker species) were identified in the stomachs of juvenile largemouth bass.

Status and Distribution

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 (56 FR 54957). Dams on the mainstem 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 human-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.

The map below of the distribution of wild and stocked razorback sucker in the Colorado River basin was reproduced from the Razorback Sucker Recovery Goals (Service 2002b, Figure 2).

Figure 2. Distribution of wild or stocked razorback sucker in the Colorado River System.

Currently, the largest concentration of wild adult 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 in 1991, 25,000 in 1993 (Marsh 1993, Holden 1994), to fewer than 3,000 in 2001 (Marsh *et al.* 2003). A repatriation program began in Lake Mohave in 1991, and repatriated fish have apparently 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 and riverine environments. The largest populations of razorback sucker 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 [CI]: 758 – 1,138) in the upper Green River. Eight years later, the population was estimated at

524 adults (95 percent CI: 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, although they are increasingly rare. Osmundson and Kaeding (1991) reported that the number of razorback sucker captured 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 seven-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 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 genetic analysis and development of brood stock from all known locations. In the short term, 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 in the recovered populations. A genetics management plan and an augmentation plan have been written for the razorback sucker (Crist and Ryden 2003).

At the time of listing, few razorback sucker remained in the San Juan River. Since the initiation of the SJRRIP, razorback sucker numbers have increased, primarily due to an aggressive augmentation program. Their long-term viability remains uncertain because of the relatively limited or degraded habitat available to them between Navajo Dam and Lake Powell, competition and predation from non-native fishes, water quality issues, and the uncertainty surrounding the changes that climate change will bring to the San Juan basin.

Southwestern Willow Flycatcher

The flycatcher is a small grayish-green passerine bird measuring approximately 5.75 in (146 mm) in height. It has a grayish-green back and wings, whitish throat, light gray-olive breast, and pale yellowish belly. Two white wingbars are visible in adults, while juveniles have buffy wingbars. The eye ring is faint or absent. The upper mandible is dark, and the lower is light yellow grading to black at the tip. The song is a sneezy "fitz-bew" or a "fit-a-bew" and the call is a repeated "whitt" (Howell and Webb 1995).

Throughout this document the terms "territory" and "site" are used to help describe flycatcher population biology. A territory is the area occupied by a single male or pair of flycatchers throughout the breeding season. Territories are the unit of measurement used by the Service to determine population numbers. Flycatchers tend to cluster their territories. A flycatcher site may include a single territory or a cluster of territories.

The flycatcher is one of four currently recognized willow flycatcher subspecies (Phillips 1948, Unitt 1987, Browning 1993). It is a neotropical migrant that breeds in the southwestern U.S. and migrates to Mexico, Central America, and possibly northern South America during the non-breeding season (Phillips 1948, Stiles and Skutch 1989, Peterson 1990, Ridgely and Tudor 1994, Howell and Webb 1995). The historic breeding range of the flycatcher included southern California, Arizona, New Mexico, western Texas, southwestern Colorado, southern Utah, extreme southern Nevada, and extreme northwestern Mexico (Sonora and Baja) (Unitt 1987).

The flycatcher was listed as endangered in 1995 (60 FR 10694; Service 1995). At that time, the final designation of critical habitat was deferred, pursuant to 16 U.S.C. 1533(b)(6)(C), citing issues identified in public comments, new information, and the lack of the information necessary to perform an economic analysis. On July 22, 1997, critical habitat was designated for the flycatcher (62 FR 39129; Service 1997) along 599 RMs in Arizona, California, and New Mexico. As a result of a lawsuit from the New Mexico Cattlegrowers' Association initiated in March 1998, the 10th Circuit Court of Appeals vacated the designation of critical habitat, citing a faulty economic analysis, and instructed the Service to issue a new critical habitat designation.

A total of 737 RMs in southern California, Arizona, New Mexico, southern Nevada, and southern Utah were included in the final designation in 2005 (70 FR 60886, Service 2005). The lateral extent of critical habitat includes areas within the 100-year floodplain. The PCEs of critical habitat include riparian plant species in a successional riverine environment (for nesting, foraging, migration, dispersal, and shelter), specific structure of this vegetation, and insect populations for food. A variety of river features such as broad floodplains, water, saturated soil, hydrologic regimes, elevated groundwater, fine sediments, and others help develop and maintain these PCEs (Service 2005).

The critical habitat designation includes the following sections of the Middle Rio Grande in New Mexico within the action area: between the Taos junction bridge in Taos County and the north boundary of Ohkay Owingeh Pueblo in Rio Arriba County; from the south boundary of the Pueblo of Isleta in Valencia County to the north boundary of Sevilleta National Wildlife Refuge (NWR) in Socorro County; from the south boundary of Sevilleta NWR to the north boundary of Bosque del Apache NWR in Socorro County; and from the south boundary of Bosque del Apache NWR to the powerline crossing of the Rio Grande near Milligan Gulch, immediately north of the pool of Elephant Butte Reservoir in Socorro County. The Pueblos of Ohkay Owingeh, Santa Clara, San Ildenfonso, and Isleta were excluded from the critical habitat designation, as were the City of Albuquerque (Rio Grande State Park), Sevilleta NWR, and Bosque Del Apache NWR.

The Service designated stream segments as critical habitat for the southwestern willow flycatcher. The designated segments provide for flycatcher habitat (nesting, foraging, migration, dispersal, and shelter) and allow for changes in habitat locations or conditions from those that presently exist. The actual riparian habitat in these areas is expected to expand, contract, or change as a result of flooding, drought, inundation, and changes in floodplains and river channels, as discussed in the Recovery Plan (Service 2002c) that result from current flow management practices and priorities. Stream segments include breeding sites with high connectivity and other essential flycatcher habitat components needed to conserve the subspecies. Those other essential components of flycatcher habitat (foraging habitat, habitat for non-breeding flycatchers, migratory habitat, regenerating habitat, streams, elevated groundwater tables, moist soils, flying insects, and other alluvial floodplain habitats, etc.) adjacent to or between sites, along with the dynamic process of riparian vegetation succession and river hydrology, provide current and future habitat for the flycatcher, which is dependent upon vegetation succession.

All river segments designated as flycatcher habitat are within the geographical area occupied by the species and contain at least one of the PCEs (Service 2005). These PCEs, especially the vegetation components, are acknowledged to be dynamic in their occurrence and may not serve all life history functions (nesting, foraging, migration dispersal, and shelter) at any given time due to unsuitability caused by age of the vegetation, hydrology, soil conditions, and other factors (Service 2005). The PCEs are the result of the dynamic river environment that develops, maintains, and regenerates the riparian forest and provides food for breeding, non-breeding, dispersing, territorial, and migrating southwestern willow flycatchers. Anthropogenic factors such as dams, irrigation ditches, or agricultural field return flow can assist in providing conditions that support flycatcher habitat. Because the flycatcher exists in disjunct breeding populations across a wide geographic and elevation range and is subject to dynamic events, critical habitat river segments are essential for the flycatcher to maintain metapopulation stability, connectivity, gene flow, and protect against catastrophic loss (Service 2005).

The PCEs listed in the final rule for the flycatcher are:

1) Riparian habitat in a dynamic successional riverine environment that comprises:
   (a) Trees and shrubs that include Goodding's willow (*Salix gooddingii*), coyote willow (*S. exigua*), Geyer's willow (*S. geyeriana*), arroyo willow (*S. lasiolepis*), red willow (*S. laevigata*), yewleaf willow (*S. taxifolia*), pacific willow (*S. lasiandra*), boxelder (*Acer negundo*), saltcedar (*Tamarix* sp.), Russian olive (*Elaeagnus angustifolia*), buttonbush (*Cephalanthus* sp.), cottonwood (*Populus* spp.), stinging nettle (*Urtica dioica*), alder (*Alnus rhombifolia*, *A. oblongifolia*, *A. tenuifolia*), velvet ash (*Fraxinus velutina*), poison hemlock (*Conium maculatum*), blackberry (*Rubus ursinus*), seep willow (*Baccharis salicifolia*, *B. glutinosa*), oak (*Quercus agrifolia*, *Q. chrysolepis*), rose (*Rosa californica*, *R. arizonica*, *R. multiflora*), sycamore (*Platinus wrightii*), false indigo (*Amorpha*

californica), Pacific poison ivy (*Toxicodendron diversilobum*), grape (*Vitis arizonica*), Virginia creeper (*Parthenocissus quinquefolia*), Siberian elm (*Ulmus pumila*), and walnut (*Juglans hindsii*).

(b) Dense riparian vegetation with thickets of trees and shrubs ranging in height from 2–30 m (6–98 ft). Lower-stature thickets (2–4 m [6–13 ft] tall) are found at higher elevation riparian forests and tall-stature thickets are found at middle- and lower elevation riparian forests;

(c) Areas of dense riparian foliage at least from the ground level up to approximately 4 m (13 ft) above ground or dense foliage only at the shrub level, or as a low, dense tree canopy;

(d) Sites for nesting that contain a dense tree and/or shrub canopy (the amount of cover provided by tree and shrub branches measured from the ground) (i.e., a tree or shrub canopy with densities ranging from 50 percent – 100 percent); and

(e) Dense patches of riparian forests that are interspersed with small openings of open water or marsh, or shorter/sparser vegetation that creates a mosaic that is not uniformly dense. Patch size may be as small as 0.1 ha (0.25 ac) or as large as 70 ha (175 ac).

2) A variety of insect prey populations found within or adjacent to riparian floodplains or moist environments, including flying ants, wasps, and bees (Hymenoptera); dragonflies (Odonata); flies (Diptera); true bugs (Hemiptera); beetles (Coleoptera); butterflies/moths and caterpillars (Lepidoptera); and spittlebugs (Homoptera).

It is important to recognize that the PCEs (1a and 2) are present throughout the river segments selected, but the specific quality of riparian habitat for nesting (PCE 1b, 1c, 1d, 1e), migration (PCE 1), foraging (PCE 1 and 2), and shelter (PCE 1) will not remain constant in their condition or location over time due to plant succession (i.e., germination and growth) and the dynamic environment in which they exist (Service 2005).

The final recovery plan for the flycatcher was issued in 2002 (Service 2002c). The plan describes the reasons for endangerment and status of the flycatcher, addresses important recovery actions, includes detailed issue papers on management issues, and provides recovery goals. Recovery is based on reaching numerical and habitat related goals for each specific management unit established throughout the subspecies range and establishing long-term conservation plans (Service 2002c).

Life History

The flycatcher breeds in dense riparian habitat from sea level in California to approximately 8,500 ft elevation in Arizona and southwestern Colorado. Historical eggs/nest collections and species descriptions throughout its range describe widespread use of willow (*Salix* spp.) for nesting (Phillips 1948, Phillips *et al.* 1964, Hubbard 1987, Unitt 1987). Currently, flycatchers primarily use Geyer's willow, coyote willow, Goodding's willow, boxelder, saltcedar, Russian olive, and live oak (*Quercus agrifolia*) for nesting. Other plant species less commonly used for nesting include buttonbush, black twinberry (*Lonicera involucrata*), cottonwood, white alder (*Alnus rhombifolia*), blackberry, and stinging nettle. Saltcedar is an important component of nesting and foraging habitat in Arizona and other parts of the species' range. During 2001 in Arizona 323 of the 404 (80 percent) known flycatcher nests (in 346 territories) were in saltcedar (Smith *et al.* 2002). Four habitat types have been described for the flycatcher: monotypic willow, monotypic exotic, native broadleaf dominated, and mixed native/exotic (Sogge *et al.* 1997).

Flycatcher habitat is dynamic and can change rapidly; nesting habitat can mature beyond habitat suitable for nesting, suitable saltcedar habitat can develop in five years, heavy runoff can reduce or remove suitable habitat in a day, or river characteristics may change. Flycatcher use of habitat in different successional stages may also be dynamic. For example, over-mature or young habitat not suitable for nest placement can be occupied and used for foraging and shelter by migrating, breeding, dispersing, or non-territorial individuals (McLeod *et al.* 2005). That same habitat may subsequently grow or cycle into habitat used for nest placement. Flycatcher habitat can quickly change and vary in suitability, location, use, and occupancy over time (Finch and Stoleson 2000).

Status and Distribution

There are currently 288 known flycatcher breeding sites in California, Nevada, Arizona, Utah, New Mexico, and Colorado (all sites from 1993 – 2005 where a resident flycatcher has been detected) holding an estimated 1,299 territories (Durst *et al.* 2006) (Table 2). Currently, rangewide population stability is believed to be largely dependent on the presence of four large populations (Cliff/Gila Valley, New Mexico; Roosevelt Lake, Arizona; San Pedro/Gila River confluence, Arizona; middle Rio Grande, New Mexico) where approximately 50 percent of the 1,214 territories currently exist. Therefore, the result of catastrophic events or losses of significant populations in either size or location could greatly change the status and survival of the species. Conversely, expansion into new habitats or discovery of other populations will improve the known stability and status of the flycatcher.

Since listing in 1995, at least 155 Federal agency actions have undergone (or are currently under) formal section 7 consultation to address effects to the species. Many activities continue to adversely affect the distribution and extent of all stages of flycatcher habitat throughout its range (development, urbanization, grazing, recreation, native and non-native habitat removal, dam operations, river crossings, ground and surface water extraction, etc.). Stochastic events also continue to change the distribution, quality, and extent of flycatcher habitat.

Table 2. Rangewide population status for the southwestern willow flycatcher based on 1993 to 2007 survey data for Arizona, California, Colorado, New Mexico, Nevada, Utah, and Texas. (There is no recent survey data or other records to know the current status and distribution within the state of Texas.) (Durst *et al.* 2007).

State	Number of sites with territories as of 2007	Percentage of sites with territories as of 2007	Number of territories as of 2007	Percentage of total territories as of 2007
Arizona	124	43.1 %	459	35.3 %
California	96	33.3 %	172	13.2 %
Colorado	11	3.8 %	66	5.1 %
Nevada	13	4.5 %	76	5.9 %
New Mexico	41	14.2 %	519	40.0 %
Utah	3	1.0 %	7	0.5%
Total	288	100 %	1299	100 %

Total territory numbers recorded are based upon the most recent year's survey information from that site between 1993 and 2007.

Unitt (1987) considered New Mexico as the state with the greatest number of flycatchers remaining. After reviewing the historic status of the flycatcher and its riparian habitat in New Mexico, Hubbard (1987) concluded, "[it] is virtually inescapable that a decrease has occurred in the population of breeding flycatchers in New Mexico over historic time. This is based on the fact that wooded sloughs and similar habitats have been widely eliminated along streams in New Mexico, largely as a result of the activities of man in the area." Unitt (1987), Hubbard (1987), and more recent survey efforts have documented very small numbers and/or extirpation in New Mexico on the San Juan River (San Juan County), near Zuni (McKinley County), Blue Water Creek (Cibola County), and the Rio Grande (Doña Ana and Socorro Counties).

In New Mexico, surveys and monitoring in 2007 documented approximately 514 flycatcher territories and 403 nests (Service and U.S. Bureau of Reclamation [Reclamation] preliminary data). During the 2003 survey season two new sites were detected in New Mexico, both were in the upper reaches of the Canadian River drainage, one in Colfax County and one in Mora County. Two more new sites were detected during the 2005 survey season, one in Mora County and one near the Mimbres River in Grant County. In 2007 a new site was found on the San Francisco River in Catron County. In 2008 a new nesting site was found on the Black River in Eddy County. Flycatchers have been observed at 42 sites in New Mexico along the Rio Grande, Chama, Canadian, Gila, San Francisco, San Juan, Pecos, and Zuni drainages.

MANCOS MILKVETCH

Species Description

The Mancos milkvetch (*Astragalus humillimus*) is a tufted, mat-forming perennial that is distinguished by its persistent, spinescent leaf stalks. It has short stems measuring 0.5–1 cm (0.2 – 0.4 in) tall. The species has compound leaves measuring 8 – 15 mm (0.3 –0.6 in) long. The leaflets are pubescent, light green, and oval. Mancos milkvetch flowers in late April through early May; the flowers are about one cm (0.4 in) long and lavender to purplish with a conspicuous lighter spot in the corolla tube. The fruit is an oblong pod measuring 5 mm (0.2 in) long that usually produces 4 – 9 seeds and is usually mature by late June (Service 1985, Service 1989).

Mancos milkvetch are found in San Juan County, New Mexico and Montezuma County, Colorado. There are 17 known sites; 13 in New Mexico, and four in Colorado. The plant is associated with cracks or depressions in sandstone ledges and mesa tops in Point Lookout sandstone at elevations between 1,500 – 1,800 m (5,000 – 6,000 ft). The associated plant community is pinyon-juniper woodland and desert scrub. The populations of Mancos milkvetch are strongly delineated by the size and extent of the sandstone (Service 1989).

Life History

Flowers of Mancos milkvetch are visited by honeybees and butterflies (Service 1989). Mancos milkvetch can produce viable seeds through outcrossing and self-pollination (Tepedino 2002). Larger plants can produce over 100 flowers during the growing season. When environmental conditions allow, the plants seem to produce numerous seedlings.

Monitoring plots in New Mexico have shown that it takes two growing seasons for seedlings to mature into reproductive plants. Many other perennial members of the genus *Astragalus* bloom after one growing season (Sivinski and Knight 2001).

Population densities of Mancos milkvetch fluctuate in response to precipitation and the availability of suitable habitat for germination and establishment of new seedlings. Seedling establishment seems greatest during favorable rainfall years that coincide with a low point in adult plant density. When the limited sandstone habitat is occupied by adult plants, there is little room for seedling establishment. As the cohort of adult plants dies, habitat is again available for seedling establishment (Sivinski and Knight 2001).

Population Dynamics

Mancos milkvetch monitoring plots have been established on New Mexico State Trust Lands (five plots at Sleeping Rock), and Bureau of Land Management (BLM) lands (five plots at Slickrock Flats). These plots were annually monitored from 1990 – 1999 and were visited in 2002 and 2008 (Sivinski 2008). In years when germination was high, seedling mortality was significant, usually during the drier months until the summer rainy seasons began. In 1990, 70 percent of seedlings within two plots at Sleeping Rock population died during the dry month of June.

It is difficult to count individuals within the plots because plants growing in close proximity to one another coalesce and form one continuous mat. Therefore, counting of individual mats may not represent the total number of genetic individuals within the monitoring plots and/or populations. Cover values of Mancos milkvetch were used to assess population vigor within these monitoring plots. Total cover values fluctuated widely during the years of this study. Starting with relatively low cover values in 1990, the two populations increased and peaked in 1993, and then decreased to another low point in 1996. Both populations were recovering and increasing when data were last taken in 1999. In 2002, total cover had decreased and fewer seedlings were detected. By 2008, 90 percent of the plots had decreased cover values (below the 2002 values) and the overall cover values from both the populations were at the lowest levels recorded during the timeframe of this study (Sivinski 2008).

There are 12 populations of Mancos milkvetch on the Navajo Nation. All of these populations were visited by the botanist from the NNHP during the springs of 2007 and 2008. As of 2008, only two of the populations had more than 50 plants. Previous survey work done in 1986 and 1989 had recorded densities of more than 500 plants in several of the existing populations. By 2008, these specific populations had less than 100 plants. The majority of plants observed at all the populations were small to medium in size and very few seedlings were observed. Many dead plants were observed; living plants were widely scattered over suitable substrate and there seemed to be quite a bit of suitable, unoccupied habitat. Currently, there are less than 400 plants on the Navajo Nation. The botanist hypothesized those populations of Mancos milkvetch declined due to drought conditions during 2001, 2002, and 2003 (Roth 2008a). This trend is also reflected in the observed declines on the Sivinski monitoring plots.

There are four known populations in Colorado, but there are no recent data on the status of those populations. All of these populations are on the Ute Mountain Ute Reservation and access is restricted. A population estimate from 1989 indicated that there were approximately 4,400 plants within the four populations in Colorado (Colorado Natural Heritage Program [CNHP] 2007).

The New Mexico populations appear to be declining. All of the populations surveyed and/or monitored have showed significant declines in numbers, cover, and germination and seedling establishment. Drought seems to be a contributing factor in this observed decline. We note that in the two populations monitored by Sivinski, there have been years where there was a significant decline in overall cover, but the populations recovered during wet periods. We are unable to assess the status of the Colorado populations because there is no recent data on population densities.

Status and distribution

The range of Mancos milkvetch is about 40 mi long and a few miles wide. From north to south it comprises mesa edges above the Mancos River, Colorado, to the New Mexico border, then southeast to the Farmington Hogback, south across the San Juan River and down the hogback to east of Little Water, New Mexico.

Mancos milkvetch is often found in shallow depressions with shallow soils on flat or gently sloping bedrock outcrops of sandstone; it can also be found growing within fissures or cracks in the sandstone. There is some evidence to suggest that plants growing within cracks or fissures may be less susceptible to drying out during drought periods (Sivinski and Knight 2001). This may indicate that the shallow depressions are marginal habitats, occupied only during wet periods (Sivinski 2008).

Mancos milkvetch was listed as endangered with no critical habitat in 1985. At the time of listing, the threats were known to be habitat fragmentation and degradation, and destruction from oil and gas development, construction and maintenance of transmission lines, and low number of populations (four) increasing the extinction risk due to stochastic events. Even though the number of populations has increased, the threats remain. There is continued oil and gas development in Mancos milkvetch habitat and many of the populations have decreased in density, likely related to prolonged periods of drought.

The entire range of Mancos milkvetch occurs within an area of intense gas and oil development. Oil and gas well pads, pipelines, and access roads are scattered through Mancos milkvetch habitat. Some of the populations have been affected by these operations. Most recently (2007), the plug and abandonment operations on Palmer Mesa have affected a known Mancos milkvetch population on the Navajo Nation. Mancos milkvetch plants were parked on, run over, and possibly killed by the operations (Roth 2007). Additional disturbances to habitat, and possibly plants, were also noted near the Navajo-C-4 well on Palmer Mesa (Roth 2008).

In addition to oil and gas development, there are roads and transmission lines associated with existing coal-fired generating stations. Eight of the New Mexico populations are a few miles west of the SJGS. The Sleeping Rock population has been disturbed by a power line and a portion of the population was destroyed by the construction of a tower (Service 1989).

An additional threat to the species is climate change. See further discussion of climate change and its effect on the Southwest in the Status of the Species for Colorado pikeminnow.

Mancos milkvetch population dynamics are correlated with rainfall. Long-lasting drought cycles could have a negative effect on the long-term viability of these populations. Periods of drought in the southwest are not uncommon. However, the frequency and duration of droughts may be altered by climate change. Almost certainly, this species and its habitat will be affected in some manner by climate change; the magnitude and extent of the change cannot be quantified at this time.

MESA VERDE CACTUS

Species Description

The Mesa Verde cactus is a small, globose, usually single-stemmed plant 3.2 – 9 cm (1.5 – 3.5 in) in diameter. Each stem has 13 – 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 – 0.1 in) per year (Colorado Natural Areas Program [CNAP] 2005). Once the stems grow to about 9 cm (3.5 in), growth essentially stops, and they tend to increase or decrease as much as 1.5 cm (0.6 in) in diameter in response to wet and dry years (CNAP 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 in) in diameter, cream to yellow-colored, and bloom in late April or early May. The seeds are black and 2.5 – 3 mm (0.09 in) long (Service 1984).

The Mesa Verde cactus was federally listed as threatened in 1979 (44 FR 62472, Service 1979). 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 disease and predation. These threats have continued since listing.

Life History

Mesa Verde cactus is a long-lived (over 40 years), slow growing perennial (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 bees 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 Mesa Verde cactus produces 200 seeds, with 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. Freezing and thawing apparently 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).

Mesa Verde cacti grow 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 typical of the habitat 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.

Population Dynamics

Cactus density varies greatly within populations; there may be as many as 20 cacti within a 50-m^2 area or only a single specimen for several hundred meters. It typically occurs on small eroded hills and ridges in groups, the size of which may also vary: from less than 10 to more than 200 plants. Adjacent clusters of cacti may be very close or widely separated by several km of what appears to be suitable but unoccupied habitat.

Reproductive characteristics were measured annually on more than 1,600 Mesa Verde cactus stems in Montezuma County, Colorado, beginning in 1986 (CNAP 2005). Coles (2003) identified recruitment events, 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 (CNAP 2005). Years in which sprout recruitment was high tended to be years with average precipitation following an infestation of the longhorn beetle (*Moneilema semipunctatum*). Conversely, several years would 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 (CNAP 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). Periodic insect infestations caused most mortality (Coles 2003). In summary, there was low recruitment and mortality in most years, punctuated by significant reproduction and recruitment events at infrequent intervals.

The NNHP began monitoring Mesa Verde cactus in 1992 at 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 near Shiprock and Sheep Springs, New Mexico, 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 cacti had died in the monitored plots, and formal monitoring was discontinued (Service 2008). No Mesa Verde cacti were 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 – 10,000 Mesa Verde cactus plants

(Service 1984). Additional populations were subsequently discovered on the Navajo Nation, 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 that resulted in increased insect attacks on the species. From 2002 – 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 NNHP. 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 cacti found. As an example, near Many Devils Wash, the survey team found 27 plants; 23 were dead and four alive. This was a 99.7 percent decrease from the 1,500 or more individuals reported at the site in 1989 (Ladyman 2004). 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).

Continued monitoring indicates that Mesa Verde cactus populations are slowly increasing. In Colorado, relatively slow recovery has been documented (CNAP 2005). Although there has been an increase in the number of stems sprouting from cacti damaged by beetle attack during the drought, the number of seedlings has been far less than expected (seven in 2004, three in 2005) in spite of average or above average precipitation (CNAP 2005). Two hypotheses have been suggested to explain the lack of seedling recruitment. First, nurse plants (plants that create less harsh conditions in which cacti may grow) such as mat saltbush (*Atriplex corrugata*, *A. gardneri, A. confertifola*) have not recovered from the drought. Second, Mesa Verde cactus seeds may be short-lived and the seed bank may be exhausted because of virtually no reproduction during the drought (CNAP 2005).

In New Mexico, the Waterflow plot currently has 113 plants compared to 74 in 2003 (Sivinski 2007). However, in 2007, only two of the plants were larger than six cm, compared to 28 in 1999 and five in 2003 (Sivinski 2007). Since reproductive output is directly related to size of plant, reproduction potential remains limited. Some areas like Sheep Springs, where no plants have been documented since the drought, may be permanently affected. 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 currently at least 1,300 plants in and near the Malpais Conservation Area. In sites monitored for transplant success, mortality rates have decreased since 2003 and new plants continue to be recruited into the population, although at a very low level (Roth 2008b).

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 stems, and upon hatching the larvae bore into the stem, usually killing the plant. Three significant mortality events caused by the beetle were recorded during long-term monitoring in Colorado (Coles 2003). During an outbreak, most stems greater than two cm (0.8 in) were killed, but plants from 0.6 – 10.4 cm (0.24 – 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). Increased mortality could have resulted from weakened plants due to water stress, increased numbers of beetles due to drought, or from the beetles targeting Mesa Verde cactus over other cactus species.

The army cutworm (*Euxoa* sp.) has also been associated with predation on Mesa Verde cactus. 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 that 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 occasionally susceptible to lethal microbial infection, possibly introduced through insect damage (Boissevain and 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 (Service 1984) recommended that a program be developed for artificial propagation of 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 cacti that are unavoidably threatened with destruction (Service 1984). Unfortunately, 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 (Service 1984). Precise conditions are needed for successful germination, cultivation, and survival, and it is especially difficult to cultivate in areas of high humidity because the stem is particularly susceptible to rot (Service 2008).

Several transplantations have moved 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. No live plants were found in 2004 (Ladyman 2004). In the spring of 1995, the NNHP transplanted 29 cacti from a road right-of-way into four 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). 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 four in 2004, and the number of naturally occurring plants dropped from 12 to two individuals in the same period (Roth 2004). Drought and insect infestation appeared largely responsible for the decline (Roth 2004).

In 2001, the NNHP 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 2008b). Forty-nine naturally occurring cacti served as controls to determine the success of the transplantation (Roth 2008b). Since 2001, 76 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 2008b). 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 2008b).

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 for unknown reasons. 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 mi 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 mi west of Shiprock. 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 Nation and another 20 percent on the Ute Mountain Ute Indian Reservation. On the Navajo Nation, the majority of plants are within a 20-mi 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. 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.

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 Colorado pikeminnow once inhabited reaches above what is now Navajo Dam and Reservoir near Rosa, New Mexico (now inundated by Navajo Reservoir). The creation of Lake Powell and Navajo Reservoir resulted in the direct loss of approximately 161 km (100 mi) of San Juan River habitat for the Colorado pikeminnow and razorback sucker (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 Colorado 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 have substantially reduced suspended sediment concentrations, 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 rainbow trout (*Oncorhynchus gairdneri*) and brown trout (*Salmo trutta*) fishery with a commensurate reduction of most native species (Miller and Ptacek 2000).

During the seven-year research period (1991 – 1997) it was estimated that there were fewer than 50 adult Colorado pikeminnow in the San Juan River in any given year (Ryden 2000a). In 2000, it was estimated that there were 19 wild adult Colorado pikeminnow in the San Juan River from RM 136.6 – RM 119.2 (95 percent C.I. 10 – 42; Ryden 2000a). No wild Colorado pikeminnow have been captured since 1999 (Ryden 2000a, 2003b; 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 Colorado pikeminnow in the San Juan River appear to have relatively small home ranges and primarily use habitats from RM 109 – RM 142 (Holden 2000). Spawning has been documented in a region of high channel complexity characterized by shifting gravel bars from RM 133.4 – 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 – 2007, spawning has occurred between June 24 and July 18 (Brandenburg and Farrington 2008).

The SJRRIP has a multi-pronged approach to recovery that has involved removal of migration barriers, augmentation, mimicry of the natural hydrograph, adult and larval fish monitoring, habitat and water quality monitoring, and control of non-native species. Between 1987 and 1996, no wild Colorado pikeminnow adults were caught above Shiprock (approximately RM 150). One of the goals of the SJRRIP is range expansion of Colorado 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 (RM 158.6), and the completion of the Public Service Company of New Mexico (PNM) selective fish passage ladder (RM 166.1) in 2003 has restored fish access to about 36 mi (58 km) of critical habitat on the San Juan River for Colorado pikeminnow. From 2003 – 2007, 27 Colorado pikeminnow passed through the selective fish passage ladder as well as over 65,000 other native fishes (Lapahie 2007, in litt). In 2004, five Colorado pikeminnow (226 – 250 TL [8.9 – 9.8 in]) were caught in the lower few mi 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 Colorado pikeminnow in the San Juan River began in 1996. Between 1996 and 2000, approximately 832,000 larval Colorado 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 2003a). Initial retention was encouraging, and over-winter survival was high (spring captures = 62.5 – 62.7 percent of fall captures); survival between age-1 and age-2 based on recapture rates neared 100 percent (Archer *et al.* 2000). Because of this initial success, an augmentation plan began in 2002 with a goal of stocking and monitoring 300,000 age-0

Colorado pikeminnow at RM 180.2 and RM 158.6 for seven years. A total of 1,781,154 Colorado pikeminnow were 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 Colorado pikeminnow is rare (Ryden 2008a), the capture of an age-11 Colorado 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.

At the time of listing, few Colorado pikeminnow remained in the San Juan River as a result of human impacts. Since the initiation of the SJRRIP, Colorado pikeminnow numbers have increased, primarily due to an aggressive augmentation program. The species' long-term viability remains uncertain because of the relatively limited habitat available between Navajo Dam and Lake Powell, competition and predation from non-native fishes, water quality issues, and the uncertainty surrounding the changes that climate change will bring to the San Juan River basin.

Razorback sucker

As described for Colorado 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. In the first 10 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, 18 adult razorback suckers were collected (six were recaptures) 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, eight were ripe males and the other four were females that appeared gravid.

In 1988, 10 razorback suckers were handled at the same general location, five of which were in reproductive condition (Platania *et al.* 1991). Six of the 10 individuals in the 1988 samples were recaptures from 1987. Also in 1988, a single adult tuberculate male 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 mainstem 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, pers. comm. 2005). A Schnabel multiple-census population model estimated that there were approximately 1,200 razorback suckers in the San Juan River from RM 158.6 – 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 to 38.1 RMs 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 Colorado 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 mi (58 km) of habitat on the San Juan River for razorback sucker. From 2003 – 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 five-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) TL, 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 154.2 in 2004 (Ryden 2005b). In 2007, 207 stocked razorback suckers were collected during annual adult monitoring (Ryden 2008a). Their sizes ranged from 221 – 516 mm (8.7 – 20.3 in) TL (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.

Southwestern Willow Flycatcher

Habitat characteristics

The San Juan River basin supports local areas of suitable flycatcher habitat; however, no birds have been documented establishing territories in over ten years, and the extent of habitat has not been quantified or mapped. The San Juan does contain dense stands of saltcedar and Russian olive, along with some areas of dense willow thickets. Flycatchers (and many other species of neotropical migrant landbirds) use the Rio Grande riparian corridor as stop-over habitat during migration. Studies have shown that during the spring and fall migration, flycatchers are more commonly found in willow habitats than in other riparian vegetation types, including the narrow band of coyote willows. There are no recent presence/absence surveys for flycatchers throughout the project area in vegetation types that are classified as suitable for breeding habitat.

Habitat availability in the action area

Vegetation within the reach has not been mapped and identified as suitable habitat for the flycatcher, but the area has some historic habitat and is included as a Recovery Area in the flycatcher Recovery Plan. Breeding habitat suitability is refined by identifying all areas that are within 100 m of existing watercourses, ponded water, or in the zone of peak inundation. The five categories of flycatcher habitat that lie within 100 m of water are defined as:

Highly Suitable Native Riparian - Stands dominated by willow and/or cottonwood.

Suitable Mixed Native/Non-native Riparian - Includes stands of natives mixed with non-natives.

Marginally Suitable Non-native Riparian - Stands composed of monotypic saltcedar or stands of saltcedar mixed with Russian olive.

Potential with Future Riparian Vegetation Growth and Development - Includes stands of very young sparse riparian plants on river bars that could develop into stands of adequate structure with growth and/or additional recruitment. U.S. Bureau of Reclamation believes this category requires regular monitoring to ascertain which areas contain all the parameters to become flycatcher habitat.

Low Suitability - Includes areas where native and/or non-native vegetation lacks the structure and density to support breeding flycatchers, or exceeds the hydrologic parameter of greater than 100 meters from water. The presence of low suitability habitats may be important for migration and dispersal in areas where riparian habitats have been lost (i.e. agricultural and urban areas).

Currently, the Service groups the first three categories listed above as equally suitable habitat for the flycatcher, because a large number of sites are currently occupied in all three categories. At this time, it is not accurate to define those suitable habitats with non-native vegetation as being less suitable than native habitat for flycatchers.

The San Juan River supports a combination of marginally suitable non-native riparian, potential for future riparian vegetation, and areas with suitable mixed native/non-native riparian vegetation. The native riparian trees and shrubs are interspersed with stands of non-native riparian plants, primarily saltcedar and Russian olive. There is native desert habitat on both sides of the floodplain. This area does have agricultural development on the outside edges of the floodplain. This area represents a relatively unfragmented landscape with associated high biological values.

<u>Flycatcher populations in the action area</u>

The San Juan River is located within the Upper Colorado Recovery Unit for the flycatcher. This unit covers much of the Four Corners area of southwestern Colorado, southern Utah, northeastern Arizona, and northwestern New Mexico. The northern boundary of this unit is delineated by the northern range boundary of the flycatcher. Flycatchers are known to breed at only four sites within this unit (less than 1 percent of the rangewide total), three of which were historically in the San Juan River. These territories have not been occupied in the last ten years. However, these low numbers of known flycatchers are probably a function of the relatively low survey effort in the recovery unit, rather than a reflection of the species' numbers and distribution. Much willow habitat occurs along drainages throughout this recovery unit, and remains to be surveyed. The recovery goal for this unit is 25 nesting pairs.

<u>Importance of the action area to the survival and recovery of the species</u>

The flycatcher recovery plan identifies five Recovery Units, the Basin and Mojave, Lower Colorado River, Upper Colorado River, Gila River, and Rio Grande. Flycatcher populations are not distributed evenly throughout these Recovery Units, with the majority of individuals found in the Coastal California, Lower Colorado, Gila, and Rio Grande Recovery Units (Service 2002c).

The Upper Colorado Recovery Unit contains the northern most population of flycatchers, and currently has approximately less than 1 percent of known territories (Durst *et al*. 2006). The Upper Colorado Recovery Unit covers a small portion of the flycatcher's previous range. In order to be well protected against disease and catastrophe, the species should be well distributed geographically. The survival and recovery of the flycatcher is dependent on healthy, self-sustaining populations of birds, which are able to exchange genetic information on occasion, and act as a source population should one area suffer significant losses (Soule 1986). The gain of populations within this Recovery Unit could have potentially significant effects to the surrounding Recovery Units.

Mancos milkvetch

Permanent monitoring plots were established in two New Mexico Mancos milkvetch populations in 1990. Five plots were located on State Trust Land at Sleeping Rocks and another five plots at Slickrock Flats on BLM land. Each plot was annually monitored from 1990 – 1999, and intermittently monitored in 2002 and 2008. Combined total cover of Mancos milkvetch fluctuated greatly from year to year in response to precipitation but also as adult cohorts aged and died. Seedling establishment was greatest during favorable rainfall years that follow a low point in the cycle of adult plant density. When adults occupy most of the root space in substrate limited habitats, few seedlings can become established. As adult plants die from old age or drought, a subsequent favorable rainfall year will bring on a flush of new seedlings (Sivinski and Knight 2001).

In years when germination is good in the spring, seedling mortality is significant until the summer rainy season begins. In 1990, 70 percent of new seedlings in two plots at Sleeping Rocks died during a dry month of June (Sivinski and Knight 2001). When two or more seedlings grow in close proximity, their above-ground portions coalesce and become indistinguishable. A pulvinate mass of Mancos milkvetch can appear to be one plant, but is often two or more genetic individuals that have merged (Sivinski and Knight 2001). Therefore, numbers of genetic individuals cannot accurately obtained by counting clumps of Mancos milkvetch.

Total Mancos milkvetch cover at the study plots represented population vigor, which varied greatly from 1990 to 2008. Starting at a low point in 1990 the two populations gradually increased and peaked in 1993, then decreased to another low point in 1996. Both population were recovering and increasing when the last annual monitoring data was taken in 1999. Overall cover of Mancos milkvetch in 2002 had declined from the 1999 total cover and had fewer seedlings. Nine of the ten plots monitored in 2008 had lower cover values than in 2002 and overall cover from both populations was the lowest value ever obtained in the 12 samples taken from 1990 to 2008 (Sivinski 2008).

Five monitoring plots were also established on Navajo Nation land in a Mancos milkvetch population on the hogback just south of the San Juan River (NNHP 1991). These plots were monitored only in 1991 and 1992. No useful population trend data were produced.

Recent field surveys by the NNHP also provide evidence for a current low point in Mancos milkvetch population densities. Several of the populations located on the Navajo Nation before 1990 were revisited and assessed in 2007. Populations with pre-1990 estimates of thousands of plants were found to have only hundreds in 2007 while populations with pre-1990 estimates of hundreds of plants were found to have only a few dozen in 2007 (Daniela Roth, personal communication, 2008). Differences in field survey methods alone cannot account for such a wide discrepancy of population estimates.

There are historical records of Mancos milkvetch occurring at the Hogback exposure just south of Navajo Route 13 where the proposed DREP transmission line approaches within 500 ft.

Potential Mancos milkvetch habitat is present along the proposed transmission line corridor just north of U.S. Highway 64 along the Hogback. Marginal potential habitat occurs along the proposed corridor where it crosses the Hogback (Ecosphere 2005). The project footprint offers potential, unoccupied habitat for this species. However, prolonged drought conditions in the area may have precluded germination over the past several years. Populations do occur within the terrestrial impact area.

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 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 consultation with the Service under the ESA, and five have resulted in formal consultations. None of the formal consultations resulted in jeopardy for the cactus. The projects have included road and transmission line construction, a BLM Resource Management Plan, and fairground construction near Shiprock.

The 1984 recovery plan includes estimates of about 5,000 – 10,000 Mesa Verde cacti across the populations (Heil 1984). Additional populations were subsequently discovered on the Navajo Nation, 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 – 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 2008b) 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 2008b).

In 2004, Ladyman conducted extensive surveys on Navajo lands for the NNHP. 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).

It is still too early to determine with certainty if climate change is affecting the status of Mesa Verde cactus. One of the predicted effects of climate change is an increase in extreme events, including drought (Intergovernmental Panel on Climate Change [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 2001 – 2003 drought, Mesa Verde cactus has returned to normal levels of low mortality and low recruitment that are typical of the species (Roth 2008b). 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 but large sediment loads to the San Juan River.

As recognized in the Final Environmental Impact Statement for Navajo Reservoir Operations (Reclamation 2008), 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 riverbanks 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 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 Navajo Indian Irrigation Project (NIIP), 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 metals, 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 that 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, Service 1998, Collier *et al.* 2000, 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, Collier *et al.* 2000, Polzin and Rood 2000, Shields *et al.* 2000). Of these, changes 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 below.

<u>Water temperature</u>

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 two months (Holden 1999). Based on cumulative degree-days, spawning could have occurred at Archuleta by July 11 each year 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 Colorado 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 two weeks later on average than prior to dam construction (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 (Holden 1999). Projected temperatures at Shiprock from 1993 – 1996 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, assimilation efficiency, and growth rate, and increases the time to sexual maturity (Lagler *et al.* 1977).

Development time of Colorado 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 nine days at 15ºC (59ºF) and 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 Colorado pikeminnow eggs tested died at incubation temperatures of 15ºC (59ºF) or lower, and survival and hatching success were maximized near 20º C (68º F) (Marsh 1985). Bestgen and Williams (1994) found a relatively wide range of acceptable incubation temperatures above 18ºC (64.4 ºF). In addition, Bestgen *et al.* (2006) found that early hatching Colorado 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, there is a greater chance that larval fish will drift into Lake Powell and be lost from the population. Dudley and Platania (2000) found that drifting larval Colorado 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 Colorado pikeminnow in the San Juan River, the consequences of lower water temperatures on survival and recruitment of Colorado 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 Colorado pikeminnow drift so far downstream (Holden 2000). The same pattern may also occur on the San Juan River.

Cold water released from Navajo Dam has affected razorback sucker and Colorado pikeminnow in a number of ways. Water temperatures that were once suitable for spawning for Colorado pikeminnow near Archuleta are no longer suitable, and, if spawning were to occur near Shiprock, it would be delayed by approximately two 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.

<u>Blockage of fish passage</u>

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 Colorado 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 (Cudei, Hogback, FCPP, SJGS [PNM weir], and Fruitland Irrigation Canal diversions) between Farmington, New Mexico, and the Utah state line that potentially acted as barriers to fish passage at certain flows. When radio telemetry studies were initiated on the San Juan River in 1991, only one radio-tagged Colorado pikeminnow was recorded moving upstream past one of the diversions. In 1995, an adult Colorado 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 Colorado 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 mi (39.4 km) 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 Colorado pikeminnow and razorback suckers. From 2003 – 2007, 65,596 native fish used the passage including 27 Colorado pikeminnow and 21 razorback suckers (LaPahie 2007 in litt). However, the FCPP 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 suggest that the rock dam structure does not significantly hinder fish passage, expect perhaps at very high discharges (8,000 cubic feet per second [cfs] and greater) (Stamp and Golden 2005).

Dams have fragmented razorback sucker and Colorado pikeminnow habitat throughout the Colorado River system. Within the San Juan River, fish passage was once impeded by five instream 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.

Colorado pikeminnow and razorback sucker can potentially navigate from Lake Powell, past the Animas River, and 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 Colorado 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 Colorado 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 Colorado 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 Colorado 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 San Juan River (120 km [75 mi]), among others (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). Colorado pikeminnow was included in the list of fish eliminated (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 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 above, 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 migrate 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 Colorado pikeminnow and during trips to remove non-native fishes (Davis 2003). The contents of 38 striped bass stomachs were analyzed and native suckers were found in 41 percent (Davis 2003). Clearly, this migratory predator is a threat to both YOY and juvenile native fish.

The transformation of riverine habitat into lake habitat had the following impacts on razorback sucker and Colorado 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.

3) The emphasis of fisheries management shifted to game fish production. Consequently, riverine habitat that supported native fish, including razorback sucker and Colorado 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 probably limit the success of Colorado pikeminnow and razorback sucker recruitment and are 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).

<u>Changes in the timing and magnitude of flows</u>

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, Service 1998, Collier *et al.* 2000, 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 non-native species that may have 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 appreciably 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 Station gauge near Shiprock. The flows for this period 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.

From 1991 – 1997, 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 of experimental flows. The research flow period was more similar to the years that followed (1998 – 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.

<u>Climate change</u>

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 levels (IPCC) 2007). The IPCC (2007) described changes in natural ecosystems with potential widespread 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 are 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 Colorado 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 DOI requires agencies under its direction to consider potential climate change effects as part of their long-range planning activities (DOI 2009).

Climate change is of particular concern in the Colorado River basin. The Colorado River Compact governs water allocations between the upper and lower Colorado River basins. It 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 reflect the relatively short gaged record (NRC 2007). Consequently, there is less water available to allocate than originally thought.

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 *et al.* 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. Additionally, 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.

Climate change may also affect the timing and magnitude of flows in the San Juan River. 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 af are currently lost annually from the reservoir (Reclamation 2003). Water and air temperatures 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, affecting the amount of water available for all uses. In addition, the Animas-La Plata project will soon divert water from the Animas River into Lake Nighthorse, a new reservoir that will be an additional source of evaporative loss from the system. Although an evaporative loss of approximately 2,700 af/yr from Lake Nighthorse 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 and Eischeid (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) demonstrated 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. These models projected a decrease in runoff of eight to 25 percent. The Colorado River basinwide snow water equivalent is projected to decline by 13 to 38 percent from 2025–2085 (Christensen and Lettenmeier 2006). Ray *et al.* (2008) and Udall (2007) summarized 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.

Increased evaporation and decreased runoff will lead to less water available to meet all demands, which could potentially affect 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 – 10,000 cfs are scheduled to occur, on average, in intervals from two 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 Reservoir storage is reduced or runoff from the Animas River decreases. This is particularly important because when high flows are reduced in magnitude or frequency, non-native vegetation encroaches on the channel, causing channel habitat to simplify (Bliesner *et al.* 2008). Habitat complexity is the desirable condition for Colorado 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 western United States, warming temperatures have resulted in a shift of the timing of spring snowmelt. Stewart *et al.* (2005) showed 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 one to four weeks earlier, resulting in less flow in the spring and summer. Rauscher *et al.* (2008) suggested that with air temperature increases of 3 – 5ºC (37 – 41ºF), snowmelt driven runoff in the western United States could occur as much as two months earlier than presently. While it is reasonable to expect that runoff in the San Juan River is occurring earlier because of warmer air temperatures, there has been no analysis of the timing of spring runoff. However, Westfall and Bliesner (2008) looked at the predictions of several models using two emission scenarios and all predicted that by 2099, runoff in the San Juan River would occur approximately one month earlier than historical conditions. There is no documentation of how much earlier spring runoff is currently occurring, if at all, compared to the historical condition.

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 fluctuations 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 (due to deep water releases from Navajo Reservoir), having a longer growing season could have a positive effect on recruitment of these fishes.

Climate change could increase Colorado pikeminnow and razorback sucker exposure to contaminants through two mechanisms. First, as stated above, 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, Colorado pikeminnow and razorback sucker may be exposed to increasing concentrations of contaminants over time as a result of climate change.

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 and evapotranspiration and decreased runoff, as well as earlier spring runoff. To the extent that climate change reduces the amount of water available in the river, we anticipate that negative impacts could occur to the endangered fishes because water demand for human uses will increase. 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 all the human demands and the needs of the Colorado pikeminnow through the Flow Recommendations could become challenging in the future. The effects of earlier spring runoff on the fishes are unknown and should be monitored.

Changes in channel morphology

The quantity and timing of flows influence how the channel and various habitats are formed and maintained. The channel width during the 1930s was likely 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). As 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 RM 67 (Holden 1999). From 1930 to 1942, suspended sediment load was approximately 47.2 million tons/year (Holden 1999). Between 1943 and 1973, suspended load dropped by half to 20.1 million tons/year (Holden 1999). The 1930s aerial photography shows a sand-loaded system; 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 – 1991) exacerbated the growth of exotic riparian vegetation (primarily saltcedar 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). Total wetted area over time, normalized for flow at mapping, shows a trend of total wetted area decreasing by about 10 percent (Bliesner and Lamarra 2007). This channel simplification has been attributed to extended drought and encroachment of Russian olive and saltcedar. 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).

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 no 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 an important component of razorback sucker and Colorado 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 saltcedar 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 percent (Bliesner and Lamarra 2007). The island count, normalized for flow at mapping, shows a significant 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 Colorado pikeminnow.

At current population levels, habitat does not appear to be a limiting factor for either the razorback sucker or Colorado 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).

There is a trend towards channel simplification, channel narrowing, reduced wetted area, and loss of islands (Bliesner *et al.* 2008) in the San Juan River. Although channel morphology has been monitored for a relatively short time and the recent drought and lack of high flows may have an overriding influence on channel-forming processes, it appears that flow manipulation alone may be inadequate to restore channel complexity.

<u>Water quality</u>

Abell (1994) conducted a contaminants review and identified irrigation and mineral extraction, processing, and utilization as major sources of contaminants in the San Juan River basin. Comparison to water quality standards was cumbersome, as both the level of protection and the criteria for protection varied according to the various water uses and the laws of each state (New Mexico, Colorado, and Utah) through which the San Juan River flowed. According to the New Mexico Water Quality Control Commission's (1992) evaluation, none of the surface waters of the San Juan River basin in New Mexico had fully supported uses. Agriculture and resource extraction activities were the most common sources of nonsupport, with metals and siltation the most common causes of nonsupport (Abell 1994). According to the Colorado Water Quality Control Division’s 1992 report, portions of all major tributaries to the San Juan River in Colorado failed to fully support their uses (Abell 1994). Narraguinnep, McPhee, and Navajo Reservoirs were each found to partially support their uses, all due to mercury levels in fish. Of the nineteen river or stream reaches whose uses were impaired, metals were cited as contaminants in twelve, sediment in eight, and salinity in three. Within the San Juan River basin in Utah, the Utah Division of Water Quality had sampled segments of Montezuma Creek and the San Juan River and found water quality impairments of temperature, dissolved oxygen, copper, iron, and zinc. Surface and ground water quality studies in the Animas, La Plata, Mancos, and San Juan River drainages were also described, as were other water quality concerns (Abell 1994).

Changes in water quality and contamination of associated biota are known to occur within Reclamation projects in the San Juan drainage (i.e., irrigated lands along the San Juan, 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 San Juan River water quality in Colorado pikeminnow critical habitat (Abell 1994; Wilson et. al. 1995a, b; Holden 1999). In particular, mercury and selenium levels have been identified as of concern in the San Juan River basin, along with other contaminants (Abell 1994; Simpson and Lusk 1999).

Information on existing water quality in the San Juan River has been derived from data gathered by various bureaus of 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. 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.

Selenium and mercury in the Four Corners area comes from natural and anthropogenic sources, and loading of these elements into this ecosystem has been ongoing for quite some time. 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 along the San Juan, 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, and PAHs), and pesticides have degraded water quality of the San Juan River within critical habitat for the endangered fish (Abell 1994, Wilson *et al.* 1995, Simpson and Lusk 1999).

Mercury

The global pool of mercury in the atmosphere is a mixture of mercury emitted from all sources (both natural and anthropogenic) and is dominated by primary and secondary anthropogenic emissions that can deposit even at the most remote locations from known sources (Lorey 2001; Lindberg *et al.* 2007). Global anthropogenic emissions of mercury in 2005 (~1,930,000 kg) were attributed to Asia (66.5 percent), North America (7.9 percent), Europe (7.8 percent), South America (6.9 percent), Africa (5 percent), Russia (3.8 percent), and Oceania (AMAP/UNEP 2008). AMAP/UNEP (2008) reported the emissions of mercury in the year 2005 and expected in the year 2020 from sources within each country. Of the mercury that then deposits within the United States, Seigneur *et al.* (2004) identified three predominant sources: (1) natural sources (e.g. volcanoes; 33 percent), (2) emissions from North America (30 percent), and (3) emissions from Asia (23 percent). In 2001, EPA reported that 711,553 grams (g) (~1,569 lbs) were deposited in the San Juan River basin. Sources of this mercury deposition in the basin were attributed to the global pool of mercury (95.8 percent), followed by "other sources" (1.8 percent), the SJGS (1.8 percent), FCPP (1.0 percent), and Mexico (0.6 percent). Using the ratio of emission sources during 2005, and projected in 2020, in conjunction with the deposition attribution sources in the San Juan River basin provided by the EPA (ISC, International 2008), a 35.5 percent increase to 964,079 g (~2125 lbs) of mercury is estimated to deposit annually in the San Juan River basin by 2020 (Appendix A).

There are three main forms of mercury occurring in the atmosphere: elemental mercury, gaseous reactive mercury, and particulate mercury. Mercury that is released to the atmosphere is transported, transformed, and deposited back to the earth's surface. The distance of mercury transport depends upon the chemical form of the emitted mercury, the height at which the emissions are released into the atmosphere, the chemical and physical processes, and the atmospheric conditions (e.g., wind speeds, precipitation, composition of oxidizing and reducing species) (Wen 2006). Atmospheric transport is likely the primary mechanism by which elemental mercury is distributed throughout the environment. The reactive form of mercury is often deposited to land or water surfaces much closer to their sources due to its chemical reactivity and high water solubility. Particulate mercury is transported and deposited at an intermediate distances depending on aerosol diameter or mass. Before any form of mercury is deposited back to the earth's surfaces, a series of complex physical and chemical transformations of mercury can take place in the atmosphere. The transformations include the equilibria of mercury species among gaseous, aqueous, and solid phases, the aqueous phase chemistry of mercury, and the gaseous phase chemistry of mercury (Wen 2006). Air pollutants, particularly volatile organic compounds, ozone, and nitrogen oxides, play an important role in affecting mercury dry and wet deposition into the watershed (Wen 2006).

Results of the National Atmospheric Deposition Program – Mercury Deposition Network show total mercury concentrations in precipitation at Mesa Verde National Park are among the highest measured in the United States (Weidner 2007). Weidner (2007) identified that eight out of ten of the high deposition samples measured at Mesa Verde National Park have trajectories that trace back to within 50 km of the FCPP and SJGS, which supports the theory that air masses passing from south Arizona and near these coal-fired power plant facilities are contributing to high deposition of mercury there.

Where mercury loading is dominated by atmospheric sources, it is thought that the degree of mercury accumulation in fish is roughly proportional to the long-term rate of atmospheric mercury deposition, other factors being equal (Munthe *et al.* 2007). Atmospheric deposition is the predominant pathway delivering mercury to aquatic systems and into fish tissues (Cocca 2001, Bullock 2005, Engstrom 2007). In aquatic systems, methylation of mercury occurs by bacteria (primarily sulfate-reducing bacteria) mostly in wetlands or in areas with anoxic conditions (EPA 1997, Lorey 2001, Wiener *et al.* 2007). Aquatic ecosystems respond to changes in mercury deposition in a highly variable manner as a function of differences in their chemical, biological, and physical properties. The biological uptake of mercury is also exceedingly complex, but generally, methylmercury enters an aquatic food chain involving plants, zooplankton and benthos, herbivorous fish, and then carnivorous fish (Potter *et al.* 1975, Grieb *et al.* 1990, EPA 1997, UNEP 2002). Uptake of methylmercury by aquatic organisms is both more rapid and more extensive than uptake of inorganic mercury (Biesinger *et al.* 1982, EPA 1997), and uptake of methylmercury differs from inorganic mercury toxicologically. Rates of methylation processes and bioaccumulation typically vary and depend on many factors (Grieb *et al.* 1990, Wiener and Spry 1996, EPA 1997, Downs *et al.* 1998, Lorey 2001, EPA 2005).

Sediment cores from several lake bottoms in southwestern Colorado demonstrate a clear increase in mercury deposition in the 1960s and 1970s. This increase is likely due, in part, to the Four Corners area power plants built between 1963 and 1977 (Nydick and Wright 2008). Not until the 1970 Clean Air Act was amended in 1990 did Congress authorize the EPA to begin regulating air emissions of mercury and other hazardous air pollutants. Engstrom and Swain (1997) analyzed sediment core data to detect recent trends in mercury emissions in the upper midwest and found that, for a number of Minnesota lakes, mercury deposition peaked in the 1960s and 1970s and then declined. The decline in deposition inputs to midwestern lakes was attributed to reduced emissions from regional and local sources, which are thought to be largely due to pollution controls (particularly on waste incinerators) and a shift from coal to natural gas for residential and commercial heating (Engstrom and Swain 1997).

There are two existing coal-fired electrical generating facilities in close proximity to the proposed DREP. The five-unit, 2,040-megawatt FCPP is located on the Navajo Nation west of Farmington, New Mexico, and the SJGS is located about 15 miles northwest of Farmington, New Mexico and consists of four coal-fired, pressurized units that generate about 1,800 gross MW. Taken together, the FCPP and SJPP emit over 2,000 lbs of mercury per year (New Mexico Environment Department 2008) and are among the largest sources of mercury emissions in the western U.S. In response to a lawsuit, the SJGS is being retrofitted with technology that will reduce mercury emissions 62 percent by 2010, a reduction of 458 lbs of mercury from local sources.

Management strategies for controlling anthropogenic mercury emissions require understanding how an ecosystem will respond to changes in atmospheric mercury deposition. Process-based mathematical models are valuable tools for informing such decisions because measurement data are often sparse and cannot be extrapolated to investigate the environmental impacts of different policy options. The EPA has developed, tested, and evaluated a set of publicly available watershed, water body, and food web models that describe the speciation, transport and bioaccumulation of mercury as a function of the physical, chemical and biological properties of different ecosystems (http://www.epa.gov/ceampubl/). These models are used both as research tools to better understand processes driving mercury cycling in terrestrial and aquatic systems, and as regulatory support tools for risk assessments and total maximum daily load determinations.

Selenium

Selenium, a trace element, is a natural component of coal and soils in the area and can be released to the environment by the irrigation of selenium-rich soils and the burning of coal in power plants with subsequent emissions to air and deposition to land and surface water. Contributions from anthropogenic sources have increased with the increases of world population, energy demand, and expansion of irrigated agriculture. Selenium, abundant in the soils of the west, 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), Abell (1994), Blanchard *et al.* (1993), and Thomas *et al.* (1997, 1998). Selenium, although required in the diet of fish at very low concentrations (<0.5 micrograms per gram [μg/g] on a dry weight [DW] basis), is toxic at higher levels (>3 μg/g) and may be adversely affecting endangered fish in the upper Colorado River basin (Hamilton 1999, Hamilton *et al.* 2005). Excess dietary selenium causes elevated concentrations of selenium to be deposited into developing eggs, particularly the yolk (Buhl and Hamilton 2000, Lemly 2002). If concentrations in the egg are sufficiently high, developing proteins and enzymes become dysfunctional or result in oxidative stress, conditions that may lead to embryo mortality, deformed embryos or embryos that may be at higher risk for mortality (Lemly 2002).

Thomas *et al.* (1998) reported that selenium concentrations in algae, odonates (dragonflies and damselflies), and western mosquitofish (*Gambusia affinis*) collected from aquatic habitats underlain by Cretaceous soils were significantly greater than in those collected from similar habitats underlain by non-Cretaceous soils. Median selenium concentrations were less than 2 µg/g DW for plant samples, less than 7 µg/g DW for invertebrate samples, and less than 6 µg/g DW for whole-fish samples collected from aquatic habitats underlain by non-Cretaceous soils. Similar samples collected from aquatic habitats underlain by Cretaceous soils contained median selenium concentrations two to five times greater. Blanchard *et al.* (1993) and Thomas *et al.* (1997) reported the concentrations of selenium in biota from aquatic habitats away from the river mainstem including biota collected from irrigation drains and ponds, which had much higher concentrations of selenium in plants (20 µg/g DW), in invertebrates (32.5 µg/g DW), and in whole fish (41.7 µg/g DW) than those found in the mainstem.

Simpson and Lusk (1999) reported on selenium concentrations in biota collected from the San Juan River mainstem (only) using data from Thomas *et al.* (1997, 1998) and others (Blanchard *et al.* 1993, O'Brien 1987, Wilson *et al.* 1995). Effects have been documented on fish and wildlife reproduction and survival in laboratory and other field studies associated with various selenium levels in the biota; high concentrations have been detected in biota from some locations within the basin that exceed thresholds of effect (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 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 mainstem of the river (Thomas *et al.* 1998). Increased selenium concentrations may also result from the introduction of groundwater to the mainstem of the river along its course (Keller-Bliesner, Inc. 1999). 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 mainstem of the San Juan River exhibited a general increase in maximum recorded values with distance downstream from Archuleta, New Mexico, to Bluff, Utah, (<1 microgram per liter [µg/L] to 4 µg/L) (Wilson *et al.* 1995). The safe level of selenium concentrations for protection of fish and wildlife in water is considered to be <2 µg/L, and chronically toxic levels are considered to be >2.7 µg/L (Lemly 1993, Maier and Knight 1994, Wilson *et al.* 1995). 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 in water to fish and wildlife.

Quartarone and Young (1995) suggested that irrigation and pollution were contributing factors to razorback sucker and Colorado 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, and because results from the seven-year research period were inconclusive, selenium concentrations were not seen as a limiting factor to native fishes in the San Juan River (Holden 2000). However, as recovery of the Colorado pikeminnow and razorback sucker proceeds, research and monitoring will need to further address this issue. These fish can live over 40 years (Behnke and Benson 1983), increasing their frequency of exposure to both dietary and waterborne 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).

Propagation and stocking

Colorado pikeminnow

Colorado pikeminnow were thought to be extirpated from the San Juan River in the early 1980s, largely due to human impacts on the Colorado and San Juan Rivers (Tyus *et al.* 1982). Surveys conducted from 1987 – 1989 revealed that Colorado pikeminnow were still present in the San Juan River, although in very low numbers (Platania *et al.* 1991). Because of these extremely low numbers of wild Colorado pikeminnow and poor recruitment into the population, a stocking program was initiated to augment Colorado 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 Colorado 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 to the inflow of 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 Colorado 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 ten miles above the Shiprock stocking location. On average, the 1997 stocked fish were smaller than those stocked in 1996 and were able to move about the river to find suitable habitats (Holden and Masslich 1997). Because of the initial success of the stocked fish, Colorado pikeminnow have been stocked every year since 1996. The number of Colorado pikeminnow stocked each year is recorded in annual reports and can be viewed at the SJRRIP website (http://www.fws.gov/southwest/sjrip/).

A total of 1,781,154 Colorado pikeminnow were stocked into the San Juan River from 2002 – 2007 (Ryden 2008b). In 2007, target stocking numbers were exceeded for both age-0 and age-1 Colorado pikeminnow, with 475,970 and 3,256 fish stocked, respectively (targets being 300,000 and 3,000, respectively). Juvenile and adult Colorado pikeminnow from several size classes are now captured in the San Juan River, indicating that there has been survival of the stocked fish from several years (Ryden 2008b). The SJRRIP augmentation program has been successful in increasing the number of Colorado 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), at present 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 suckers (Platania *et al.* 1991). Because of the limited number of razorback sucker and the lack of recruitment, the SJRRIP initiated a five-year augmentation program to supplement the population (Ryden 1997). The number of razorback sucker stocked each year is recorded in annual reports available at the SJRRIP website (http://www.fws.gov/southwest/sjrip/).

Between 1994 – 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 suckers were stocked, the second consecutive year that the target stocking number (11,400 fish) for razorback sucker was met or exceeded. Razorback suckers that have been in the river for six 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 successfully 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, Service 1998, Collier *et al.* 2000, 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 because 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 Colorado 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 determined through section 7 consultation 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 Colorado 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 1999 BO but would still require consultation.

Consultations contributing to the baseline 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 eight 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 (in Christensen *et al.* 2007) for warmer temperatures and 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.

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) presented 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 Colorado pikeminnow below Hogback Diversion structure, 63 larvae were collected from the Cudei Diversion canal. This number represented 0.013 percent of the total stocked, and the catch rate was 4.39 Colorado pikeminnow/100 m^3 of water sampled.

In December 2004, 140 Colorado pikeminnow in three 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 four were 210 – 264 mm SL (8.3 – 10.4 in) (Platania and Renfro 2005). Colorado pikeminnow were caught from 0.5 – 17.8 canal miles from the diversion structure (Platania and Renfro 2005). In 2005, recently stocked Colorado pikeminnow were captured in the Hogback and Fruitland Diversion canals.

Colorado pikeminnow that enter diversion structures face an uncertain fate, although fish may find their way back to the river. The SJRRIP is analyzing entrainment at all of the diversion structures, and 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, brown trout, striped bass, walleye, channel catfish, black bullhead, yellow bullhead (*Ameiurus natalis*), largemouth bass, smallmouth bass, green sunfish, longear sunfish (*Lepomis megalotis*), bluegill, white crappie (*Pomoxis annularis*), fathead minnow, red shiner, western mosquitofish, common carp, white sucker (*Catostomus commersonii*), white sucker-flannelmouth sucker hybrids, white sucker-bluehead sucker hybrids, threadfin shad (*Dorosoma petenense*), grass carp (*Ctenopharyngodon idella*), and plains killifish (*Fundulus zebrinus*) (Ryden 2000a, Buntjer 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 an important biological threat to Colorado 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 non-native 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 between both flannelmouth sucker and bluehead sucker that corresponds with the intensive non-native fish removal efforts that began in 2001.

Southwestern willow flycatcher

In the San Juan River, past and present Federal, State, and private activities that may affect the flycatcher include irrigated agriculture, river maintenance, flood control, dam operation, and water diversions. The San Juan River associated riparian areas are a dynamic system in constant change. Without this change, the riparian community will decrease in diversity and productivity. Sediment deposition, scouring flows, inundation, base flows, and channel and river realignment are processes that help to maintain and restore the riparian community diversity. Habitat elements for the flycatcher are provided by thickets of riparian shrubs and small trees and adjacent surface water, or areas where such suitable vegetation may become established.

The San Juan River historically had highly variable annual and seasonal discharge patterns. Flows in the San Juan River have been determined mainly by regulation of dam facilities and irrigation diversions. The highest flows generally result from snow-melt (April – May), irrigation water releases, and variable thunderstorms. Lowest flows generally occur from July – October, when most of the available river flow is diverted for irrigation. Summer monsoons can elevate river flows during this time period depending on their frequency and intensity. Water and sediment management may have resulted in a large reduction of suitable habitat for the flycatcher. Overbank flooding is needed to create shallow, low velocity backwaters, and to maintain and restore native riparian vegetation for flycatcher habitat. The lack of large peak flows combined with the effects of channelization contributes significantly to channel narrowing and the elimination of overbank flooding. These factors severely limit the development of backwater habitats essential to the survival of the flycatcher.

Mancos milkvetch

The entire range of Mancos milkvetch occurs within a region of intense energy exploration and development. Oil or gas well pads, pipelines, and access roads already occur within and near some Mancos milkvetch populations and more development in this region can be expected in the future. Small portions of the Slickrock Flats and Palmer Mesa habitats have been impacted by oil and gas development (Service 1989; Daniela Roth, personal communication, 2008). Power generation and distribution from coal-fired generating stations also impact this region with transmission lines and access roads. Eight of the New Mexico populations are only a few miles west of the SJGS and the Little Water population is only a few miles west of the proposed DREP (Service 1989; Daniela Roth, personal communication, 2008). The Sleeping Rocks population has been impacted by a tower supporting a transmission line from SJGS (Service 1989).

Most Mancos milkvetch populations occur on Navajo Nation lands that are remote from urban areas and unlikely to be severely impacted by land uses other than energy development (Daniela Roth, personal communication, 2008). A population on the Hogback, New Mexico, just south of the San Juan River was impacted decades past by a quarry operation that took sandstone to build an irrigation diversion. Thin soils that developed on the floor of this quarry were being recolonized by Mancos milkvetch in 1991 (NNHP 1991).

Adult Mancos milkvetch plants that are weakened by severe drought are frequently infested with spider mites, which appear to hasten the demise of large individuals (NNHP 1991; Sivinski and Knight 2001).

Mesa Verde cactus

Threats to the Mesa Verde cactus were well documented when the species was listed; these threats continue to be a source of mortality. 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 (CNAP 2005).

<u>Energy and mineral development</u>

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.

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 SJGS was built on Mesa Verde cactus habitat and that power transmission lines had been built through the Waterflow population. 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, pers. comm., 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).

In 2006, Western Area Power Administration destroyed about 20 mi of Mesa Verde cactus habitat, including 4.5 mi through the Malpais Conservation Area. Based on a width of 12 ft, about 22 acres of what was at least moderate habitat was mowed (Service 2007). Obviously, habitat degradation remains a problem for this species.

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, pers. comm. 2004). These impacts are not severe on the Ute Mountain Ute Reservation in the Colorado portion of the Mesa Verde cactus range (Coles, pers. comm., 2006).

ORV use is increasing as the population of the Navajo Nation and San Juan County, New Mexico, 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. ORV use was determined to be the greatest threat to the population at the time of listing, and several sites were noted as being heavily impacted by ORV use (Ecosphere 1985).

The amount of impervious land will increase with increasing population growth and with changes in land use such as urbanization (Liu *et al.* 2005). In San Juan County, New Mexico, human populations are likely to increase 1.7 percent per year through 2013 (EDIS 2009: Economic Data Intelligence System = https://edis.commerce.state.nc.us/docs/countyProfile/NM/35045.pdf, US Department of Commerce, North Carolina). As impervious areas increase in a watershed, the delivery of atmospheric deposition fluxes to the waterbody will also increase (EPA 2005). Even when the fraction of watershed covered by impervious surfaces can be small (~ 3 percent), modest growth over many years can increase the total watershed delivery of deposited mercury, working against any overall reductions in atmospheric emissions. If we assume a modest impervious surface growth rate within a watershed, total loads of mercury may increase significantly due to overland transport alone without sufficient reductions in atmospheric sources (EPA 2005).

Livestock grazing

Livestock compact the soil, eliminating potential Mesa Verde cactus growth or recovery (Sivinski, personal observations, 1990 – 2004). 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 (CNAP 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. Of 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, pers. comm., 2008).

Disease and predation

All Mesa Verde cacti are susceptible to disease and predation (see above, "Status of the Species"). The native cactus longhorn beetle (*Moneilema semipunctata*) preys upon Mesa Verde cactus, usually with lethal consequences. This beetle may have caused significant, undocumented die-offs of Mesa Verde cactus in the past. The beetle cannot fly and 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 that were eating both the stem and roots (BLM 2003), and the cacti were thought to have perished from extreme army cutworm infestations during the drought (Roth 2003).

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 the Mesa Verde cactus to return to former population levels.

Climate change

Highly specialized or endemic species, like Mesa Verde cactus, are likely to be most susceptible to the stresses of changing climate. Over a 41 year period, the average annual precipitation at Shiprock 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 average. In 2002, no precipitation was recorded, and in 2004, 1.27 in was recorded, 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, particularly in summer. Although warmer air temperatures alone may not have an effect on the species, it is evident that widespread and/or long-lasting drought can 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, climate changes could lead to the establishment or spread of non-native plants, to the detriment of Mesa Verde cactus.

Because it has been observed that germination and recruitment improve 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.

EFFECTS OF THE ACTION

'Effects of the action' means the direct and indirect effects of an action on the species or designated 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.

COLORADO PIKEMINNOW AND RAZORBACK SUCKER

Water Quality

Effects of mercury on the Colorado pikeminnow and razorback sucker

The Colorado pikeminnow and razorback sucker would be exposed to mercury emissions from the proposed power plant through ambient air exposure, deposition, and runoff into aquatic habitats, and subsequent bioaccumulation through the food chain. Upon entering the San Juan River ecosystem, microorganisms convert mercury to methylmercury, a highly toxic form of mercury. Because methylmercury is stable and accumulates through the food chain, the highest mercury concentrations are found in top predators, such as the Colorado pikeminnow, potentially causing reproductive impairment, behavioral changes, and brain damage.

The EPA offers water quality guidance for mercury in water, as well as a tissue-based approach to protect human health from methylmercury (EPA 2001). This approach calls for deriving a tissue criterion and translating the criterion into concentrations in water and aquatic organisms. While site-specific estimates of bioaccumulation are ideal, nationally representative parameter values have been developed for use when site-specific data are lacking (EPA 2001). Using site-specific data, the Navajo Nation adopted into their Water Quality Standards (NNEPA 2007), criteria for total mercury (1 nanogram/liter [ng/L]) and total methylmercury (0.011 ng/L) in water and total methylmercury in edible fish tissue (0.3 mg/kg). The relationship between total mercury loadings in water and mercury levels in fish is still poorly understood, particularly for a lotic system like the San Juan River. While fish tissue provides insights into how mercury is adversely affecting the endangered fish and their habitat, it should not be taken as a substitute for further efforts to obtain empirical data or more sophisticated modeling in order to understand the cycling of mercury in the San Juan River ecosystem and implement the management strategies necessary to meet the appropriate mercury load targets to achieve recovery.

In this assessment, the estimated increase in freshwater fish methylmercury is assumed to be proportional to the change in mercury deposition, including local mercury emission and deposition from nearby power plants. This means, for example, that a 35.5 percent increase in mercury deposition in the San Juan River basin is projected to lead to a 35.5 percent increase in mercury concentrations in fish. No information was provided in the BA on the ecosystem-specific factors that can affect the methylation and bioaccumulation in fish over time. Therefore, like others (Cocca 2001, EPA 2005, Downs *et al.* 1998, Engstrom 2007, Harris *et al.* 2007), we assumed that atmospheric deposition is the principal source of mercury to the San Juan River basin and environmental factors that affect methylmercury production and accumulation in organisms will remain constant, allowing it to reach steady state. While this approach has several limitations, we were provided no alternative tool for performing a basin-wide assessment of the relative potency of the proposed project's mercury emissions. Additionally, there are no reliable data available on the concentrations of methylmercury in the San Juan River water.

Uncertainty of Mercury Cycling in the San Juan River Environment

There are a number of uncertainties regarding the emissions and deposition of mercury in the San Juan River ecosystem, other sources of emissions, mercury methylation rates, and diet and bioenergetics in piscivorous fish. The analysis used in this opinion assumes a proportional relationship between air deposition of mercury and total mercury concentrations in fish. By simplifying the assumptions inherent in the freshwater ecosystem models, we assume that mercury concentrations in fish are proportional to changes in mercury inputs from atmospheric deposition. This solution only applies to situations where air deposition is the only significant source of mercury to the San Juan River ecosystem (and other tributary basins) that support the Colorado pikeminnow, and the physical, chemical and biological characteristics of the ecosystem remain constant over time. The Service recognizes that concentrations of mercury in Colorado pikeminnow or other fishes may not be at steady state and that ecosystem conditions affecting mercury dynamics are not likely to remain constant over time. To the extent that sources of mercury to the environment were described as part of the proposed action, or as part of the baseline conditions or as part of the cumulative effects, these activities were considered in the analysis; changes in the sources of mercury that are part of other Federal agency actions were not considered. The Service recognizes that there may be a time lag between mercury concentrations in Colorado pikeminnow and other fishes of the San Juan River basin and various activities that have reduced or may change the deposition of mercury in the environment (or have reduced or may change the conditions that contribute to the bioaccumulation of mercury in fish habitats), however, information on how the physical, chemical, and biological characteristics may affect mercury bioaccumulation rates in the San Juan River basin was not provided in the BA or other materials; therefore mercury bioaccumulation rates were considered constant. The Service also recognizes that there may be areas of historic gold and mercury mining or other sources in the watershed that could contribute non-air sources of mercury; however, as these sources were not described in the BA, the EIS or any supplemental materials, they were considered insignificant. Furthermore, Scudder *et al.* (2009) found that mercury concentrations in fish were not significantly different between unmined basins and mined basins, except for smallmouth bass from the Carson River. Concentrations of methylmercury in bed sediment and unfiltered stream water from sites in unmined basins were not significantly different from those in mined basins (Scudder *et al.* 2009).

Colorado pikeminnow sampling

In response to data needs identified during this consultation, as well as an ongoing mercury study being conducted in various tributaries of the upper Colorado River basin (Osmundson and Darnall 2007), the Service collected San Juan River Colorado pikeminnow tissues in July 2009 and had them chemically analyzed (Lusk 2009). Twenty-nine Colorado pikeminnow, ranging in size from 2.2 – 4.4 cm (average 3 cm) in TL with masses ranging from 46 – 535 g (average 182 g) were collected from the San Juan River near Shiprock, New Mexico, to near Mexican Hat, Utah. Analytical results for all Colorado pikeminnow data available are provided in Appendix B. Additional information on samples, the laboratory methods, and quality assurance results are provided in Appendix B. The preliminary results were made available on September 8, 2009 (B. Taylor, written comm. 2009; Appendices B). Summary results for Colorado pikeminnow muscle tissues collected from other tributaries in the upper Colorado River basin are provided Table 3.

Table 3. Total length, weight, and mercury concentrations in muscle tissue collected from Colorado pikeminnow from several tributary rivers in the upper Colorado River basin.

Tributary River	• Total Length (mm)					• Weight (grams)					• Total Mercury (ug/g wet weight)				
	n	mean	min	max	std	n	mean	min	max	std	n	mean	min	max	std
Colorado	25	602	243	820	141	25	2370	110	5880	1433	25	0.59	0.31	1.04	0.19
Gunnison	29	499	340	690	68	29	1057	380	2600	502	29	0.71	0.32	1.08	0.16
San Juan	29	300	216	437	55	28	182	46	535	109	29	0.14	0.03	0.43	0.10
White	4	572	486	680	83	3	1727	812	2620	904	4	0.80	0.66	1.02	0.16
Yampa	9	585	530	692	52	9	2058	1425	3400	597	9	0.49	0.39	0.58	0.07
Combined	96	477	216	820	152	94	1263	46	5880	1192	96	0.49	0.033	1.08	0.28

Note: n= number of observations, min= minimum, max= maximum, std= standard deviation, combined= data summary from Colorado, Gunnison, San Juan, White and Yampa Rivers – see Appendix B for more information.

Colorado pikeminnow collected from the San Juan River basin were also smaller in size than Colorado pikeminnow collected from other basins and had lower average mercury concentrations. Total mercury concentrations in Colorado pikeminnow muscle tissues of sizes less than 400 mm TL (n = 26) ranged from 0.03 – 0.28 ug/g wet weight (WW) (average 0.11 ug/g WW). Total mercury concentrations in Colorado pikeminnow in size greater than 400 mm TL (n = 3) ranged from 0.31 – 043 ug/g WW (average 0.37 ug/g WW) (Table 4). Looking at all

Colorado pikeminnow collected from the upper Colorado River basin tributaries and using a Kruskal-Wallis analysis of variance by ranks (H(5,96)=57.8), we found mercury concentrations were significantly lower in fish less than 400 mm TL than were found in fish greater than 400mm TL. There was a strong relationship between mercury measured in Colorado pikeminnow muscle tissue collected throughout the upper Colorado River basin and TL that can be described by the following equation:

EQUATION 1: (logarithm of mercury in muscle = $-5.8803+0.0171*TL-1.3182x10^{-5}*TL^{2}$; as depicted in Figure 3.

Table 4. Distribution of total mercury concentrations in muscle tissue collected from Colorado pikeminnow from several tributary rivers in the upper Colorado River basin by size class (range of total fish length in mm).

Total Length	200- 299			300-399			400-499			500-599			600-699			700-850		
	n	avg	std	n	mean	std	n	mean	std	n	mean	std	n	mean	std	n	mean	std
Colorado	2	0.51	0.27	0			3	0.57	0.07	2	0.60	0.06	14	0.55	0.16	4	0.79	0.27
Gunnison	0			2	0.35	0.04	14	0.73	0.16	11	0.76	0.12	2	0.69	0.07	0		
San Juan	14	0.10	0.06	12	0.12	0.07	3	0.37	0.06	0			0			0		
White	0			0			1	0.66		2	0.86	0.22	1	0.84		0		
Yampa	0			0			0			6	0.48	0.08	3	0.50	0.07	0		
Combined	16	0.15^{A}	0.17	14	0.15^{A}	0.11	21	0.65^{B}	0.18	21	0.67^{B}	0.17	20	0.57^{B}	0.16	4	0.79^{B}	0.27

Note: n= number of observations, avg= average, std= standard deviation, combined= data summary from Colorado, Gunnison, San Juan, White and Yampa Rivers; ^{A,B}= mean concentrations that share letter are not significantly different ($p<0.05$)

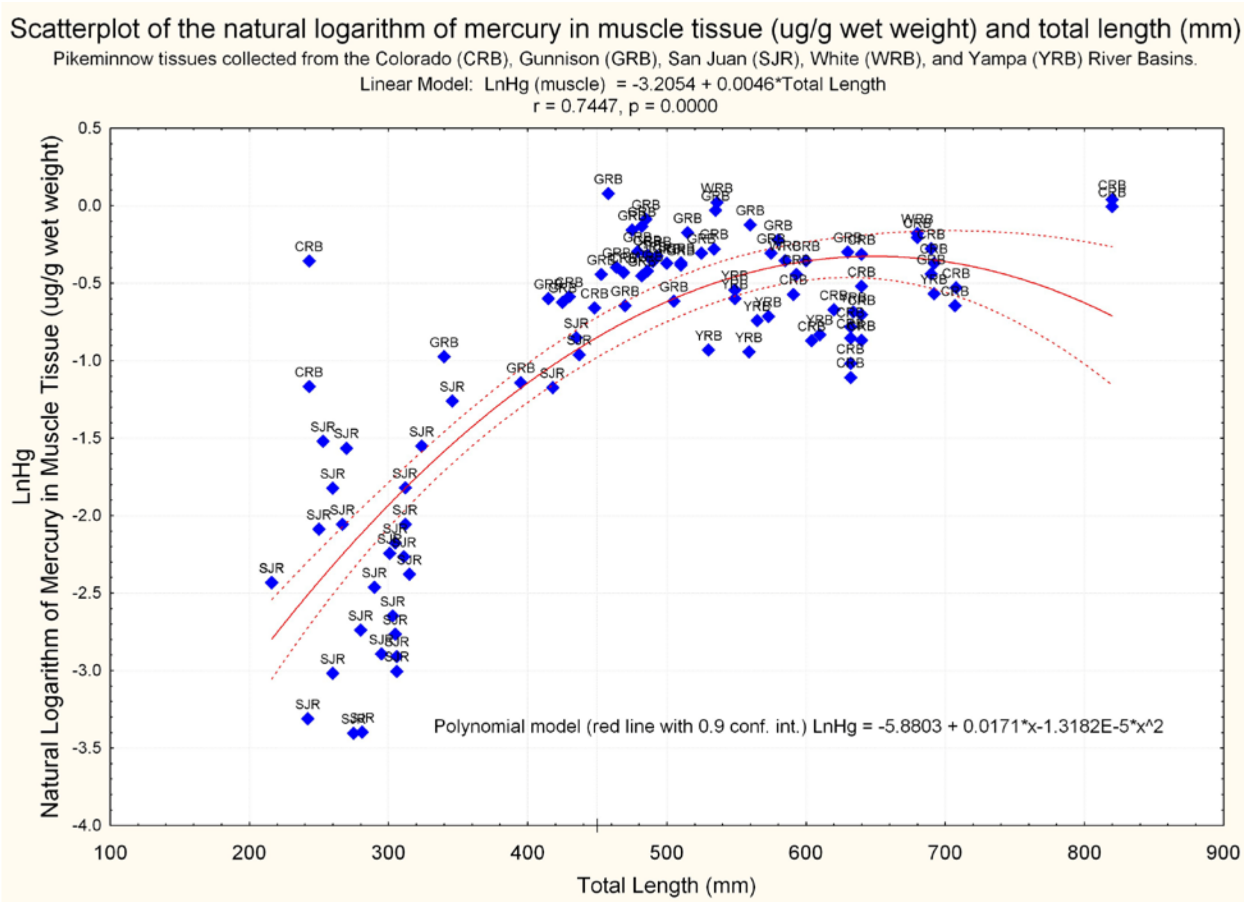

Figure 3. Distribution of total mercury concentrations in muscle tissues of Colorado pikeminnow collected from several tributary rivers in the upper Colorado River basin by total length (CRB= Colorado River basin, GRB= Gunnison River basin, SJR= San Juan River, WRB= White River basin, YRB= Yampa River basin).

Peterson *et al.* (2007) also described a strong relationship between mercury in piscivorous fish and length. However, they found that mercury concentrations stopped increasing with fish length when the northern pikeminnow exceeded 400 – 500 mm. For Colorado pikeminnow, we found that mercury concentrations appeared to stop increasing when fish exceeded 600 – 700 mm TL. There is insufficient information available to determine why mercury concentrations appear to plateau with respect to length. It could be that Colorado pikeminnow reach bioenergetic equilibrium with their dietary concentrations with respect to length and growth, or Colorado pikeminnow that accumulate elevated mercury concentrations have reduced survival in the wild. Few Colorado pikeminnow tissue concentrations were >1.0 ug/g WW. Using Equation 1, an adult Colorado pikeminnow of 450 mm TL would be expected to have muscle tissues of 0.43 ug mercury/g WW (90 percent CI =0.38-0.49 ug/g WW). Using an equation to estimate whole body mercury concentrations from muscle tissues (Peterson *et al.* 2007), and Figure 3, an adult (450 mm TL) Colorado pikeminnow would be expected to have a whole body concentration of 0.21 ug/g WW (90 percent CI =0.18-0.25 ug/g WW). Peterson *et al.* (2007) also described a weak relationship with environmental variables measured (e.g. runoff, slope, watershed area, pH, mean depth, substrate characteristics, etc.) compared to feeding attributes and length. If the mercury concentration in San Juan River Colorado pikeminnow is primarily related to diet and size, as fish age, whole body mercury concentrations are expected to increase in proportion to those described by Equation 1 and Table 5.

Table 5. The 90 percent CI of mercury concentrations expected in whole body Colorado pikeminnow in the San Juan River by total length (mm) based on Equation 1 (logarithm of mercury in muscle = $-5.8803+0.0171*TL-1.3182x10^{-5}*TL^{2}$) for Colorado pikeminnow collected in the upper Colorado River basin.

Total Length	250	350	450	550	650	750
90% CI	0.03-0.05	0.09-0.12	0.18-0.25	0.29-0.38	0.32-0.45	0.24-0.45

Pikeminnow species and their prey (i.e., sucker species) have been collected in the Sacramento River in California, the Clark Fork River in Montana, and the Yakima River in Washington (Peterson *et al.* 2007). Additionally, muscle tissues collected from Colorado pikeminnow were converted into whole body concentrations (using Peterson *et al.* 2007) and used with whole body concentrations in sucker species collected from the Gunnison and White Rivers in Colorado (Peterson *et al.* 2005) for additional comparisons. The ratio of average mercury concentrations in whole body Colorado pikeminnow to average mercury concentrations in whole body suckers ranged from 2.6 – 8.1 and averaged 4.2 (Table 6; Appendix C). This ratio (4.2) is less than the median predator-prey factor of 5 reported by EPA (1997) but greater than the ratio of 3:1 reported by Peterson *et al.* (2007).

Note: min = minimum; max = maximum

Table 6. Wet weight concentrations of mercury in whole body Colorado pikeminnow and sucker prey (reported by Peterson *et al.* 2007, Peterson *et al.* 2005, and Osmundson 2009).

Mercury µg/g Wet Weight	Sucker mean	Pikeminnow mean	Mean ratios	Sucker min	Pikeminnow min	Min ratios	Sucker max	Pikeminnow max	Max ratios
Sacramento	0.17	0.43	2.6	0.04	0.09	2.2	0.45	0.95	2.1
Montana	0.15	0.44	2.9	0.05	0.13	2.7	0.33	0.59	1.8
Washington	0.04	0.32	8.1	0.03	0.09	3.5	0.07	0.78	11.0
Gunnison R.	0.07	0.37	4.1	0.04	0.15	3.8	0.12	0.59	4.9
White R.	0.13	0.43	3.3	0.11	0.34	3.1	0.17	0.56	3.3
Averages	**0.12**	**0.40**	**4.2**	**0.05**	**0.16**	**3.0**	**0.23**	**0.69**	**4.6**

The range of mercury concentrations reported in flannelmouth sucker species collected from the San Juan River (O'Brien 1987, Blanchard *et al.* 1993, and Simpson and Lusk 1999) ranged from <0.005 – 0.3 ug mercury/g WW and averaged 0.10 µg/g WW (Appendix D). Sucker species from the San Juan River had similar average concentrations to those in Table 6. Using the Colorado pikeminnow-to-sucker ratio of 4.2, the estimated whole body Colorado pikeminnow mercury concentrations would likely range from 0.02 – 1.3 µg/g WW and average 0.46 µg/g. If the minimum average Colorado pikeminnow-to-sucker ratio of 3.0 was used, then San Juan River whole body Colorado pikeminnow mercury concentrations would likely range from 0.02 – 1.0 µg/g WW and average 0.3 µg/g, similar to those expected in Colorado pikeminnow 550 mm TL (Table 5).

Effects of methylmercury in Colorado pikeminnow

Mercury bioaccumulates in the aquatic environment and is a potent neurotoxin that affects the reproductive health of fish (Crump and Trudeau 2009). Fish are shown to receive mercury mainly via food rather than directly from water (Hall *et al.* 1997). The concentration of mercury in any given fish depends on species factors, their diet, and habitat conditions. Within a given species of fish, older and larger fish tend to have higher levels of methylmercury than smaller fish, but the size relationship is not as strong as the piscivory itself for different species (Peterson *et al.* 2002, 2007). Once methylmercury enters the body, it poses the highest threats of toxicity because it can be absorbed into living tissues and blood. Once in the blood it crosses into the brain and accumulates, there is no known way to be expelled. For example, Gonzalez *et al.* (2005) reported that fish have no inherent ability to demethylate mercury, leaving the brain vulnerable to accumulations of the metal.

Beckvar *et al.* (2005) reviewed existing residue-effects publications (10 papers, 8 fish species), dealing with mercury to identify whole-body tissue concentrations of mercury that are protective of fish. Beckvar *et al.* (2005) associated survival, growth, reproduction, and behavior with whole body mercury concentrations and recommended that 0.2 mg/kg WW in whole body adult or juvenile fish be viewed as protective, while at higher concentrations adverse biological effects are more likely. Beckvar *et al.* (2005) also indicated that 0.02 mg/kg WW may also be protective for the early life stages of fish. Finally, Beckvar *et al.* (2005) noted that attempts to derive protective tissue residues for fish continue to be hampered by a paucity of high quality, toxicological studies specifically designed to link residues and biological effects and encouraged investigators to conduct studies designed specifically to produce technically sound residue-effect information. For example, Beckvar *et al.* (2005) indicated that experimental designs such as ones used by Hammerschmidt *et al.*(2002), Drevnick and Sandheinrich (2003), Faulk *et al.* (1999) and Webber and Haines (2003) provided valuable guidelines, endpoints, and results (e.g., at least three dosing concentrations, multiple sensitive endpoints evaluated, exposure through diet, rigorous data analyses).

To protect human health, EPA (2001) recommended a methylmercury criterion of 0.3 mg/kg WW in edible fish tissue that should not be exceeded based on an average consumption of fish. Yeardley *et al.* (1998) identified a concentration to protect piscivorous mammals at 0.1 µg/g WW. Heinz (1979) identified adverse reproductive and behavioral effects in avian species above a diet of 0.1 mg/kg WW. Reproduction has been identified as the demographic parameter most likely to be negatively affected by exposure to methylmercury in birds, mammals, and now fish. There is consistent evidence across a number of species that wild populations of fish, birds, and mammals consume diets with methylmercury concentrations sufficiently high to be toxic to individuals as determined from controlled dosing studies. Laboratory dosing studies with fish and with piscivorous fish, birds, and mammals, indicate that ecologically relevant methylmercury exposures can cause significant behavioral, physiological, immunological, neurochemical, reproductive, and histological changes. During this consultation, the Service requested additional information from federal agencies, project proponents, and peer reviewers on the appropriateness of 0.2 mg/kg WW whole body mercury concentrations as associated with the onset of adverse behavioral, growth, and reproductive effects in fish, and no alternatives were provided. Beckvar *et al.* (2005), Crump and Trudeau (2009), and Webb *et al.* (2006) also indicate that adverse effects in sensitive species of fish may begin at concentrations less than 0.2 mg/kg WW. Therefore, for the purposes of this analysis, adverse effects are assumed to begin at 0.2 mg/kg WW in whole body and increase in severity and extent as described by Beckvar *et al.* (2005) and others (Figure 4) until further scientific research is conducted on Colorado pikeminnow.

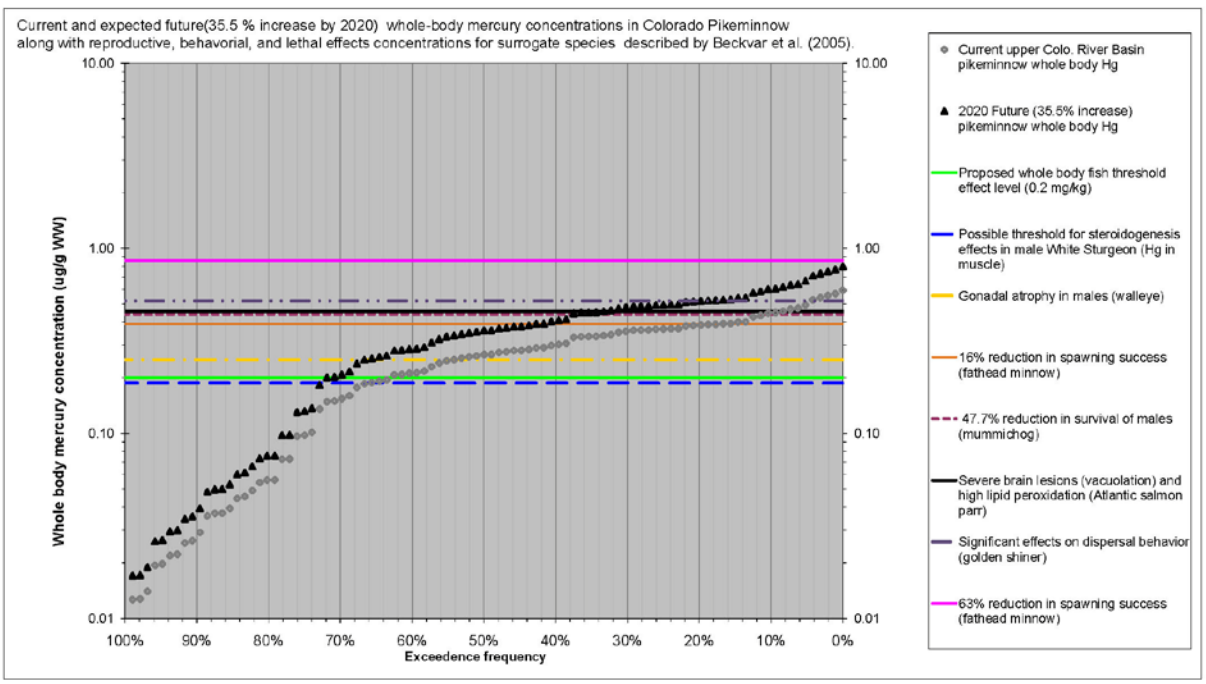

Figure 4. Current and expected future (2020) mercury concentrations in Colorado pikeminnow.

The brain and the central nervous system are very sensitive to mercury (ATSDR 1999; EPA 2001, 2005). The effects of mercury on the nervous system are primarily the consequence of the reaction of mercury with the sulfur atoms of brain proteins, enzymes, and other macromolecules, which detrimentally affects the brain's normal function (Rabenstein 1978, Eccles and Annau

1987, Wiener and Spry 1996, ATSDR 1999, Clarkson and Magos 2006, Crump and Trudeau 2009). Methylmercury in the brain causes lysis (death) of cells of the central nervous system (Rabenstein 1978). Because nervous system cells are replenished only by cell division during an organism's development, cell lysis by methylmercury in adult fish results in permanent brain damage. Thus, nerve cell damage is irreversible and most likely cumulative (Rabenstein 1978, Eccles and Annau 1987, Clarkson and Magos 2006, Crump and Trudeau 2009).

Crump and Trudeau (2009) found that accumulation of mercury in the fish brain has resulted in reduced hormone secretion, hypothalamic neuron degeneration, and alterations in neurotransmission. The inhibitory effect of mercury on reproduction in fish has been suggested to occur at multiple sites within the reproductive system, including the hypothalamus, pituitary, and gonads (Crump and Trudeau 2009). At the level of the pituitary, mercury exposure would reduce and/or inactivate gonadotropin-secreting cells necessary for reproduction. Studies that have examined the effects of mercury on the reproductive organs demonstrated a range of effects, including reductions in gonad size, circulating reproductive steroids, gamete production, and spawning success.

To determine whether the mercury concentrations in Colorado pikeminnow brain would likely be associated with brain lesions found in laboratory studies of fish, we used the expected concentrations of mercury in muscle tissues to predict the concentrations in brain tissue. Then we converted the muscle concentration into a whole body threshold for comparison with whole body fish. In five studies, trout, striped bass, and walleye were fed methylmercury, and after accumulation and observations for effect, both muscle and brain tissues were analyzed (Scherer *et al.* 1975, McKim *et al.* 1976, Niimi and Kissoon 1994, Mason *et al.* 2000, Cizdziel *et al.* 2003). The average ratio of methylmercury in muscle and brain tissues was 0.9 from these five studies (Appendix E). Berntssen *et al.* (2003) identified lesions and impairment of locomotor and feeding activity of Atlantic salmon when brain concentrations were measured at 0.68 µg/g WW (see Figure 4, above). Using the muscle-to-brain ratio (0.9), the concentration of mercury in muscle tissue would be approximately 0.75 µg/g WW and the whole body concentration would be 0.45 µg/g WW. Therefore, 10 percent of Colorado pikeminnow may currently be experiencing brain lesions and impairment of essential behaviors, and the population affected will likely increase to 32 percent by 2020. Additional research will be necessary to determine whether these studies adequately describe the likely brain pathology found in Colorado pikeminnow with elevated mercury burdens.

Despite some variation between studies, Crump and Trudeau (2009) report that there is sufficient evidence from laboratory studies to link exposure to mercury with reproductive impairment in many fish species. Friedmann *et al.* (1996) identified gonadal atrophy at whole body concentrations of 0.25 µg/g WW. Drevnick *et al.* (2006) identified reduced testosterone in fathead minnows fed diets from 0.87 and 3.93 µg/g WW, and Webb *et al*. (2006) identified reduced testosterone at 0.19 µg/g WW in the muscle of male sturgeon. In reviewing some of these studies, Beckvar *et al.* (2005) concluded that reproductive effects likely begin at 0.2 µg/g WW in whole body tissues. Based on this threshold, the majority of Colorado pikeminnow would likely experience reproductive impairment through a combination of effects to the portions of the brain that regulate the production and timing of sex steroids. Further, during larval development, elevated methylmercury exposure would also lead to impaired testicular development and atrophy. At the expected whole body mercury concentrations, 64 percent of Colorado pikeminnow may be experiencing reproductive impairment currently. If increases in mercury deposition increases 35.5 percent by 2020, then the proportional increase in San Juan River Colorado pikeminnow could result in as many as 72 percent of the population experiencing reproductive impairment and other adverse effects to behavior, survival and growth. The proposed project would account for about 0.1 percent of the increase expected in Colorado pikeminnow by 2020.

In various studies, an overall decrease in spawning success was observed as a consequence of reduced gonadal growth and correlated to a decrease in 17β-estradiol levels, decreased fecundity, and increased number of days to spawning in fish with whole body mercury concentrations ranging from 0.57 – 3.68 µg/g WW (Hammerschmidt *et al.* 2002). Days to spawning appears to be influenced by the female, as contaminated females mated with control males took on average three days longer to spawn than control females mated with contaminated males. Sandheinrich and Miller (2006) found that male fathead minnows with whole body mercury concentrations of 0.71 – 4.23 µg/g WW, spawning behavior and spawning success were reduced after dietary methylmercury exposure as juveniles through to sexual maturity. A female-specific delay in spawning can be especially detrimental if sperm release is not similarly delayed. Delayed spawning can have significant effects on the survival of offspring, as timing of feeding relative to seasonal food resources may be disrupted (Crump and Trudeau 2009). Reproductive timing of male and female Colorado pikeminnow may become more critical if climate change disrupts runoff cues.

Effects of methylmercury on Colorado pikeminnow populations

Mercury exposure can affect Colorado pikeminnow populations through reproductive impairments. Laboratory experiments have shown diminished reproduction and endocrine impairment in fish exposed to dietary methylmercury at environmentally relevant concentrations, with documented effects on production of sex hormones, gonadal development, egg production, spawning behavior, and spawning success. Field studies have found declining levels of sex hormones with increased methylmercury exposure (Crump and Trudeau 2009). Compared to pairs of fish raised on normal diets, of those that ate contaminated diets, fewer spawned, and those that did spawned later and produced fewer eggs. In the wild, those effects could impair Colorado pikeminnow populations. Normally, Colorado pikeminnow can hedge their reproductive bets by producing hundreds of thousands to millions of eggs and young per year. Mercury contamination reduces the number of successful spawn, and those that do spawn may produce fewer eggs; therefore, fewer larval fish would be given a chance to reach adulthood. If we assume that a recovered population of Colorado pikeminnow in the San Juan River is 700 individuals, and that approximately one-third are female, and each female spawns an average of 77,400 eggs, then over 18 million eggs would potentially be available for recruitment annually. Currently, over 64 percent of eggs are likely adversely affected due to the reproductive and behavioral impacts to the female fish. By 2020, over 72 percent of these eggs would likely be adversely affected due to the reproductive and behavioral impacts to the female fish, leaving an average of 5 million eggs to endure other environmental stressors (predators, competition, disease, parasites, selenium toxicity, etc.) and survive.

Assuming fish collected during 1987 – 1996 represent steady state equilibrium with mercury emissions and deposition, then concentrations in fish collected from the San Juan River are currently above thresholds of effect for predatory fish. In fact, concentrations in other predatory fish species from lakes and reservoirs in the San Juan River basin exceed these thresholds currently (EPA 2005, NMED 2009, CDPHE 2007). Mercury concentrations have been measured in Colorado pikeminnow from the San Juan River system; we expect that the concentrations increase as the fish age and grow; at 550 mm TL the concentrations in Colorado pikeminnow will be proportional to the concentrations in their prey as has been demonstrated in pikeminnow and other piscivorous fish by other studies (EPA 1997, ODEQ 2006, Peterson *et al.* 2007). Colorado pikeminnow likely contain mercury concentrations that have been associated with brain lesions and reproductive impairment. An increase in the mercury concentrations in Colorado pikeminnow due to the increase in mercury emissions and deposition in Colorado pikeminnow habitat will increase the extent of adverse effects on the species. The DREP mercury emissions are projected at 171 pounds per year beginning 2013. Because the current levels of mercury in the system are expected to cause reproductive impairment in 64 percent of Colorado pikeminnow in the basin, it is expected that by 2020 and with the project, 72 percent of Colorado pikeminnow in the basin would experience reproductive impairment due to mercury alone. The distribution of mercury concentrations in fish from the upper Colorado River basin was used to quantify the percentage of fish in the San Juan River basin above a threshold of effect.

Effects of methylmercury in razorback sucker

Several researchers (Blanchard *et al.* 1993, Thomas *et al.* 1997) reported mercury concentrations in whole body flannelmouth sucker collected from the San Juan River (n=81) that ranged from <0.005 – 0.32 µg/g WW and median concentration 0.08 µg/g WW. Mercury concentrations in whole body flannelmouth sucker collected from other tributaries of the upper Colorado River basin were similar to those in the San Juan River as well as similar to concentrations in whole body razorback sucker collected from other tributaries of the upper Colorado River basin (n=20, range from 0.01 – 0.11 µg/g WW, median 0.07 µg/g WW; B. Nierwinski, Service, written communication, May 22, 2009). Therefore, we agree with the approach taken in the BA that mercury concentrations in flannelmouth sucker may be representative of mercury concentrations in razorback sucker. By 2020, the mercury concentrations in San Juan River razorback sucker are expected to increase by approximately 35.5 percent, to range from 0.003 – 0.43 µg/g WW with median concentration 0.11 µg/g WW.

To determine whether the expected mercury concentrations in whole body razorback sucker would be associated with concentrations in the brain associated with brain lesions found in laboratory studies of fish, we first converted whole body concentrations of mercury into muscle concentrations and then used muscle tissue concentrations to predict the concentrations in brain tissue associated with injury. No relationship between mercury in whole body razorback sucker and their muscle tissues has been published. Therefore, we used the equation for all fish species reported by Peterson *et al.* (2007) to estimate muscle concentrations in razorback sucker to range from 0.1 – 0.22 µg/g WW. By estimating brain concentrations as 90 percent of those in muscle tissues, we would not expect the range of mercury concentrations in razorback sucker brain tissue (0.01 – 0.20 µg/g WW) to exceed the concentration (0.68 µg/g WW) associated with brain lesions in other fish species (Berntssen *et al.* 2003).

Beckvar *et al.* (2005) concluded that reproductive effects likely begin at 0.2 µg/g WW in whole body tissues. Therefore, by assuming the distribution of mercury concentrations in razorback sucker are similar to flannelmouth sucker concentrations, we would not expect razorback sucker to experience reproductive impairment at 0.2 µg/g WW without the proposed project. By 2020, including the effects of implementation of the proposed project (an increase of 0.1 percent), razorback suckers would not likely experience reproductive impairment due to mercury.

<u>Effects of Selenium on Razorback sucker and Colorado Pikeminnow</u>

Forms of Selenium

Selenium occurs naturally as six stable isotopes, in four oxidation states, and in a variety of inorganic and organic forms. Each form of selenium has a unique chemical, biological, and toxicological behavior (Cutter and Bruland 1984, Maier *et al.* 1987, Besser *et al.* 1989, EPA 1998d). Therefore, the impact of selenium on the aquatic environment is governed more by the forms and proportions of the various selenium species present than on the total concentrations in water (Maier *et al.* 1987, Cutter 1989).

Selenite and selenate forms are the most common dissolved inorganic species of selenium predominant in oxygenated, alkaline soils and water (Geering *et al.* 1968, Elrashidi *et al.* 1987, Albasel *et al.* 1989). Several different primary reactions can transform (or affect transformation of) dissolved species of selenium to particulate selenium. Selenate is not strongly absorbed by clays, organic matter, or other soil constituents and is therefore quite mobile in surface waters, soils, sediments, and soil porewater (Robberrecht and Van Grieken 1982, Alemi *et al.* 1988, Neal and Sposito 1989, Alemi *et al.* 1991). Selenate is the form most readily taken up by plants (Eisler 1985, 2000). Conversely, selenite has a strong affinity for sorption to clays, organic matter, and other soil constituents (Ahlrichs and Hossner 1987, Bar-Yosef and Meek 1987, Weres *et al.* 1989).

Selenium is available to all organisms and has been demonstrated to be an essential element to certain bacteria, algae, plants, and all animals (Stadtman 1974, Hilton *et al.* 1980, EPA 1987, Maier *et al.* 1987, Burk and Hill 1992, Hesketh 2008). Selenium is widely distributed in the environment, averaging 0.05 – 0.09 mg/kg (~ parts per million [ppm]) in the Earth's crust (Taylor 1964, Lakin 1972, Combs and Combs 1986). However, geophysical and biological processes have resulted in the creation of regions where soils have relatively high selenium concentrations (Beath *et al.* 1940, 1941; Mayland *et al.* 1989). Regions in North America consisting of shale and sandstone can contain soil selenium concentrations from 2 – 130 mg/kg (Combs and Combs

1986). Such soils are often termed 'seleniferous.' Shacklette and Boerngen (1984) identified the United States west of the 97th parallel (western USA) as having an elevated selenium concentration of 0.23 mg/kg. Concentrations of selenium in plants and animals generally reflect the levels in the underlying soils (Rosenfeld and Beath 1964; Birkner 1978; Thomas *et al.* 1998) except in selenium-contaminated areas (Tamari 1998).

Sources of Selenium in the San Juan River Basin

The San Juan River is a dynamic system. The underlying alluvial substrate was deposited recently, in the Quaternary Era, while portions of the surrounding uplands were deposited during the Cretaceous Era and are selenium-rich (Thomas *et al.* 1998). Snowmelt from tributaries originating in southwestern Colorado comprises the majority of source water for the San Juan River (Holden 1999), and given its steep slope, this snowmelt provides an abundant dilution capacity for selenium-rich tributary waters downstream. Total selenium concentrations in San Juan River water are dilute (often less than 1 µg/L) (Blanchard *et al.* 1993, Thomas *et al.* 1998) but increase downstream (average concentration ~1.4 µg/L at Mexican Hat, Utah [Keller-Bliesner Engineering 1999, Reclamation 2000]). Selenium concentrations in the San Juan River are elevated in relation to national baseline values (i.e. nationwide concentrations <0.1 ug/L [Radtke *et al.* 1988, Cutter 1989, Blanchard *et al.* 1993, Tamari 1998]). Selenium concentrations in San Juan River water likely reflect the dynamics of geography, climate, topography, and biotic (especially human) activity within the watershed (Decamps and Decamps 1989). Sources of selenium to the San Juan River watershed include:

- Weathering of sedimentary rocks (e.g. shales) and soils rich in selenium (Rosenfeld and Beath 1964, Radtke *et al.* 1988, Berrow and Ure 1989, Mayland *et al.* 1989, Blanchard *et al.* 1993, Thomas *et al.* 1998);

- Drainage from irrigated agricultural projects on seleniferous soils (Williams and Byers 1935; Feltz *et al.* 1991; Blanchard *et al.* 1993; Wilson *et al.* 1995a, b; Engberg 1998; Thomas *et al.* 1998);

- Coal mining and other energy development, including oil and gas exploration and refining (Gernerd *et al.* 1983, Medine 1983, Eisler 1985, Abell 1994, Eisler 2000); and,

- Emission and deposition, as well as wastes and effluent discharges from coal-fired power plants (Reclamation 1973, Goetz and Abeyta 1987, Lemly 1985, BIA 2008).

Tributaries to the San Juan River often carry higher concentrations of selenium than are found in the river immediately upstream from their confluence (Blanchard *et al.* 1993, Thomas *et al.* 1998). Average selenium concentrations in waters from tributaries such as McElmo Creek (~6 µg/L), Ojo Amarillo (~26 µg/L), Gallegos Wash (~14 µg/L), irrigation returns (~ 10 µg/L) or runoff from selenium-rich soils (~9 µg/L) have been reported to exceed water quality standards

(Butler *et al.* 1991, 1993, 1995; Blanchard *et al.* 1993; Reclamation 2000). Selenium concentrations were elevated in areas where irrigation occurs on soils that are derived from or which overlie shale and sedimentary rock developed during the late Cretaceous Period (Thomas *et al.* 1998). Selenium-enriched ground water from the percolation of irrigation water also seeps to the mainstem (Keller-Bliesner Engineering 1999). Although selenium concentrations are diluted by the incoming flows to the San Juan River, the net effect is a gradual accumulation of selenium concentrations in river water as it travels downstream (Keller-Bliesner Engineering 1999). However, Blanchard *et al.* (1993) indicated that shale underlying the San Juan River downstream of Shiprock, New Mexico, may also be a factor. Additionally, seeps of selenium-rich water from reclaimed uranium mill tailings near the San Juan River have been reported by the U.S. Department of Energy (2000, 2001, 2007). Nonetheless, waterborne exposure to selenium in all its various forms is less important than dietary exposure when determining the potential for chronic effects to a species (EPA 1998d). A number of studies have recommended tissue-based selenium benchmarks for fish and birds (Lemly 1993a, 1996b; DOI 1998; DeForest *et al.* 1999; Hamilton 2003; Ohlendorf 2003; Adams *et al.* 2003; Chapman 2007). Although there is not always consensus on the benchmarks recommended, there is consensus that tissue-based selenium benchmarks are the most appropriate medium for linking selenium concentrations to toxicity. Therefore, predictions of effects are based on concentrations of selenium in fish tissues and their dietary concentrations in this opinion.

Transfer of inorganic selenium into dietary organic selenium occurs via a complex series of interconnected hydrological, biogeochemical, and biological pathways that vary over time, among sites, and among receptor biota (Lemly 1998). Organic selenium toxicity commences when plants, algae, or bacteria absorb selenium and employ it as a sulfur analog in the synthesis of amino acids and possibly other organic selenium-containing compounds (Maier *et al.*1987).

Selenium teratogenicity

Lemly (1998) reported that one of the outward manifestations of selenium toxicosis in fish is teratogenic deformity. Teratogenic deformities (or terata) are permanent congenital malformations that have been attributed to excessive selenium in eggs (Lemly 1998). Excess dietary selenium of the female is deposited into the developing egg, particularly in the yolk (Lemly 1993b, 1998). In fish, yolk precursors (vitellogenin) are synthesized in the maternal liver, exported via blood, and incorporated into the developing ovarian follicle and become yolk proteins (Arukwe and Goksøyr 2003). When eggs hatch, larval fish use the selenium-contaminated yolk, both as an energy supply and as a source of protein for building new body tissues. During this life stage (fry), permanent developmental anomalies (e.g., spinal curvatures, missing or deformed fins, and craniofacial deformities) and other effects (e.g., edema) in fish can be related to elevated selenium in eggs (Hodson and Hilton 1983; Lemly 1993a; Maier and Knight 1994; Hamilton 2003). While hatchability is not affected, Lemly (1996a) reported an increase in the incidences of teratogenic deformities when selenium concentrations in egg exceed 10 µg/g DW. Teratogenesis is induced when the early life stages of fish rely on their yolk sac for nourishment and development (Lemly 1998; Hamilton *et al.* 2001a, b). The deformities in themselves may not always be lethal, but they lower the probability that a deformed individual will survive in the wild if these effects impact their ability to adequately feed, escape predators or endure environmental stress (Gillespie and Baumann 1986, Coyle *et al.* 1993). At sufficiently high selenium concentrations in eggs, larvae are unable to survive (Lemly 1993b, 1998; Hamilton *et al.* 2005b, 2005c). Teratogenic deformities can be very subtle; as they impact early life stages of fish they are not easily observed. In fish, deformed larvae either die or are quickly eaten by predators, and thus terata are rarely observed in the juvenile or adult populations of wild fish (Lemly 1993b).

Feeding excessive selenium to larvae, fry, or adults does not directly cause malformations in the recipient, but survival of larvae from adults fed elevated selenium can be severely compromised (Lemly 1998; Hamilton *et al.* 1990, 2001a, 2001b). Nonetheless, dietary selenium toxicity is an important cause of reproductive impairment in fish and can occur at the same time that adult fish appear healthy. Fish population collapse is also difficult to detect in demographically open systems such as a river system, as measurements can be taken on populations that are replenished by outside immigrants or stocked.

Mechanisms of selenium toxicity

Thresholds for dietary selenium toxicity in fish are easily reached and exceeded in contaminated aquatic systems (Lemly 1998). For example, naturally occurring selenium leached from soils because of agricultural irrigation in California bioaccumulated in wetland to extremely elevated concentrations in fish, resulting in massive fishkills and poisoning of wildlife (Cumbie and Van Horn 1978; Lemly 1993a; Skorupa 1998a). Excessive selenium concentrations in fish tissues can cause a wide variety of toxic effects at the biochemical, cellular, organ, and tissue levels (Sorensen 1991). Selenium is beneficial in small amounts but can be toxic to animals at slightly higher concentrations (Sharma and Singh 1984). Maier *et al.* (1987) suggest the safety margin between recommended and toxic dietary concentrations may only be 10-fold. Selenium is generally one of the most toxic elements to fish, and researchers (Hilton *et al.* 1980; Hodson and Hilton 1983; Sorenson 1991) have reported selenium toxicity to occur at dietary concentrations only 7 – 30 times greater than those considered essential for proper nutrition (i.e., > 3 mg selenium/kg DW). However, toxicity varies with fish species, temperature, life stage, exposure concentration, chemical form, the presence of pathogens, and other factors (Sorenson 1991).

Several mechanisms for selenium toxicity have been suggested: creation of superoxide radicals, oxidative stress, and substitution of selenium for sulfur in proteins (Frost and Lish 1975; Spallholz and Hoffman 2002). Until recently, researchers had focused on the substitution of selenium for sulfur into the bonds of proteins, which distorted their three-dimensional structure and thereby disrupted their functions, especially during embryonic development. Since the normal tertiary structure of proteins depends upon the formation of di-sulfide linkages, erroneous incorporation of selenium during protein synthesis could result in improperly folded or dysfunctional proteins (Diplock and Hoekstra 1976; Reddy and Massaro 1983; Maier and Knight 1994). Deformities were believed to result from this non-specific substitution (Lemly 1993b).

Oxidative stress has more recently been proposed as the initiating event of embryo mortality and teratological effects from several chemicals (Hansen 2006; Kovacic and Somanathan 2006; Wells *et al.* 2009) including avian species exposed to selenium (Hoffman 2002; Spallholz and Hoffman 2002). Emerging evidence shows that reduction-oxidation pathways in tissues regulated by glutathione/glutathione disulfide and cysteine/cystine (to name a few) are critical for developmental processes, including cell proliferation, differentiation, and apoptosis, and chemicals that induce oxidative stress may induce teratogenesis by misregulation of these same pathways (Hansen 2006). The concentration-dependent incorporation of selenomethionine in exposed adults and the subsequent generation of reactive metabolites in the developing embryo is hypothesized to initiate generation of reactive oxygen species and development of oxidative stress. In a review, Hoffman (2002) documented that exposure to selenium caused lower ratios of reduced glutathione to glutathione disulfide and increased indices of oxidative cell damage. In feeding studies, ducks exposed to elevated selenomethionine demonstrated elevated plasma and hepatic glutathione peroxidase activity as well as increased tissue selenium concentrations (Hoffman *et al.* 1989, 1991, 1992; Fairbrother and Fowles 1990; Hoffman 2002;). These mallard studies demonstrate that there is a dose-dependent increase in the hepatic ratio of glutathione disulfide to glutathione in the presence of elevated dietary selenium. Palace *et al.* (2004) hypothesized that oxidative stress may be involved in the pericardial and yolk sac edema observed in trout embryos exposed to elevated selenium. Wells *et al.* (2009) argued that oxidative stress is likely the mode of action in teratogenesis. Currently, there is only correlative evidence of oxidative stress and incidence of terata after embryo exposure to selenium in fish.

Toxicity Benchmarks for Selenium in Biological Samples

Benchmarks for Selenium in the Diet of Fish

Studies have shown that diet is the primary route of exposure that controls chronic toxicity to fish, the group considered the most sensitive to chronic selenium exposure (Coyle *et al.* 1993, Hamilton *et al.* 1990, Hermanutz *et al.* 1996, EPA 1998d). Selenium is required in the diet of fish at very low concentrations (< 0.5 µg/g DW) (Hilton *et al.* 1980, Hodson and Hilton 1983, Doroshov *et al.* 1992). Threshold and concern levels encompass a range of dietary selenium of 2 – 10 µg/g DW, with adverse effects a certainty as the upper limit is exceeded (Presser and Luoma 2006, Skorupa 1998a). Selenium concentrations in diets >10 µg/g DW have been consistently implicated in adverse effects on reproduction in a variety of avian, fish, and mammalian predators (Hodson and Hilton 1983; Woock *et al.* 1987; Heinz *et al.* 1989; Doroshov *et al.* 1992; Coyle *et al.* 1993; Lemly 1996a, 1997a; Hamilton *et al.* 1990, 2005b; Heinz 1996; Hamilton 2003, 2004). Reproductive failure has been associated with dietary concentration of 30 – 35 µg/g DW (Skorupa 1998a, Woock *et al.* 1987, Coyle *et al.* 1993). A review of dietary concentrations and effects to fish is provided in Table 7.

For larval razorback sucker, however, the range of dietary concern reportedly has narrowed to 2 – 5 µg/g DW because of studies involving sensitive species, life stages, and endpoints (Beyers and Sodergren 1999; Hamilton *et al.* 2001a, 2001b, 2002, 2005b). A study by Hamilton *et al.* (2001b) showed that egg concentrations from fish in some backwaters along the Colorado River in the Grand Valley were as high as 30 – 40 µg/g DW. Nevertheless, larval survival was 70 percent if those larvae were transferred to clean water and fed brine shrimp (a low selenium diet). Survival was near zero when the fish were fed site food that ranged in concentration from 4.5 – 37 µg/g. Larvae from broodstock that were fed food with 4.6 µg/g of selenium also showed much lower survival (approximately 20 – 80 percent survival in three trials)—a survival rate lower than for the larvae hatched from the high-selenium eggs and fed brine shrimp. We will associate this dietary concentration (4.0 ug/g DW) as a threshold for the onset of adverse effects in the diet of both larval razorback sucker and larval Colorado pikeminnow for this analysis.

Table 7. Dietary selenium exposure guidelines for sensitive endpoints and life stages of fish and selenium concentrations in potential prey organisms (invertebrates and whole body fish) collected from the San Juan River mainstem.

Diet (µg/g selenium dry weight)	Approach or Site	Effects and Species	Reference(s)
2 − 4	Synthesis	Threshold ranges for reproductive failure	Engberg *et al.* 1998
3	Synthesis	Maximum allowable concentrations (protective of reproduction)	Lemly 2002
2 − 4	Synthesis	Diagnostic residues; ecosystem contamination sufficient to cause reproductive impairment	Lemly 1998b
3 – 7	Synthesis	Range of concern; toxicological and reproductive effects a certainty if upper limit exceeded; impaired development and survival in larval fish.	Engberg *et al.* 1998; Reclamation *et al.* 2004, Hamilton *et al.*1996, 2004; Presser *et al.* 2004
3 − 8	Synthesis	Reproductive impairment threshold via lethal larval exposure (salmon, bluegill, razorback sucker)	Skorupa 1998b
2 – 5.9	Belews Lake, North Carolina	Teratogenesis in fry of four recovering fish species (common carp, bluegill, largemouth bass, mosquitofish)	Lemly 1997b, 2002
4.6	Lab	Mortality in razorback sucker larvae	Hamilton, 2004; Hamilton *et al.* 2002, 2005d
3.2 – 5.3	Lab	Reduced growth in chinook salmon (*Oncorhynchus tshawytscha*) swim-up larvae	Hamilton *et al.* 1990
5.1	Lab	40% overwinter mortality (winter stress) in juvenile bluegill	Lemly 1993b
5 − 20	Synthesis	Sufficient to load eggs beyond teratogenic threshold	Lemly 1997a, 1998a, 2002
30 – 35	Synthesis	Complete reproductive failure (100 percent effect level) in bluegill; parental exposure	Skorupa 1998a based on Coyle *et al.* 1993; Woock *et al.*

			1987
15 – 57	Belews Lake, North Carolina (1973 – 84)	Massive poisoning of fish community (16 – 20 species disappeared; two species rendered sterile, but persisted as aging adults; one occasionally re-colonized as adults; and one unaf-fected; deformities in survivors; some recovery after selenium)	Cumbie and Van Horn 1978; Lemly 1985, 1997b, 1998a
<0.13 – 18.0	Invertebrates (1990 – 96)	Range in invertebrates as potential diet for razorback sucker and young pikeminnow	Simpson and Lusk (1999)
0.08 – 15.1	Whole fish (1990 – 96)	Range in whole fish as potential diet for larger pikeminnow	Simpson and Lusk (1999)

Guidelines for selenium in the tissues of fish

EPA (2004) identified that fish tissue integrates all selenium exposures, whether from food or water. The best tissue in which to measure selenium are fish eggs (or ovaries) as concentrations have been linked to reproductive effects in some species (EPA 2004). There are, however, few data available for warmwater fishes on the relationship between the selenium content of the egg and the survival of the hatched larvae (<16 days old) and generally prior to exogenous feeding (e.g., Doroshov *et al.* 1992, Coyle *et al.* 1993, Buhl and Hamilton 2000, Hamilton *et al.* 2002). However, fish ovarian tissue is only available seasonally and is sometimes difficult to extract in quantities sufficient for chemical analysis; therefore, it was not available from the Colorado pikeminnow or the razorback sucker. Additionally, because a sufficient database containing chronic effects based on whole-body tissue is present in the literature, EPA (2004) and others have focused on whole-body tissue criteria over specific tissue types (such as ovary or muscle tissues) to identify potential adverse effects. A toxicity threshold for selenium in sensitive species and life stages in whole fish of 4 µg/g DW has been reported by a number of researchers (Hilton *et al.* 1980; Hodson and Hilton 1983; Ogle and Knight 1989; Cleveland *et al.* 1993; Lemly 1996a, b; Skorupa 1998a; Hamilton *et al.* 2002; Hamilton 2003, 2004; see Table 8) and so, where appropriate, we associated 4 µg/g DW in whole body fish with the onset of adverse effects (i.e., growth, survival, reproductive impairment).

Table 8. Tissue selenium guidelines for sensitive endpoints and life stages of fish and selenium concentrations in tissues of Colorado pikeminnow and razorback sucker from the San Juan River Mainstem.

Fish tissue (µg/g selenium dry weight)	**Approach or site**	**Effects, species, or San Juan River fish**	**Reference(s)**
4 – 12 (whole-body)	Synthesis	Range of concern; toxicological and repro-ductive effects a certainty if upper limit	Engberg *et al.*1998

		exceeded.	
4 (whole-body) 8 (muscle)	Synthesis	Maximum allowable concentrations (protective of reproduction)	Lemly 2002
5 – 7 (whole-body) 6 – 8 (muscle) 8 – 12 (larvae and fry)	Synthesis	Diagnostic residues for reproductive impairment (deformity or mortality of larvae/fry); applies to centrarchids, fathead minnows, salmonids, percichthyids	Lemly 1998b
4 – 6 (whole-body)	Synthesis	Reproductive impairment (10 percent effect level) in sensitive species (perch, bluegill, salmon)	Skorupa 1998b; Presser *et al.* 2004
4 – 6.5 (whole-body)	Lab and synthesis	Growth and survival (swim-up Chinook salmon larvae)	Hamilton *et al.*1990; Hamilton 2002, 2003
3.6 – 8.7 (whole-body)	Field	Survival (razorback sucker larvae)	Hamilton *et al.* 1996, 2005c, 2005d; Hamilton 2002, 2004
5.85 (whole-body)	Lab	40% overwinter mortality in juvenile bluegill (winter stress)	Lemly 1993b
6 coldwater (whole-body) 9 warmwater (whole-body)	Synthesis	Recommended toxicity guidelines (10 percent effect level)	DeForest *et al.* 1999
40 – 125 (whole-body)	Field	16 fish species extirpated; 10 – 70 percent rates of teratogenesis	Cumbie and Van Horn 1978; Lemly 1985, 1997b, 1998a, 2002
3 – 4	San Juan River mainstem (1993 – 1995)	Colorado pikeminnow whole body (based on muscle [EPA 2004])	Simpson and Lusk (1999)
1 – 10	San Juan River mainstem (1993 – 1995)	Razorback sucker whole body (based on muscle [EPA 2004])	Simpson and Lusk (1999)

Conversion of selenium in whole body fish to muscle tissue and vice versa

EPA (2005) estimated the median concentrations of selenium in the whole body as a function of selenium concentration in selected tissues. They used the data from four dietary exposure studies that sampled whole-body as well as muscles, ovary, or liver to allow for the projection of whole-body concentrations as a function of concentrations in these individual tissues. Such models implicitly assume that selenium concentrations in the whole body are independent of selenium concentrations in liver, muscle, or ovary tissues. However, a consensus has not been reached on these conversions for selenium, as individual species can vary with respect to the EPA (2005) equations. However, for this analysis, no species-specific equations were available to convert selenium in muscle tissues into whole body concentrations and vice versa and therefore, the EPA (2005) muscle-to-whole body conversion is the best available and follows:

Muscle tissue-to-whole body selenium conversion equations:

$Se_{whole\text{-}body} = \exp(0.1331+(0.8937 \times \ln[Se_{muscle}]))$ Source: EPA 2005; Equation 2.

Interactions of selenium and other elements

Many different compounds interact with selenium. Selenium does not aid the excretion of mercury; instead, it increases the accumulation of an inert form, including mercury-selenide (Himeno and Imura 2002), although conflicting studies exist; Huckabee and Griffith (1974) reported selenium increased the toxicity of mercury. Interactions between selenium and mercury are known to be concentration-dependent (Kim *et al.* 1977). Interactions between selenium and mercury can be synergistic at low mercury concentrations (<0.07 ppm) and antagonistic at high concentrations (>0.10 ppm) in water (Kim *et al.* 1977). Cuvin and Furness (1988) reported that selenium protected minnows against mercury toxicity as a molar ratio of 2.5:1 mercury:selenium. However, a 1.3:1 molar ratio caused increased mortality compared with 0.3 ppm mercury only. Therefore, the studies of Cuvin and Funess (1988) and Kim *et al.* (1977) demonstrated that antagonistic and synergistic toxic interactions between selenium and mercury are possible and are a function of the concentrations of the two elements and the molar ratio of one to the other (Sorensen 1991). The underlying mechanisms regarding the interactions between mercury and selenium, the compounds that are formed in tissues and the conditions that are responsible for mercury:selenium antagonism remain unclear (Kahn and Wang 2009).

Numerous pollutants are often released into the environment and result in a mixture of elements that is unique to each aquatic system. Categorization of various elemental mixtures in the environment or in the fish as synergistic or antagonistic can depend on the concentrations, their bioavailability, water temperature, the molar ratios of selenium and mercury, the fish species, and other factors (Sorensen 1991). The available data also do not show whether the various inorganic and organic compounds and oxidation states of selenium are equally effective sources of selenium as a trace nutrient, or as reducing the toxic effects of various pollutants (EPA 2004). As some of the accumulations of selenium and mercury will result in irreversible injury, and the optimal antagonistic molar ratios for selenium and mercury in the environment (along with other elements and environmental stressors) have not been determined for the Colorado pikeminnow, razorback sucker, or their prey sufficiently to address the antagonistic interactions between selenium and mercury, they were not further addressed by this analysis.

Species variation in selenium accumulation and toxicity

Resistance to selenium toxicity varies widely between closely related species. For example, rainbow trout are impacted by selenium-induced teratogenesis, but brook trout (*Salvelinus fontinails*) are not (Holm *et al.* 2005). Additionally, bluegill disappeared from Belews Lake, North Carolina, after selenium contamination, but green sunfish recolonized the lake successfully (Hamilton 2004). Three mechanisms have been suggested for sensitivity differences: enzyme induction, intestinal availability, and differential accumulation rates (Miller 2006). Ogle and Knight (1989) suggested selenium availability to fathead minnows may be low because their gut contains fewer and less diverse microflora than other fish; thus, there is less selenium incorporated into amino acids for uptake. Additionally, fathead minnow guts are less acidic than the guts of other fish, favoring the less toxic selenate form over selenites and selenides (Ogle and Knight 1989). Finally, different accumulation rates may also affect an organism's ability to resist selenium toxicity. Both brook trout and rainbow trout accumulate selenium in their muscle and eggs; however, brook trout (with selenium-induced teratogenesis considered rare) accumulated less selenium in their eggs for equal muscle concentrations than did rainbow trout (where selenium-induced teratogenesis was common) (Holm *et al.* 2005). Differences in sensitivity to selenium may alter competitive interactions between fish species, changing community compositions and putting additional pressure on species populations that are fragmented or reduced from known historic trends.

Forecast selenium concentrations

The BA describes the deposition of selenium from emissions by the proposed DREP through continuous operation and combustion of coal. Mass weight, fine particle, and total particulate deposition loadings over a 300 km radius from the DREP were estimated for a nominal one gram per second emission rate from the proposed power plant. The deposition loadings and runoff fractions were then estimated for two different regions in the San Juan River watershed. A portion (~13.6) of the deposited selenium (~145 lbs per year) was returned to the San Juan River from the lowlands, and a portion (~27 percent or ~289 lbs per year) was returned to the San Juan River from the mountain watersheds (e.g., Animas River, upper San Juan River, Piedra River). The increase in selenium concentration in the San Juan River was computed by dividing the estimated loadings by the minimum threshold flow rate in the river (500 cfs). Increases in water concentration were directly related to proportionate increases in fish tissue concentrations and compared with various thresholds and criteria. Selenium concentrations are expected to increase one percent due to DREP and 119 percent due to increases projected from NIIP at Shiprock and increase two percent due to DREP and 71 percent due to NIIP at Mexican Hat, Utah.

Selenium in razorback sucker and Colorado pikeminnow from the San Juan River

Simpson and Lusk (1999) reported on the concentrations of selenium in whole body fish and muscle tissues collected from four individual Colorado pikeminnow and 28 razorback suckers from the San Juan River mainstem. Six razorback sucker muscle plugs were collected prior to stocking to determine pre-San Juan River exposure concentrations of selenium in the muscle tissue, three whole body razorback sucker samples were collected in October 1995, and muscle tissues were collected from fish that had been stocked into the San Juan River for approximately 1 year.

Selenium concentrations in 28 razorback sucker muscle plugs collected prior to the introduction of these fish to the San Juan River in 1994 ranged from 2.9 – 4.8 µg/g DW. The geometric mean selenium concentration in razorback muscle tissue was 3.2 µg/g DW prior to San Juan River introduction and was 3.9 µg/g DW after their introduction (Simpson and Lusk 1999). There were no statistically significant differences in the accumulation of selenium concentrations in muscle plugs of cohort razorback suckers before and after exposure to the San Juan River environment. Spatial trends were not found using razorback sucker or the Colorado pikeminnow muscle plug selenium concentrations by Simpson and Lusk (1999). Razorback sucker muscle tissue selenium ranged from 1.1 – 11 µg/g DW. When muscle tissue concentrations are converted into whole body razorback sucker selenium concentrations, they ranged from 1.2 – 9.7 µg/g DW. During 1994 – 1995, 45 percent of whole body razorback sucker concentrations exceeded the 4.0 ug/g DW level of concern. However, if selenium concentrations in fish tissues increase 119 percent due to NIIP, the concentrations expected would range from 2.7 – 21.3 µg/g DW, and 93 percent would exceed the 4.0 ug/g DW level of concern. When selenium concentrations from DREP are added, the range of concentration increases slightly to 2.7 – 21.5 µg/g DW.

Simpson and Lusk (1999) reported on the concentrations of selenium in muscle tissues collected from four individual Colorado pikeminnow from the San Juan River mainstem. Selenium concentrations in the four Colorado pikeminnow muscle tissues collected ranged from 2.9 – 3.9 µg/g DW. Converting these muscle tissues using Equation 2, whole body selenium concentrations range from 3.0 – 3.9 µg/g DW. Based on an analysis of only four samples (which reduces the confidence of the extrapolation), no adverse reproductive effects would be expected as the range of whole body concentrations are less than 4 µg/g DW. However, if selenium concentrations in fish tissues increase 119 percent due to NIIP, the concentrations expected would range from 6.5 – 8.4 µg/g DW, and therefore all whole body Colorado pikeminnow would be above the threshold for adverse reproductive effects. When selenium concentrations from DREP are added, the range of concentration increases slightly to 6.5 – 8.5 µg/g DW.

Effects of increased selenium in the diet by NIIP and DREP

Razorback sucker

McAda and Wydowski (1980) and Bestgen (1990) suggested that the diet of razorback sucker was composed primarily of “ooze,” (e.g., plant detritus with associated bacteria, fungus and zooplankton) as well as insect larvae, such as found in low-velocity habitats of the San Juan River. Potential dietary items of larval razorback sucker would likely be small invertebrates (such as zooplankton) found in the mainstem or at the mouths of tributaries, in irrigation drains, and in associated wetlands. Papoulias and Minckley (1992) found that razorback sucker larvae exhibited prey-size selection, based on body width, and consumed prey from 0.1 – 0.4 mm. Selenium concentrations in zooplankton have not been reported.

From a caloric standpoint, zooplankton have similar energy content to invertebrate brine shrimp (Hamilton *et al.* 2001a). Studies by van Hattum *et al.* (1991, 1996) reported that invertebrate size, rather than species or sex, explained most of the variation in inorganic element accumulation in aquatic invertebrates. Timmermans *et al.* (1989) and Farag *et al.* (1998) also reported that small-sized aquatic invertebrates had higher concentrations of inorganic elements than larger-sized invertebrates. Because the caloric contents of zooplankton and aquatic invertebrates are similar (even though concentrations in zooplankton may be higher than those in invertebrates), it seemed appropriate to estimate the dietary concentrations to larval razorback sucker based on the selenium concentrations reported in invertebrates by Simpson and Lusk (1999). However, the invertebrates sampled for selenium may not be representative of selenium concentrations in invertebrates found in the San Juan River system nor of dietary doses to young Colorado pikeminnow or razorback sucker based on their diet selection. For example, chironomids have been identified as having elevated selenium concentrations in comparison to other invertebrates (Citation). Chironomids have also been identified as an important dietary item for both Colorado pikeminnow and razorback sucker (Service 2002a,b). Selenium concentrations in aquatic invertebrates (n=77, geometric mean 3.41 µg/g DW; range <0.13 – 18.0 µg/g DW) were not significantly different throughout the river. If NIIP increased invertebrate selenium concentrations by 119 percent, then selenium concentrations would range from 0.14 – 39.4 µg/g DW and the geometric mean would increase to 7.47 µg/g DW. If DREP increased invertebrate selenium concentrations by about one percent, then selenium concentrations would increase slightly from 0.14 – 39.5 µg/g DW and the geometric mean would increase to 7.50 µg/g DW. If the concentrations in the invertebrates sampled were indicative of the diets of razorback sucker, then 40 percent of them exceed the 4.0 ug/g DW dietary level of concern. If NIIP increased dietary invertebrate selenium concentrations by 119 percent, then 84 percent of them exceed the 4.0 ug/g DW dietary level of concern. If DREP increased dietary invertebrate selenium concentrations by about one percent, then 85 percent of them exceed the 4.0 ug/g DW dietary level of concern. In other words, 85 percent of the razorback sucker population in the San Juan River basin would experience adverse effects in offspring such as growth limitations, reproductive impairment, and death.

Colorado pikeminnow

The relationship between the toxicity of dietary selenium to larval Colorado pikeminnow reported by Buhl and Hamilton (2000) was invalid as mortality occurred in the control treatment; therefore, no species-specific model for determining the relative toxicity associated with dietary selenium is available. If larval Colorado pikeminnow diets included invertebrates with concentrations of selenium similar to those reported by Simpson and Lusk (1999). If the concentrations in the invertebrates sampled were indicative of the diets of young Colorado pikeminnow, then 40 percent of them exceed the 4.0 ug/g DW dietary level of concern. If NIIP increased dietary invertebrate selenium concentrations by 119 percent, then 84 percent of them exceed the 4.0 ug/g DW dietary level of concern. If DREP increased dietary invertebrate selenium concentrations by about one percent, then 85 percent of them exceed the 4.0 ug/g DW dietary level of concern. Selenium concentrations in whole fish were significantly different by river reach, being lower near the confluence of the Animas River. However, for the basis of estimating dietary doses to Colorado pikeminnow, whole fish of all sizes, but not including trout, were grouped (n=502, geometric mean 2.43 µg/g DW; range <0.2 – 14.3 µg/g DW). If NIIP increased these fish selenium concentrations by 119 percent, then selenium concentrations would range from 0.2 – 31.3 µg/g DW and the geometric mean would increase to 5.3 µg/g DW. If DREP increased invertebrate selenium concentrations by about one percent, then selenium concentrations would increase slightly from 0.2 – 31.4 µg/g DW and the geometric mean would be 7.3 µg/g DW. If the concentrations in the fish samples were indicative of the diets of Colorado pikeminnow, then 14 percent of them exceed the 4.0 ug/g DW dietary level of concern. If NIIP increased dietary invertebrate selenium concentrations by 119 percent, then 71 percent of them exceed the 4.0 ug/g DW dietary level of concern. If DREP increased dietary invertebrate selenium concentrations by about one percent, then 71 percent of them would still exceed the 4.0 ug/g DW dietary level of concern. In other words, 71 percent of the Colorado pikeminnow in the San Juan River basin would experience adverse effects in offspring such as growth limitations, reproductive impairment, and death.

Colorado Pikeminnow and Razorback Sucker Critical Habitat

Colorado pikeminnow and razorback sucker critical habitat consists of the following PCEs:

(1) Water: enough water of sufficient quality delivered to habitats in accordance with a hydrologic regime that is required for the particular life stage for the species;

(2) Physical habitat: areas of the Colorado River system that are inhabited or potentially habitable for spawning and feeding, as a nursery, or as corridors between these areas, including oxbows, backwaters, and other areas in the 100-year floodplain which when inundated provide access to spawning, nursery, feeding, and rearing habitats; and

(3) Biological environment: adequate food supply and ecologically appropriate levels of predation and competition. Following is a discussion of how the project will affect these PCEs.

Water Quality and Quantity

Water, of sufficient quality and quantity, is required for all life stages of the Colorado pikeminnow and razorback sucker. As discussed above, the concentrations of mercury and selenium in the water are currently at levels that impair the species' abilities to reproduce and survive in the wild. Further discussion of the effects of mercury and selenium on the fish may be found above.

Water quantity will not be affected by this project.

Physical Habitat

The physical habitat of the San Juan basin will not be affected by this project.

Biological Environment

An adequate food supply must be of sufficient quantity and quality to fulfill the species' needs at all life stages. As discussed above, the concentrations of mercury and selenium in the biota of the San Juan River system will increase due to the project. Both mercury and selenium are detrimental to the Colorado pikeminnow and razorback sucker through concentrations in their diet such that both species will experience significant reproductive impairment. Therefore, the food supply in the San Juan River system is not currently adequate nor will be after project completion, as it will not be free of detrimental levels of contaminants. See above analyses for further discussion of the effects of mercury and selenium on the fish.

EFFECTS OF THE ACTION ON SOUTHWESTERN WILLOW FLYCATCHER

It is difficult to predict how increased mercury and selenium will affect the flycatcher because there is no knowledge of how the levels of these contaminants directly impact invertebrate prey or flycatchers. By using information on the effects of mercury and selenium on other avian species, the Service has determined that there would be some level of adverse effects on the flycatcher from the proposed action. Sampling the invertebrates commonly preyed upon by flycatchers would be necessary in order to determine the levels of mercury and selenium present in the flycatcher's food source. Samples could also be taken from flycatcher feathers and addled eggs in order to determine the levels of mercury and selenium that have accumulated.

Mercury

Inorganic forms of mercury are not highly toxic, however once inorganic mercury enters an aquatic system, it is rapidly converted to organic forms (e.g., methyl mercury) which are highly bioaccumulative and toxic at very low doses. For birds such as flycatchers, mercury is accumulated via ingestion of aerial insects emerging from benthic life stages in aquatic environments containing mercury. Once ingested, this mercury rapidly moves into the bird's central nervous system, resulting in behavioral and neuromotor disorders. The developing central nervous system in avian embryos is especially sensitive to this effect, and permanent brain lesions and spinal cord degeneration are common (DOI 1998, Young 1998). High concentrations of inorganic mercury result in kidney necrosis and failure (DOI 1998). Because of bioconcentration of mercury from one trophic level to the next, high trophic level predatory birds such as eagles and osprey that eat fish and small mammals are at a greater risk than lower trophic level feeding birds such as the flycatcher. There is evidence that mercury concentrations can accumulate in tissues of terrestrial songbirds with diets composed of invertebrates (Cristol *et al.* 2008).

Due to bioaccumulation up the food chain and conversion of mercury into methyl mercury in the water column and sediments, water concentrations as low as 0.00064 µg/L total mercury can result in harmful bioaccumulation into prey items of the bald eagle. Dietary total mercury concentrations associated with adverse effects to birds are generally less than 0.1 µg/g (ppm) WW (DOI 1998). Considering these studies and others, a recommended overall daily dietary intake dose rate of less than 0.019 mg total mercury/kg body weight/day is reported by Los Alamos National Laboratories (LANL) (2005) as a "No Observed Adverse Effect Level" (NOAEL) for an aerial insect feeding bird. The DREP ecorisk assessment uses the total mercury value from LANL (2005) in its calculations. The Service has not found that there will be measurable adverse effects to the flycatcher due to minimal increased mercury levels within the action area.

Selenium

While there is no known beneficial biological function of mercury, selenium is an essential trace element important in many biochemical and physiological processes. However, there is a narrow range between selenium intake resulting in deficiency and that causing toxicity (Opresko 1993). For birds, selenium in its inorganic form is not highly toxic. However, once selenium enters an aquatic ecosystem, it is converted to selenomethionine, resulting in a variety of adverse effects to both aquatic and terrestrial organisms (DOI 1998). Excessive uptake of selenomethionine in birds causes oxidative stress and formation of free-radicals that interfere with enzyme function and synthesis. At low to mid-range doses, selenomethionine is a potent avian reproductive toxin and may cause decreased resistance to disease and infection (DOI 1998). Interference in enzyme dynamics is believed to be a major contributor to abnormal avian embryonic development (reduced hatchability and deformed embryos). At higher doses, selenium is a hepatotoxin (i.e., results in liver failure).

Dietary selenium concentrations of 3 µg/g (ppm) or higher are clearly associated with adverse effects in birds. In general, according to Lemly (1996a), no effects are observed when total dietary selenium concentrations are less than 2 µg/g (ppm). However, winter stresses have been associated with increased susceptibility to selenium, so these toxicity thresholds may underestimate effects during certain times of the year (Sorenson 1991). Concentrations of 0.9 mg/kg (ppm) in sediments have been associated with adverse effects on avian reproduction (USDI 1998). Considering these studies and others, a recommended overall daily dietary intake dose rate of less than 0.44 mg selenium/kg body weight/day is reported by LANL (2005) as a NOAEL for an aerial insect feeding bird. Depending on assumptions within the ecorisk model, this value corresponds to a dietary concentration of approximately 0.7 µg/g, which is lower than the value reported above by Lemly (1996a). The DREP ecorisk assessment uses an even more conservative daily intake dose value of 0.29 mg selenium/kg body weight/day based on EPA (2007), corresponding to a dietary threshold of approximately 0.6 µg/g. Using these levels, there is a predicted adverse effect to flycatchers in the San Juan River basin. There are currently no known flycatcher territories present within the San Juan River basin, and the available habitat is unknown. However, future restoration activities along the San Juan River are likely to increase flycatcher habitat. An increased monitoring effort along the San Juan River could result in the increased knowledge of territories and nesting flycatchers in the drainage. For this reason, the Service concludes that there will be indirect effects of the proposed action to the flycatcher with increased selenium in the San Juan River.

EFFECTS OF THE ACTION ON MANCOS MILKVETCH

The Desert Rock Energy Project could adversely affect Mancos milkvetch through destruction and modification of approximately one acre of suitable unoccupied habitat. Although no known Mancos milkvetch populations are located within or near locations of proposed construction or mining activities, dormant seedbeds could be adversely affected. No impacts to this species are expected from increased fugitive dust levels occurring during construction or mining activities. Human activity has the potential to disturb vegetation in the action area, particularly in areas where cross country travel, associated with maintenance, could occur.

Although current maximum 8-hour concentrations of ozone in the area are at a level that could have adverse effects on vegetation in the action area, we have no specific data from the project area in order to evaluate the potential for impacts from ozone concentrations on Mancos milkvetch. Additionally, concentrations of certain heavy metals (particularly barium and vanadium) in the action area are elevated and baseline conditions (i.e., pre-project) may already be affecting the Mancos milkvetch. Project operations are expected to lead to minor incremental increases in these and other metals. It is unknown whether an increase in ozone or heavy metal concentrations would have any measurable effect to Mancos milkvetch. Without this knowledge, the conservative approach (erring on the side of the species) would lead us to assume that there may be an adverse effect to the species leading to potential death of individual plants or inhibited reproduction. However, it is unknown whether some aspect of the species' biology or the critical nature of a specific population would be compromised by the incremental increases in ozone or heavy metal concentrations. Based on the absence of data, the potential for adverse effects on Mancos milkvetch cannot be quantified at this time. As such, potential biological responses to individuals or populations of Mancos milkvetch remain unknown.

EFFECTS OF THE ACTION ON MESA VERDE CACTUS

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. Approximately seven tower locations are located within occupied Mesa Verde cactus habitat. Thirteen cacti were recorded within the 200-ft^2 tower construction areas, based on the preliminary alignment. Construction and maintenance of transmission access roads and the construction footprint of tower locations would result in some permanent loss of potentially viable habitat and/or seed bank for Mesa Verde cactus. Construction of tower structures could potentially result in cacti damage or mortality where the populations occur within the project footprint. Blading and leveling of tower sites could potentially kill or severely damage plants at those locations either by vehicle compression, soil removal, or plants buried under spoils. Vehicles and heavy equipment traveling along the proposed corridor or access roads could crush plants. Human or vehicular activity outside the proposed right-of-way or access roads may trample individuals or disrupt soils. Though potential impacts would be greatest during construction, human or vehicular activity during transmission line maintenance would potentially trample individuals or disrupt soils. Conservation measures and best management practices

(BMPs) will be implemented prior to any construction activities. Reclamation techniques will be specifically designed to address site-specific soil properties and the potential for long-term erosion.

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 two individual cacti. This number is based on the proposed location of the facilities and the likelihood that effects to cacti in this area may be unavoidable.

If, during the course of the construction, more than two cacti are damaged or transplanted, this would constitute new information about the extent of the effects of the action not considered in this BO and may necessitate reinitiation of consultation per the Reinitiation Notice. If more than two cacti are damaged or destroyed, BIA 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.

Temporary soil disturbance may negatively impact seed sources if dead individuals are damaged or removed. Seedbed disturbance could potentially result in a loss of seed viability and decrease the success of recolonization. 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. It is likely that seeds of the Mesa Verde cacti survive in the seed bank present in many of these sites, awaiting the return of more favorable conditions. As unoccupied but potential habitat may host ecologically important seed banks, appropriate conservation measures (described in the *Proposed Action* section of this document) should be applied to these areas as well.

Individual plant mortality could be caused from root exposure due to soil loss. However, removal and trampling of vegetation around individual cacti are expected to be short in duration, and vegetation is expected to recover following construction activities. Because best management practices will be used during construction activities and mining activities would occur downwind and four km (2.3 mi) away, we also do not anticipate an increase in fugitive dust, sedimentation/erosion, or increased risk of fire or fuel spill. The number of plants that may not become established in the future because of these altered soil conditions cannot be estimated.

Occasional vehicle use from maintenance activities is an indirect effect resulting from the implementation of the proposed action. It is our expectation that the majority of these actions will likely result in insignificant and discountable effects to the cacti; however, it is possible that crushing of individuals may occur through road use.

Public ORV use currently occurs on existing transmission corridors, two track roads and trails within these areas. The level of current public ORV use is unknown and cannot be quantified.

However, the expected increase of ORV use in areas of suitable habitat would be minimal, if any, as the proposed transmission line would be adjacent to existing power lines which already experience ORV use. Mitigation measures will be implemented to discourage public OHV use in areas of suitable habitat and would include locked gates, signage, and other barriers. Additionally, the Mitigation and Monitoring Plan identifies a conservation measure that would monitor sites along transmission line Segment D to evaluate potential impacts of increased ORV activities and the potential invasion of exotic species. Restrictive fencing or flagging of existing populations for extended periods could attract the public and result in illegal collection of specimens.

Additional indirect impacts to the cactus may occur from soil deposition related to construction activities, which could reduce reproduction and/or recruitment. Moreover, individual plant mortality could be caused from root exposure due to soil loss. Still, removal and trampling of vegetation around individual cacti are expected to be short-term in duration and vegetation is expected to recover following construction activities. Because BMPs will be used during construction activities, we also do not anticipate an increase in fugitive dust, sedimentation/erosion, or increased risk of fire or fuel spill.

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.

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 National Environmental Policy Act or other environmental laws.

COLORADO PIKEMINNOW AND RAZORBACK SUCKER AND CRITICAL HABITAT

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 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 was being conducted by the Colorado Oil and Gas Conservation Commission in cooperation with the Southern Ute Indian Tribe, BLM, the Forest Service, and the industry. The mapping and modeling studies were completed in 2000. A follow-up project was funded by the Ground Water Protection Research Foundation (GWPRF).

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. BLM prepared an Environmental Impact Statement to address coalbed methane development on the Southern Ute Indian Reservation. 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 would be addressed during future section 7 consultation with BLM. Future section 7 consultations are not expected for coalbed methane development on private or State lands; therefore, these water depletions 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 three-dimensional 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 9.

Table 9. 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 af/yr to the San Juan River. Modeling shows approximately 74 af/yr is currently being depleted with existing wells and predicts the maximum depletions to be approximately 200 af/yr.

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 af/yr. 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, we conclude that an additional future depletion of approximately 200 af/yr 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 should 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. Irrigation ditches and canals below Navajo Dam could entrain Colorado pikeminnow and razorback sucker, including 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 Colorado pikeminnow. Livestock grazing may adversely impact razorback sucker and Colorado 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 Colorado pikeminnow need for their various life history stages.

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

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

Gradual change in floodplain vegetation from native riparian species to non-native species

Channel narrowing leads to a deeper channel with higher water velocity. Colorado 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 Colorado 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 non-native fish species can enter the San Juan River.

Increased boating, fishing, ORV 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 non-native species, and the potential for harassment of native fishes.

SOUTHWESTERN WILLOW FLYCATCHER

Cumulative effects to the flycatcher would result from human activities, wildfire, and global warming.

Increases in development and urbanization

Increases in development and urbanization in the historic floodplain would affect the flycatcher by reducing peak flows because of the flooding threat. Development in the floodplain makes it more difficult, if not impossible, to transport large quantities of water that will overbank and create low velocity habitats that create habitat for flycatchers.

Increased urban use of water

Increased urban use of water, including municipal and private uses, would affect the flycatcher by reducing river flow and decreasing available habitat for the flycatcher.

Water contamination

Contamination of the water from sources such as sewage treatment plants, runoff from small feed lots and dairies, and residential, industrial, and commercial development could adversely affect the flycatcher. A decrease in water quality and gradual changes in floodplain vegetation could adversely affect the flycatcher, its prey base and its habitat.

Other human activities

Human activities may adversely impact the flycatcher by decreasing the amount and suitability of habitat. These activities include dewatering the river for irrigation, increasing water pollution from non-point sources; habitat disturbance from recreational use, suburban development, and removal of large woody debris.

Wildfire

Wildfires and wildfire suppression in riparian areas may have an adverse affect on flycatchers. Wildfires are a fairly common occurrence in riparian areas. The spread of the highly flammable saltcedar and drying of river areas due to river flow regulation, water diversion, lowering of groundwater tables, and other land practices are largely responsible for the increase in fuel loading along riparian areas. Wildfires have the potential to destroy flycatcher habitat.

Non-native vegetation removal

The removal of non-native vegetation, such as saltcedar and Russian olive, can adversely affect the amount of available flycatcher habitat in the short term. In areas where non-native trees are removed and replaced with native vegetation as part of a restoration project, habitat may be created. Where phreatophyte removal is not followed by restoration, habitat for the flycatcher is lost.

Climate change

The effect climate change may have on the flycatcher is still unpredictable. However, mean annual temperature in Arizona increased by one degree per decade beginning in 1970 and 0.6 degrees per decade in New Mexico (Lenart 2005). In both New Mexico and Arizona the warming is greatest in the spring (Lenart 2005). Higher temperatures lead to higher evaporation rates which may reduce the amount of runoff, groundwater recharge, and lateral extent of rivers such as the Rio Grande. Increased temperatures may also increase the extent of area influenced by drought (Lenart 2003).

The Service anticipates that these conditions and types of activities will continue to threaten the survival and recovery of the flycatcher by reducing the quantity and quality of habitat through the continuation and expansion of habitat degrading actions. Future restoration activities along the San Juan River have the potential to increase flycatcher habitat, and the effects described above may limit habitat expansion.

MANCOS MILKVETCH

Oil and gas development, as discussed above, is the primary threat to Mancos milkvetch in the action area. Most of these developments would be considered a future Federal action and therefore are not considered cumulative effects, although development on the Navajo Nation may not have a Federal nexus.

MESA VERDE CACTUS

The growth of Shiprock, New Mexico, has affected plants in the vicinity of the town. The open clay badlands where this plant occurs are attractive for ORV use. Oil and gas development and pipeline and powerline construction occur throughout the range of this species. This plant is very difficult to keep alive under cultivation because of its specialized soil requirements, so there are few commercial sources of plants. As a result, signs of limited collecting are periodically seen at the best known localities. Depending on the intensity of these actions, individual cacti can be killed or habitat may be fragmented. These types of activities contribute the cumulative effects to the proposed action.

The Federal Register notice of intent to prepare a environmental impact statement and announcement of public scoping meetings identified that a long-term high quality municipal and industrial water supply is needed to improve the standard of living for current and future populations and to support economic growth of the Navajo Nation, the City of Gallup, New Mexico, and the City of Window Rock, Arizona (59 FR 16219). The BA further explains that the proposed project will deliver treated municipal water to selected Navajo communities and a portion of the Jicarilla Apache Nation. Although the proposed project would provide water for future residential or commercial development activities within the action area, the majority of the water supply would service the southeastern area of the Navajo Nation, which is not considered cactus habitat. 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 systems and additional residential development is expected to be limited to those areas. Still, it is unknown whether any of these developments would occur within occupied cactus habitat. If development does occur within cactus habitat, we would expect this species to be adversely affected.

CONCLUSION

COLORADO PIKEMINNOW AND RAZORBACK SUCKER

After reviewing the current status of the fish, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is our biological opinion that implementation of the DREP, as proposed, is likely to jeopardize the continued existence of the Colorado pikeminnow and razorback sucker. Jeopardy is defined in the regulations as engaging in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the Colorado pikeminnow and razorback sucker in the wild by reducing the reproduction, numbers, or distribution of the species (50 CFR 402.02)..

Mercury in the environment accumulates in watercourses through emissions, deposition, and runoff into the waterbody. Fish are exposed to mercury through diet; mercury in the water column accumulates up the food chain and primarily affects top predators, such as the Colorado pikeminnow. Mercury is a potent neurotoxin that affects the reproductive health of fish through affecting the portions of the brain that regulate the production and timing of sex steroids; therefore, it primarily impacts fecundity rather than directly killing individuals exposed to it. Once ingested and absorbed into the blood, there is no known way for an organism to excrete it. A threshold for adverse effects has been shown to be 0.2 mg/kg WW in a number of species of fish; in the absence of data specific to the Colorado pikeminnow and razorback sucker, we employ this threshold. Using this approach, the environmental baseline is degraded to the extent that 64 percent of Colorado pikeminnow experience reproductive impairment due to mercury presently. By 2020, mercury deposition in the San Juan River basin is expected to increase 35.5 percent, with the proposed DREP adding approximately 0.1 percent (171 lbs per year) of mercury to the local system. With this additional mercury, 72 percent of Colorado pikeminnow in the San Juan River basin are expected to experience reproductive impairment. The razorback sucker, an omnivore, is not expected to experience reproductive impairment due to mercury after project completion.

Sources of selenium in the San Juan River include erosion of naturally occurring selenium-rich soils and rocks within the basin, coal mining and energy development, and emissions and discharges from coal-fired power plants, such as the proposed DREP. Fish are exposed to selenium through a selenium-rich invertebrate diet. Like mercury, adult fish with diets high in selenium do not experience mortality themselves; instead, they deposit excess selenium in the yolks of developing eggs. Newly hatched fry from these eggs use the yolk as an energy and protein source; it is at this stage that developmental anomalies occur. The deformities are either lethal or cause the fry to be more susceptible to predators or other environmental stressors. A threshold for adverse effects to offspring of 4 µg/g DW (whole body) has been reported by a number of researchers; in the absence of data specific to the Colorado pikeminnow and razorback sucker, we employ this threshold. Using this approach, 40 percent of razorback suckers in the San Juan River basin exceed this threshold currently. The NIIP, when fully constructed, is expected to increase selenium concentrations in the San Juan River basin by 119 percent, at which time 84 percent of razorback suckers in the basin will exceed this threshold. After DREP project completion, a total of 85 percent of razorback suckers in the San Juan River basin would exceed the threshold, and their offspring would experience growth limitations, reproductive impairment, and/or death due to selenium.

For the Colorado pikeminnow, which eats fewer invertebrates, 14 percent of the population is currently exceeding the selenium threshold of adverse effects. The NIIP, when fully constructed, is expected to increase selenium concentrations in the San Juan River basin by 119 percent, at which time 71 percent will exceed this threshold. After DREP project completion, a total of 71 percent of Colorado pikeminnow in the San Juan River basin would exceed the threshold, and their offspring would experience growth limitations, reproductive impairment, and/or death due to selenium.

The San Juan River basin is one of only three subbasins inhabited by the Colorado pikeminnow. In the Recovery Goals for the Colorado Pikeminnow (Service 2002a), criteria for downlisting and delisting the species are identified. In order to downlist the species, the San Juan River population of Colorado pikeminnow must reach at least 1,000 age 5+ fish. Given the baseline levels of mercury and selenium in the system as well as the amounts added to the system due to DREP, 72 percent of Colorado pikeminnow would experience reproductive impairment due to mercury levels in their diets. Of those that did successfully reproduce, 71 percent of their offspring would experience deformities that would lead to growth limitations, reproductive impairment, and/or death due to selenium. Due to these factors, it is extremely unlikely the Recovery Goals would be met and the survival and recovery of the Colorado pikeminnow in the wild would be significantly diminished.

In the Recovery Goals for the Razorback Sucker (Service 2002b), the San Juan River system is one of two that must show stable or increasing trends in order to achieve downlisting or delisting. According to our analysis, razorback suckers would not be affected by mercury in the system. However, given baseline levels of selenium in the system as well as the amounts added by DREP, 85 percent of their offspring would experience deformities that would lead to growth limitations, reproductive impairment, and/or death. Recovery of the San Juan River population of razorback sucker would not be achievable, significantly diminishing survival and recovery in the wild.

COLORADO PIKEMINNOW AND RAZORBACK SUCKER CRITICAL HABITAT

This draft BO does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat (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 Colorado pikeminnow critical habitat to determine whether the current proposal destroys or adversely modifies critical habitat for these species.

After reviewing the current status of the fish, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is our biological opinion that implementation of the DREP, as proposed, is likely to adversely modify critical habitat for the Colorado pikeminnow and razorback sucker. We reached this conclusion based on the following findings, the basis for which is presented in the preceding *Status of the Species and Critical Habitat, Environmental Baseline, Effects of the Action,* and *Cumulative Effects* sections of this document.

(1) The conservation role of Colorado pikeminnow and razorback sucker critical habitat is to provide spawning and rearing habitat conditions necessary for successful pikeminnow and sucker recruitment at levels that will provide for the conservation of the species. Appropriate water (PCE 1), physical habitat (PCE 2), biological environment (PCE 3) are essential for successful Colorado pikeminnow and razorback sucker spawning and survival.

(2) Past and present activities within the San Juan River basin have degraded these habitat elements to the extent that their co-occurrence at the appropriate places and times is insufficient to support successful Colorado pikeminnow and razorback sucker recruitment at levels that will provide for the species' conservation.

(3) Implementation of the proposed action is expected to exacerbate the very limited co-occurrence of PCEs at appropriate places and times by: (a) contaminating the water with mercury and selenium and (b) contaminating the food supply of the fish with mercury and selenium to the extent that both the water and the food supply would lead to the reproductive impairment of the species.

(4) On the basis of findings (1)-(3) above, the Service concludes that implementation of the proposed action is likely to prevent Colorado pikeminnow and razorback sucker critical habitat from serving its intended conservation role.

SOUTHWESTERN WILLOW FLYCATCHER

After reviewing the current status of the flycatcher, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is our biological opinion that implementation of the DREP, as proposed, is not likely to jeopardize the continued existence of the southwestern willow flycatcher. Flycatchers have not been found to occur in the San Juan River basin to date, and any adverse effects would be to future flycatchers that inhabit that action area. We have already concurred that the action is not likely to adversely affect critical habitat in the Rio Grande.

We find that implementation of the proposed action is not expected to result in high levels of flycatcher mortality in the future. Since the project proposes continued surveys of the San Juan River basin for flycatchers, the Service will be able to monitor presence of the species in the action area as habitat increases. Due to the absence of flycatchers in the San Juan River basin at this time, the Service concludes that the DREP would not be likely jeopardize the continued existence of the southwestern willow flycatcher.

MANCOS MILKVETCH

After reviewing the current status of the Mancos milkvetch, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is our biological opinion that implementation of the DREP, as proposed, is not likely to jeopardize the continued existence of the Mancos milkvetch. No critical habitat has been designated for the species; therefore, none will be affected.

We find that the implementation of the proposed action is not expected to result in high levels of milkvetch mortality, especially with implementation of the conservation measures to limit adverse effects. Only approximately one acre of suitable unoccupied habitat could be affected ground-disturbing activities associated with the proposed project, and the minor increases in atmospheric levels of heavy metals would have an unknown effect on the species. Due to the absence of data on the effects of heavy metals on the species, the Service concludes that the DREP would not be likely to jeopardize the continued existence of Mancos milkvetch.

MESA VERDE CACTUS

After reviewing the current status of the Mesa Verde cactus, 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 implementation of the DREP, 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 find that the implementation of the proposed action is not expected to result in high levels of cactus mortality, especially with implementation of the conservation measures to limit adverse effects. The range of Mesa Verde cactus is within remote areas that have not been thoroughly surveyed. The plant is sporadically distributed within its suitable habitat with the total number of plants probably exceeding 10,000 (Service 1984). For the most part, Federal agencies have been able to effectively conserve Mesa Verde cactus by making only minor modifications in project plans or by carefully executing project activities to avoid plants that might otherwise have been damaged or destroyed. Because Mesa Verde cactus is almost completely on either Indian lands or Federal lands managed by 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. The Service concludes that the potential loss of up to 100 Mesa Verde cactus plants from the proposed DREP would not be likely to jeopardize the continued existence of the species. In addition, even these losses can be greatly reduced with implementation of the conservation recommendations given below.

Reasonable and Prudent Alternative

This space is intentionally left blank for the following reasons:

1. The Service cannot at this time formulate an RPA to the proposed action that can be implemented in a manner consistent with the intended purpose of the action, will be consistent with the scope of the action agencies' legal authority and jurisdiction, and is economically and technologically feasible.

2. The Service and the action agencies are working together to formulate an RPA that the action agencies can accept.

Should the Service and the action agencies agree upon an RPA it will be inserted in future drafts of this BO. If the Service and the action agencies determine that no RPA is available, future drafts will indicate this fact and provide an explanation.

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.

The measures described below are non-discretionary and must be undertaken by BIA 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. BIA has a continuing duty to regulate the activity covered by this incidental take statement. If BIA (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, BIA 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

Colorado pikeminnow and razorback sucker
Take for the Colorado pikeminnow and razorback sucker cannot be determined until and unless an RPA is developed and agreed to by all parties.

Southwestern willow flycatcher
The Service has developed the following incidental take statement based on the premise that the DREP will be implemented as proposed. The Service does not anticipate that the proposed action will incidentally take any flycatchers. The Service has determined that there is no anticipated take because there are currently no known flycatcher territories present within the San Juan River basin. The conservation measures in the BA, including habitat restoration and monitoring will be implemented to minimize effects to the flycatcher.

Mesa Verde cactus and Mancos milkvetch
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

The effect of the take on Colorado pikeminnow and razorback sucker will be calculated once it is determined if an RPA is feasible.

Reasonable and Prudent Measures

Reasonable and prudent measures will be crafted once it is determined if an RPA is feasible.

Terms and Conditions

Terms and conditions will be crafted once it is determined if an RPA is feasible.

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:

- Any collection of Mesa Verde cacti within the action area should be reported to the Service.
- Populations of Mesa Verde cactus in Colorado on the Ute Mountain Ute Reservation should be surveyed.
- We recommend that BIA participate in the development, approval, and management of the Mesa Verde Cactus Conservation Areas.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, we request 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 BIA 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 DREP. 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.

In future communications regarding this project please refer to consultation number 22420-2005-F-117. 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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