United States Department of the Interior

FISH AND WILDLIFE SERVICE
New Mexico Ecological Services Field Office
2105 Osuna NE
Albuquerque, New Mexico 87113
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SUMMARY
BIOLOGICAL OPINION ON
THE ALBUQUEQUE MS4 STORMWATER PERMIT

Cons. # 22420-2011-F-0024

Date of the biological opinion: September 29, 2011

Action agency: Environmental Protection Agency (EPA) NPDES Permit No. NMS000101.

Project: Discharge of pollutants in stormwater and certain nonstormwater discharges from the Large Municipal Stormwater Sewer Systems (MS4) in the Albuquerque urbanized area in Bernalillo County, New Mexico.

Species and critical habitat affected:

Endangered Rio Grande silvery minnow (*Hybognathus amarus*) and its critical habitat
Endangered southwestern willow flycatcher (*Empidonax traillii extimus*) and its critical habitat

The EPA determined that the Project "may affect, but is not likely to adversely affect nor likely to destroy or adversely modify the designated critical habitat" of the southwestern willow flycatcher. We concur with this determination based on the lack of flycatcher nesting in the action area and low risk to critical habitat.

Biological Opinion: The action, is neither likely to jeopardize the continued existence of the Rio Grande silvery minnow, nor likely to destroy or adversely modify its designated critical habitat.

Incidental take statement: The Service anticipates that take in the form of harassment of up to 10,548 silvery minnows and harm through suffocation mortality of up to 1,528 silvery minnows.

Reasonable and Prudent Measures

1. Implement remedial action on the North Diversion Channel Embayment to significantly reduce the likelihood and magnitude of low dissolved oxygen (DO) discharges into silvery minnow habitat in the Middle Rio Grande.

2. Monitor DO and temperature in the water column in the Embayment and Rio Grande to determine the effectiveness of the remedial action.

Terms and Conditions

RPM 1 1. Ensure that the remedial action selected for the North Diversion Channel Embayment is completed within 1.5 years of the Albuquerque MS4 permit effective date.

RPM 2 1. Ensure that continuous monitoring of DO and temperature in the Embayment and at one location in the Rio Grande downstream of the North Diversion Channel outfall

within the action area (e.g., Rio Bravo Bridge) to verify the remedial action is successful for the duration of the permit.

2. Ensure that all data and information necessary to complete Table 1 (Biological Opinion page 76) for all qualifying storm events are provided to the Service. The information on qualifying storm events to be provided includes: date of any qualifying stormwater events, DO value in Embayment, DO value at downstream monitoring station, flow rate in the North Diversion Channel, daily flow rate in the Rio Grande, and sum of silvery minnows taken.
3. Ensure that annual reports cite or describe all standard operating procedures, quality assurance plans, maintenance, and implementation schedules to assure that timely and accurate water temperature, dissolved oxygen, oxygen saturation, and flow data are collected and reported.
4. Ensure that the Service receives electronic copies of all incidental take, interim, and annual reports described in the Albuquerque MS4 permit no later than March 31 for the preceding calendar year ending December 31. These should be sent to the email address nmesfo@fws.gov or by mail to the New Mexico Ecological Services Field Office, 2105 Osuna Road NE, Albuquerque, New Mexico 87113.
5. EPA, Applicants, and the Service will meet annually (via teleconference) during the permit period to review the remedial action progress, information gathered, and incidental take estimates associated with qualifying storm events.

Conservation Recommendations: We recommend the following conservation recommendations be implemented.

1. Identify suspended solid and sediment sources and transport pathways in the storm runoff events from urban area basins.
2. Encourage the simultaneous or replacement of methods to determine total suspended solids with the more accurate methods to determine suspended sediment concentration (SSC).
3. Identify pollutant concentrations on SSC and develop best management practices (BMPs) to reduce SSC containing pollutants effects on silvery minnow habitat.
4. Estimate carbonaceous oxygen demand, sediment oxygen demand, SSC and ammonia concentrations associated with stormwater and their relationship to low DO events in the Rio Grande and potential effects to silvery minnow.
5. Improve mixing model accuracy of stormwater runoff and its effects on DO concentrations in the Middle Rio Grande.
6. Identify the chronic effects or avoidance of low DO concentrations to silvery minnow under a range of water temperatures from 5 to 35 °C (41 to 95 °F).
7. Amend the Stormwater Management Program to include PCB monitoring (according to methods recommended by the New Mexico Environmental Department (2010) within the North Diversion Channel outfall, San Jose Drain outfall, and the Middle Rio Grande both upstream and downstream of the Albuquerque urban area.
8. Measure polychlorinated biphenyl chemicals (PCBs) in insect prey of the flycatcher, conduct PCB accumulation studies on the flycatcher or a surrogate, including collection of addled flycatcher eggs by the permittee through Service's issuance of ESA 10(A)1(a) permits and then analyze them for PCBs and other pollutants.
9. Implement recovery actions identified in the flycatcher and silvery minnow recovery plans.
10. Encourage volunteers, educators and classrooms to "adopt-a-watershed" for the stormwater basins that their schools reside in.

Table of Contents

Southwestern Willow Flycatcher 2

Consultation History 3

BIOLOGICAL OPINION 6

I. DESCRIPTION OF THE PROPOSED ACTION 6

Albuquerque MS4 Permit Area and Facilities 6
Stormwater Pollutants and their Controls under the Albuquerque MS4 permit 7
Stormwater Quality Monitoring 10
Potential Remedial Action to North Diversion Channel Low DO Condition 11

Action Area 11

II. STATUS OF THE SPECIES 12

Rio Grande Silvery Minnow 12
Description 12
Legal Status 13
Habitat 13
Designated Critical Habitat 14
Life History 15
Population Dynamics 16
Distribution and Abundance 16
Middle Rio Grande Distribution Patterns 18
Reasons for Listing/Threats to Survival 19
Recovery Efforts 19
Silvery Minnow Propagation and Augmentation 20
Silvery Minnow Salvage and Relocation 21

III. ENVIRONMENTAL BASELINE 21

Status of the Species in the Action Area 21

Factors affecting the Species Environment within the Action Area 22

Changes in Hydrology 22
Loss of Water in Silvery Minnow Habitat 22
Changes to Magnitude and Duration of Peak Flows 24

Changes in Channel and Floodplain Morphology 25

Water Quality 25
Pesticides 26
Heavy Metals and other Stormwater Pollutants 27

Table of Contents (continued)

Sediment and Sediment Quality 27
PCBs 28
Dissolved Oxygen 29
Sediment Oxygen Demand 29

Floodplain Flooding 30

Petroleum Spills and PAHs 31

Other Stressors 32

Climate Change 32
Increased water temperature 34
Decreased streamflow 34
Change in the hydrograph 35
Increased occurrence in extreme events 35

Past Projects in the Middle Rio Grande including the Angostura Reach 36

Summary of the Environmental Baseline 38

IV. EFFECTS OF THE ACTION 38

Effects on Silvery Minnow 39

Effects on Silvery Minnow Designated Critical Habitat 43

V. CUMULATIVE EFFECTS 43

VI. CONCLUSION 45

INCIDENTAL TAKE STATEMENT 45

Amount or Extent of Take Anticipated 45

Effect of Take 48

Reasonable and Prudent Measures 48

Terms and Conditions 48

CONSERVATION RECOMMENDATIONS 49

REINITIATION NOTICE 50

LITERATURE CITED 52

List of Figures and Tables

Figure 1. Map of the Albuquerque MS4 Permit Area in Bernalillo County, New Mexico. 74

Figure 2. Location of the Pilot Canal Embayment in the North Diversion Channel at confluence of the Rio Grande in Albuquerque Bernalillo County, New Mexico. 75

Figure 3. Location of the Angostura Reach in the Middle Rio Grande. 76

Figure 4. Silvery Minnow Population Monitoring Data (1993-2010) based on October catch per unit effort (CPUE) (values are numbers of silvery minnow caught per 100 m2) (Dudley and Platania 2010). 77

Table 1. Incidental take of Rio Grande silvery minnow (RGSM) for stormwater events that equal or exceed cumulative discharge of 16,035 m^3 (13 af) through the North Diversion Channel (NDC) into Rio Grande by season. 78

Appendix A. Calculations of area impacted and number of silvery minnows affected were made in an Excel spreadsheet, Appendix A. DO mixing model_NDC_RG.xlsx. 82

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September 29, 2011

Cons. #22420-2011-F-0024

Claudia V. Hosch, Associate Director
Water Quality Division, NPDES Permits and TMDLs Branch
U.S. Environmental Protection Agency, Region VI,
1445 Ross Avenue, Suite 1200,
Dallas, Texas 75202-2733

Dear Ms. Hosch:

This letter transmits the U.S. Fish and Wildlife Service's (Service) biological opinion (BO) on the effects of the action described in the July 16, 2010, Biological Evaluation (BE) of the U.S. Environmental Protection Agency's (EPA) action authorizing the discharge of pollutants in stormwater and certain nonstormwater discharges from the Large Municipal Stormwater Sewer Systems (MS4) in the Albuquerque urbanized area in Bernalillo County, New Mexico (proposed action; Albuquerque MS4 permit) (EPA 2010a). The EPA's action is further described in the draft "Authorization to Discharge under the National Pollutant Discharge Elimination System (NPDES) for NPDES Permit No. NMS000101" (EPA 2010b) and accompanying Factsheet (EPA 2010c). The City of Albuquerque (City) Department of Municipal Development, Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA), New Mexico Department of Transportation District III (NMDOT), and University of New Mexico (UNM) Department of Safety, Health and Environmental Affairs are the Applicants.

The Albuquerque MS4 permit is applicable to all operators of large municipal storm sewer systems within the City's corporate boundary in Bernalillo County, New Mexico. The storm drainage system in the City is complex and consists of underground storm sewers and inlets, lined and unlined open channels, natural arroyos, detention basins and flood control dams and is primarily operated by the City and AMAFCA as well as the other Applicants. These stormwater conveyance systems intercept runoff from the nearby mountains and mesas, from the City's storm drainage network, and areas east and south of the City, and convey it to the Rio Grande. The action area is identified as occurring in the upper reaches of the Middle Rio Grande (EPA 2010b, page 4 of Part 1.B.1.c.).

The BO analyzes the effects of the proposed Albuquerque MS4 permit action on the endangered Rio Grande silvery minnow, *Hybognathus amarus* (silvery minnow), endangered southwestern willow flycatcher, *Empidonax traillii extimus* (flycatcher), and their designated critical habitats in the action area. Based upon information provided in the draft Albuquerque MS4 permit, the

BE, the remedy identified for low dissolved oxygen (DO) in the North Diversion Channel, the monitoring of the polychlorinated biphenyl chemicals (PCB) in stormwater, and other information, we expect that there will be interim adverse effects to the silvery minnow during the period in which the Albuquerque MS4 permit is fully implemented. It is the Service's opinion that the issuance of the Albuquerque MS4 permit is not likely to jeopardize the continued existence of the endangered silvery minnow. Working with the EPA and the Applicants, we have provided reasonable and prudent measures as well as terms and conditions necessary to minimize the incidental take of silvery minnow associated with the stormwater permit action.

The EPA's request for formal consultation, in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 United States Code [USC] 1531 et seq.; ESA), was received on July 16, 2010, and was amended on December 15, 2010. A review of the consultation history associated with the proposed action is provided below. Additional information regarding effects to silvery minnow was received on March 9, 2011. This BO is based upon information submitted in the BE; conversations and communications among EPA, AMAFCA, U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (Corps) and the Service; and other sources of information available to the Service. A complete administrative record of this consultation is on file at the Service's New Mexico Ecological Services Field Office.

This BO does not rely on the regulatory definition of "destruction or adverse modification" of designated critical habitat at Title 50 Code of Federal Regulations (CFR) Section 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 versus U.S. Fish and Wildlife Service (CIV No. 03-35279) to complete the following analysis with respect to designated critical habitat. This consultation analyzes the effects of the action and its relationship to the function and conservation role of silvery minnow designated critical habitat to determine whether the current proposal destroys or adversely modifies designated critical habitat.

Southwestern Willow Flycatcher

The EPA has determined the proposed project "may affect, but is not likely to adversely affect," the flycatcher or its designated critical habitat. We concur with this determination based on the rationale below.

The flycatcher is a migrant through the Middle Rio Grande, and may be present from April through August. No flycatcher breeding habitat or occupied nest territories are known to exist along the mainstem of the Rio Grande within the action area. The closest known breeding flycatchers in or adjacent to the action area (observed in 2008 and 2009) were located near La Joya, New Mexico, approximately 88 kilometers (km) (55 miles [mi]) downstream (SWCA 2010). Flycatchers nesting near Isleta, New Mexico, are off-channel and outside the action area. Given there are no known flycatcher nesting territories in the action area, we do not anticipate any breeding flycatchers would occur, and be exposed to the potential contaminants, such as PCBs, in the stormwater discharged under the proposed action. Should flycatchers be reported to nest in the action area, the EPA should review this new information and if effects are likely, reinitiate consultation with the Service.

The action area occurs in the Rio Grande below the discharges authorized by the Albuquerque MS4 permit and within designated critical habitat for the flycatcher. However, we do not anticipate the proposed action will result in adverse effects to the Primary Constituent Elements (PCEs) that comprise designated critical habitat (see 70 FR 60886; Service 2005a) because the abundance of their insect prey is not likely affected by PCBs (Mayer et al. 1977) even though bioaccumulation of PCBs in insects to elevated concentrations would be expected (Neigh et al. 2009). However, as the quality of insect prey is not a PCE, we do not expect the effects of the proposed action will appreciably alter the PCEs of flycatcher designated critical habitat in the action area. Since breeding flycatchers are not found in the action area where PCB contamination is expected, the anticipated effects to flycatcher from the proposed action are considered discountable.

Please contact the Service if: 1) surveys detect nesting flycatchers using a new breeding territory established within the action area (in the area of stormwater mixing in and adjacent to the Middle Rio Grande); 2) surveys detect listed, proposed or candidate species in habitats where they have not been previously observed; 3) the proposed action changes or new information reveals effects of the proposal to listed species that have not been considered in this analysis; or 4) a new species is listed or critical habitat designated that may be affected by the action. The remainder of this document addresses the effects of the proposed action on the silvery minnow and its designated critical habitat.

Consultation History

June 26-28, 2004. The USGS conducts toxicity testing of stormwater and sediment collected from the AMAFCA North Diversion Channel Pilot Canal Embayment (Embayment) (Buhl 2005). During these toxicity tests, an extensive fish kill was observed in the Embayment (Lusk 2004). The low oxygen concentration in the stormwater was a major cause of the observed mortality of silvery minnow in the laboratory toxicity tests and of the native fish (Buhl 2005). The Service informs EPA of the fish kill, observed toxicity, and low DO condition by email and telephone.

June 30, 2004. After review of draft reports by the New Mexico Environmental Department (NMED) on PCBs in the action area, the Service informs the EPA by email of the PCB contamination reported in stormwater collected from the San Jose Drain that is part of the Albuquerque MS4 permit.

November 29, 2006. The Service provides a presentation to the Applicants, EPA, and the public on how to conduct an Endangered Species Act consultation, examples of how stormwater can affect endangered species in the major river drainages in New Mexico, and recommendations for conserving endangered species while implementing stormwater best management practices (BMPs) (Service 2006a).

June 1, 2007. The Service provides a letter informing the EPA that formal consultation is required on the Albuquerque MS4 permit based on new information that revealed stormwater may adversely affect federally listed species.

May 5, 2008. A Service-sponsored study conducted by UNM provides information that identifies low DO concentrations in the Rio Grande that are linked with stormwater discharges from the North Diversion Channel (Van Horn 2008).

August 5, 2009. AMAFCA provides report that reviewed DO concentrations in the North Diversion Channel upstream, in the Embayment and in the Rio Grande nearby (Daniel B. Stevens and Associates, Inc. (DBS&A) (2009). This report identified that as long as the Embayment remains in place, oxygen-depleted water from the Embayment will continue to cause short-term decreases in oxygen concentrations in the Rio Grande and recommended possible solutions to the problem.

August 14, 2009. The EPA provides the Service a revised BE finding that the proposed action will not adversely affect the silvery minnow.

September 1, 2009. The Service sent EPA a letter indicating that we did not concur with the "may affect, but is not likely to adversely affect" determination for the silvery minnow, and the BE did not include adequate information to begin formal consultation.

March 22, 2010. The Service sent a letter to EPA stating that due to other EPA consultation priorities, we were unable to consult on any stormwater permits during the remainder of fiscal year 2010.

July 16, 2010. The EPA provides the Service a revised BE and letter affirming that issuance of the Albuquerque MS4 permit "may affect, but is not likely to adversely affect" the flycatcher, silvery minnow, or their designated critical habitat.

September 9 to October 15, 2010. The EPA and the Service exchange information about the Albuquerque MS4 permit and potential effects to the flycatcher and silvery minnow.

October 22–27, 2010. The EPA and Service discuss the potential for interim adverse effects to endangered species through issuance of the Albuquerque MS4 permit, and discuss the need to proceed with a formal consultation.

December 15, 2010. The EPA requests formal consultation on the Albuquerque MS4 permit.

December 16, 2010. The EPA and Service discuss the Albuquerque MS4 permit, workload issues, and priorities for other stormwater permit consultations in New Mexico.

January 4, 2011. The Service requests a meeting with AMAFCA to obtain DO data, mixing calculations, and discharge statistics from the North Diversion Channel.

January 31, 2011. The Service informed EPA by letter that sufficient information for formal consultation was provided and started formal consultation.

March 7–9, 2011. The Service AMAFCA, EPA, and Corps discuss mixing zone size calculations and a potential remedy for the low DO conditions found in the North Diversion Channel.

March 9, 2011. AMAFCA provides information on the DO concentrations in the North Diversion Channel and the Middle Rio Grande upstream.

March 24, 2011. The Corps provides information on a proposed fill project by AMAFCA to remedy the low DO events in the North Diversion Channel.

April 28, 2011. The Service requests of EPA a two-week extension for preparing the draft BO.

May 18, 2011. The Service provides a draft BO to EPA for review. The Service also provided a copy of the draft BO to the Pueblo of Sandia, Pueblo of Isleta, and Bureau of Indian Affairs (BIA) for review pursuant to our obligations in Secretarial Order 3206 (U.S. Department of the Interior 1997).

June 21, 2011. The Service, EPA, and Applicants (City and AMAFCA) met to discuss written and oral comments provided by the City, AMAFCA, and EPA on the draft BO.

June 29, 2011. The Service requests concurrence from Pueblo of Sandia and Pueblo of Isleta on the draft BO.

July 5, 2011. The Service requests additional time from EPA to obtain concurrence from Pueblo of Sandia for the BO. Pueblo of Isleta concurs with BO.

July 19, 2011. The Service sends to EPA a draft final BO with a response to written comments.

July 29, 2011. Pueblo of Sandia concurs with BO subject to monitoring throughout permit.

August 9, 2011. EPA provides comments on the draft final BO to the Service.

BIOLOGICAL OPINION

I. DESCRIPTION OF THE PROPOSED ACTION

Albuquerque MS4 Permit Area and Facilities

The proposed action is the EPA's authorization of the Albuquerque MS4 permit (NPDES No. NMS000101) for a term of 5 years. The EPA issues this Albuquerque MS4 permit under the authority of the Clean Water Act (CWA), as amended (33 USC26 1251–1387). The regulatory definition of an MS4 is provided in 40 CFR 122.26 (b)(4) and (b)(7). The Albuquerque MS4 permit is applicable to the operators of large and medium municipal stormwater sewer systems within the City's current corporate boundary in Bernalillo County, New Mexico.

The Albuquerque municipal stormwater sewer system is primarily operated by the City and AMAFCA (Figure 1; http://12.23.244.78/amafcapublic/. Accessed April 27, 2011). UNM operate several storm sewer systems on each of its three college campuses. The NMDOT owns, operates, and maintains the storm sewer system that conveys runoff from roads and right-of-ways along the highways and roads within the City. However, small MS4s in the remainder of Bernalillo County (NPDES Permit No. NMR040000), as well as agricultural drainages, are not included in the proposed action.

Precipitation falls onto the mountains and mesas, and areas east and south of the City, and the runoff is collected by the Applicants' stormwater sewer systems and conveyed to the Rio Grande. The City's stormwater sewer system is vast and complex and contains approximately 1,161 kilometers (km) (722 miles [mi]) of storm pipes, 53 km (33 mi) of lined channels, 29 km (18 mi) of unlined arroyos, 12,300 storm manholes, and 16,100 storm inlets. Some of the major arroyo channels including Bear Canyon, Hahn, Embudo, Piedra Lisa, Calabacillas, Ladera, La Cueva and San Antonio Arroyos. In its entirety, the Albuquerque stormwater sewer system is comprised of a immense series of conveyance structures including streets, highway and road drainages, curbs, gutters, ditches and man-made channels, underground storm sewers, pipes and inlets, man-hole covers, lined and unlined open channels, natural arroyos, detention basins and flood control dams, and a variety of other physical locations that interconnect these structures and convey stormwater to channels and then to the Rio Grande. These stormwater sewer systems are often delineated by the large collection basins that include a single collection channel that connects to the Rio Grande, for example the North Diversion Channel, South Diversion Channel, and San Jose Drain basins, to name a few (Figure 1).

The North Diversion Channel drains the largest basin in the stormwater sewer system, approximately 238 square kilometers (km^2) (92 square miles [mi^2]) (of which 142 km^2 (55 mi^2) is in the Albuquerque MS4 permit area (Figure 1). The basin extends on the east side of the City, from the Sandia Pueblo on the north, to Gibson Boulevard on the south, and from Interstate 25 on the west to the Sandia Mountain foothills on the east (SWCA 2004). The channel is concrete lined, except for 0.8 km (0.5 mi) from the outfall where it is a wide, unlined area with a combination of upland, riparian, and wetland vegetation (SWCA 2004; Figure 2). The North Diversion Channel drains onto Pueblo of Sandia lands and finally into the Rio Grande. At the

end of the North Diversion Channel is the Pilot Canal Embayment (the area between an earthen retaining feature and the Rio Grande) (Figure 2).

Stormwater Pollutants and their Controls under the Albuquerque MS4 permit

According to EPA (2010d) and the City of Albuquerque et al. (2010), stormwater discharges from urbanized areas are a concern because of the higher concentration of pollutants typically found in these discharges. Polluted stormwater runoff generally happens anywhere people use or alter the land. Some common examples include excessive fertilization, excessive pesticide use, littering, not picking up pet waste, using salt or other compounds to deice the driveway and letting oil drip out of vehicles. In developed areas, the water that falls on hard surfaces like roofs, driveways, parking lots or roads cannot seep into the ground. These impermeable surfaces create large amounts of runoff that can easily pick up debris, pollutants including sediment and wash them into nearby storm drains and downstream to the Rio Grande. Sediment conveyed during stormwater runoff can cloud the water and make it difficult or impossible for aquatic plants to grow by reducing light penetration. In most cases, stormwater is either not treated at all or is not treated enough before it enters the Rio Grande.

According to Hoover (2010), the 2.4×10^7 cubic meters (m^3) (6.4 billion gallons) of stormwater are discharged annually from the Albuquerque MS4 Permit Area (and other small stormwater dischargers in Bernalillo County, New Mexico). The average total suspended solids concentration of this stormwater is 640 milligrams per liter (mg/L) and when multiplied by discharge volume is approximately 1.5×10^6 kilograms (kg) per year (3.4×10^6 pounds per year) of sediment and other solids to the Rio Grande. Stormwater pollutants that are commonly found in stormwater discharges include petroleum hydrocarbons (from oil spills, parking lot runoff, illicit dumping, roadways, atmospheric deposition); the metals aluminum, cadmium, lead, nickel, copper, chromium, mercury, and zinc; nutrient runoff (phosphates, nitrogen compounds, potassium, trace elements); pesticide runoff (herbicides, insecticides, fungicides, etc.); solid waste; velocity and erosion; sediment, salts and toxic chemicals such as PCBs and other controlled substances, industrial solvents, and petroleum products (Kelly and Romero 2003; Kelly et al. 2006; EPA 2002, 2010a, 2010b; NMED 2010).

The proposed action authorizes stormwater discharges and its pollutants conveyed to waters of the United States from all outfalls owned or operated by the Applicants. The Albuquerque MS4 permit authorizes the flow velocity of the stormwater, the temperature of the water, the placement of the outfalls of discharge, and the quality of water through those outfalls. The Albuquerque MS4 permit also authorizes certain nonstormwater discharges such as potable waters from line flushing, lawn and landscape irrigation waters, rising groundwaters, air conditioning condensates, residential or charity car washes, wetland flows, flows from fire fighting activities, and other similar occasional incidental discharges unless determined by the Applicants, EPA, or the NMED to be significant contributors of pollutants (EPA 2010b).

The Albuquerque MS4 permit also identifies requirements necessary to minimize pollutants in the stormwater discharges. For example, the Albuquerque MS4 permit requires that the Applicants implement a comprehensive Stormwater Management Program (SWMP) including pollution prevention measures, treatment or removal techniques, stormwater monitoring, use of

legal authority, and other appropriate means (i.e., BMPs) to control the pollutants in stormwater discharged from the MS4 to the maximum extent practicable. These BMPs include:

- Identifying major outfalls and pollutant loadings.
- Detecting and eliminating nonstormwater discharges to the system.
- Reducing pollutants in runoff from industrial, commercial, and residential areas.
- Controlling stormwater discharges from new development and redevelopment areas.

The draft Albuquerque MS4 permit requires implementation of BMPs to ensure that discharges do not cause or contribute to exceedances of State of New Mexico or Tribal water quality standards (including numeric and narrative water quality criteria). In determining whether the SWMP is effective at meeting this requirement, the Applicants consider the most recent available stormwater quality monitoring data, a visual assessment, or any site inspection reports. Of these, the ambient stormwater quality monitoring data is most critical to identify the efficacy of BMPs for treating stormwater that may contain potentially toxic chemicals (e.g., pesticides, heavy metals, nutrients, PCBs) or other pollutants (e.g., oxygen demanding substances, suspended sediment concentrations). In the event that EPA receives Discharge Monitoring Reports (DMR) from the Applicants (or other credible scientific information) identifying discharge(s) that cause or contribute to an exceedance of water quality standards, the EPA will notify the Applicant of such an exceedance, and the Applicant shall (within 60 days of notification) submit to the EPA, NMED, Pueblo of Isleta, and Pueblo of Sandia, a report that describes controls that are currently being implemented, additional controls that will be implemented to sufficiently prevent pollutants, and ensure that the discharge will no longer cause or contribute to an exceedance of any applicable water quality standards.

Most important to the Service, the draft Albuquerque MS4 permit (EPA 2010b) seeks to addresses the concerns raised by various individuals and agencies (Lusk 2004; Yanick 2006; Service 2007a; Van Horn 2008; NMED 2010) regarding low DO and PCBs discharges from the North Diversion Channel, and PCBs in the San Jose Drain. The Albuquerque MS4 permit (EPA 2010b, Table III, page 11 of Part VI) describes the compliance with water quality standards requirement for DO. According to the draft Albuquerque MS4 draft permit (EPA 2010b, page 11 of Part V, Table III), the Applicants shall take measures to address concerns regarding discharges to receiving waters of the Rio Grande, including modifications to the North Diversion Channel, by developing and implementing a strategy to eliminate conditions that cause or contribute to low DO in the Rio Grande. In Table III, Activity A, the requirements are referred to part I.C.1.d. (EPA 2010b, page 4 of Part I) where the Applicants are required to develop and implement a strategy to eliminate the conditions that cause or contribute to exceedance of water quality standards for DO within 6 months, and provide annual reports on this activity as described in Part VI, Table III. The Service has interpreted this Albuquerque MS4 permit requirement as achieving no exceedances of water quality standards for DO within 1.5 years from the permit's effective date.

The Albuquerque MS4 permit also seeks to address PCBs in discharges from the San Jose Drain and the North Diversion Channel. The Applicants are required to identify and evaluate controllable sources of PCBs in these two drainage basins within 3 months of the effective date; to design and implement a monitoring study to evaluate presence and magnitude of PCB levels

in stormwater discharges in both drainage basins within 6 months; eliminate controllable sources of PCBs that cause or contribute to exceedances of State or Tribal water quality standards in waters of the United States within 1 year in the Annual Report; and report annually on all PCB-related activities. The Service has interpreted this Albuquerque MS4 permit requirement as achieving no exceedances of water quality standards for PCBs within 5 years from the effective date (unless evaluation and control activities of PCB discharges within these two drainages go beyond the 5-year term).

Additionally, the EPA provides for the protection of threatened and endangered species by annual acute toxicity monitoring. The Applicants shall conduct monitoring to collect samples from the North Diversion Channel, and test that stormwater for its acute toxic effects on the fathead minnow (*Pimephales promelas*) and water flea (*Daphnia pulex*). The monitoring strategy includes monitoring of one storm event per year, at a minimum, with compliance determined by toxicity defined as the lethal concentrations to 50 percent of the test population is less than exposure to 100 percent effluent during a 24-hour (hr) acute toxicity test. If toxicity is found, it must be reported to the EPA along with attempts to identify and reduce the toxicity. The EPA determines what actions will be taken if toxicity is reported.

The Albuquerque MS4 permit requires a variety of activities that affect the quality of stormwater discharges including:

- Implementation of measures necessary to bring stormwater discharges into compliance with the Middle Rio Grande Total Maximum Daily Load for bacteria.
- Addition of control measures of construction site stormwater runoff.
- Addition of post-construction stormwater management in planned development and redeveloped areas.
- Addition of pollution prevention requirements and procedures to ensure that new flood management projects are assessed for impacts on water quality.
- Addition of procedures to ensure existing flood management projects are reassessed for incorporation of additional water quality protection devices or practices.
- Addition of procedures to control the discharge of pollutants related to the storage and application of pesticides, herbicides, and fertilizers applied, to public right-of-ways, parks, and other municipal property; and to commercial application and distribution of pesticides, herbicides, and fertilizers where Applicants hold jurisdiction over the landscape.
- Addition of requirements to identify and control pollutants in stormwater discharges from municipal landfills; other treatment, storage, or disposal facilities for municipal waste (e.g., transfer stations, incinerators, etc.); hazardous waste treatment, storage, disposal and recovery facilities; and any other industrial or commercial discharges that the Applicants determines are contributing a substantial pollutant loading to the MS4.
- Addition of a requirement that the Applicants implement and enforce an Illicit Discharge Detection and Elimination program to systematically detect and eliminate illicit discharges entering the MS4, and to implement defined procedures to prevent illicit connections and illegal dumping into the MS4.

- Requires control of floatables (e.g., litter and other human-generated solid waste) that describes controls and, where necessary, includes structural controls.
- Requires waste collection programs to collect used motor vehicle fluids (at a minimum, oil and antifreeze), and to collect household hazardous waste materials (including paint, solvents, fertilizers, pesticides, herbicides, and other hazardous materials) for recycle, reuse, or proper disposal.
- Requires spill prevention planning and spill response to prevent, contain, and respond to spills that may discharge into the MS4.
- Requires public education and outreach on stormwater impacts and an assessment of the overall success of the program, including such activities that:
  - increases public awareness about the causes and effects of stormwater pollution;
  - identifies actions that citizens, commercial, industrial, and institutional entities may take to control the impact of stormwater pollution on water quality;
  - promotes, publicize, and facilitates the various elements of the SWMP through varied public education and outreach methods including public websites;
  - disseminates information to the general public regarding the proper handling, disposal and recycling of used motor vehicle fluids, household hazardous waste, grass clippings, car wash waters, and proper use of fertilizers, pesticides, and herbicides, and oil and toxics used on roadways, including information on the steps to report illicit discharges, or improper disposal of materials;
  - educates pet owners about proper disposal of pet waste; and
  - educates owners and operators of commercial, industrial, and institutional facilities regarding their responsibility to control pollutants in stormwater discharges from their property to the MS4.

The Albuquerque MS4 permit conditions reduce some of the pollutants in stormwater (except those pollutants described below) such that they are not likely to adversely affect silvery minnow. In summary, the EPA (2010c) describes the Albuquerque MS4 permit as an improvement over their previously issued permit with additional conditions that address concerns about PCBs, low DO, and other stormwater water quality issues including bacteria, heavy metals, and temperature (EPA 2010c). Additionally, the Applicants are likely to improve stormwater quality as it contributes to the surface water collected for the City's drinking water source diverted downstream of the North Diversion Channel outfall (Langman 2007; Hoover 2010).

Stormwater Quality Monitoring

The City, AMAFCA, and USGS began collecting and analyzing stormwater resources in the Albuquerque area in 1976 (Kelly and Romero 2003). Beginning in 1994 the USGS sampling program has been included as part of an urban stormwater monitoring program (Kelly and Romero 2003). Currently there are five discharge outfalls monitored for the Albuquerque MS4 permit and they provide data on the quality of stormwater discharges from the Albuquerque MS4 permit area. Parameters analyzed include priority pollutants, conventional, nonconventional, organic toxics, and other pollutants. Conventional pollutants and metals are reported annually while monitoring for the other parameters was performed biannually (Kelly et al. 2006).

Potential Remedial Action to North Diversion Channel Low DO Condition

The AMAFCA (DBS&A 2009) has identified the water standing in the Embayment, a large 427 meters (m) by 122 m (1,400 feet [ft] long by 400 ft) wide (5.2 hectares [ha] [12.8 acres]) lake-like feature within the North Diversion Channel between the earthen retaining feature and the Rio Grande (Figure 2) as contributing to the low DO condition. This is based on data that shows stormwater that passes a USGS gage station (08329900, North Floodway near Alameda) prior to entering the Embayment, contains adequate DO (5 to 10 mg/L) (DBS&A 2009). When the stormwater stands in the Embayment (i.e., flow stops) it quickly becomes stagnant, and contains little to no DO (less than 0.1 mg/L) (DBS&A 2009). Simple mixing calculations demonstrated that the volume and low DO concentrations of Embayment water were sufficient to cause decreases in DO of the Rio Grande downstream. When the stagnant water in the Embayment is pushed by stormwater runoff conveyed through the North Diversion Channel into the Rio Grande, it is sufficient to decrease the DO content of the Rio Grande as far as 33 km (20 mi) downstream (Van Horn 2008; DBS&A 2009). DBS&A (2009) identified that as long as the Embayment remains in place, oxygen-depleted water will continue to cause short-term decreases in oxygen concentrations in the Rio Grande. They identified three possible solutions to the low DO problem including aeration, mixing the Rio Grande with the water in the Embayment, or removing the Embayment by filling (DBS&A 2009). AMAFCA has proposed to partially fill and reshape the Embayment with up to 42 m^3 (76,650 cubic yards) of earthen fill (Paulsgrove 2011) to allow stormwater to flow over the earthen fill in a modified channel configuration and mix more immediately with the Rio Grande. Therefore, the remedial action would be designed such that stormwater would not become stagnant in the Embayment. However, the Service remains concerned that elevated chemical oxygen demand (COD) in stormwater is contributing to the low DO concentrations in water of the Embayment, or in any other standing water in the North Diversion Channel such as the sediment settling basin. Therefore, DO monitoring in the Embayment and Rio Grande after completion of the remedial action is warranted for the duration of the permit to demonstrate the remedial action was successful.

Action Area

This BO uses the term “Middle Rio Grande” to refer to the river channel and its floodplain (within the levees) in the Rio Grande-Albuquerque Watershed (USGS Hydrologic Cataloging Unit 13020203; Seaber et al. 1987) in central New Mexico. The Middle Rio Grande is often divided into river reaches identified by an upstream diversion dam (Figure 3). Therefore, we refer to the Angostura Reach as that portion of the Middle Rio Grande between the Angostura and Isleta Diversion Dams.

The action area includes all areas to be affected directly or indirectly by the proposed action (50 CFR 402.02). The action area includes the MS4, the stormwater discharges, and their mixing zones within in the Middle Rio Grande. EPA (2010b) generally describes discharges from the Albuquerque MS4 permit area as flowing downstream into waters of the Pueblo of Sandia and the Pueblo of Isleta. Therefore, the action area is defined as the entire width of the 100-year floodplain of the Rio Grande from the outfall of the North Diversion Channel with the Rio Grande including any areas of mixing. Exact mixing zone size was not described by EPA.

For the purposes of this BO, we further divided the action area into an impact area and a lethal zone using the rationale described below. Langman (2007) identified traveltimes of Rio Grande streamflow from the North Diversion Channel input to locations downstream. The traveltime curves can be used to describe the time and distance that pulse inputs (such as stormwater runoff) from the North Diversion Channel can travel down the Middle Rio Grande. Pulse event traveltimes in the Rio Grande measured at the Albuquerque Gage ranged from 13 to 25 hr, and would travel from less than 40 km (25 mi) to 80 km (50 mi) respectively (Langman 2007). However, Langman (2007) evaluated pulse events ranging in duration from 1 to 11 days, whereas stormwater runoff events from the North Diversion Channel associated with low DO are of short duration (usually less than 1 hr) (DBS&A 2009). In addition, Langman (2007) provided no indication of concentrations within a potential plume, only how long it might take a plume to travel. Pulse events are likely to disperse from streamflow interaction with the bed, banks, and broader channel in the Rio Grande near the City because of available in-channel area for braiding, meandering, filling, which create longer flow paths and increase dispersion because of larger wetted perimeters that increase interaction with the channel substrate (Langman 2007).

In the Angostura Reach, the City's Southside Water Reclamation Plant (SWRP) and tributary inputs provide dilution water. In addition, changes in flow occur at the Isleta Diversion Dam that affect plume dispersion in the Rio Grande. As a check to determine if this mixing zone size was appropriate, we compared these data to Van Horn (2008) who identified stormwater from the North Diversion Channel mixing with the Rio Grande approximately 33 km (20 mi) downstream, and that increased approximately 3 mg/L in that distance. However, as the impact area associated with low DO pulse events from the North Diversion Channel is likely dispersed within 50 km (31 mi), and the size of the mixing zone is concordant with estimates by Van Horn (2008) and Langman (2007), this BO will analyze the effects of the low DO events within the mixing zone as it occurs in the 50 km (31 mi) Angostura Reach of the Middle Rio Grande (Figure 3).

II. STATUS OF THE SPECIES

The proposed action considered in this BO may affect the silvery minnow provided protection as an endangered species under the ESA. In addition, the action area overlaps designated critical habitat for the silvery minnow. A description of this species, its status, and designated critical habitat are provided below and inform the effects analysis.

Rio Grande Silvery Minnow

Description

The silvery minnow currently occupies a 275-km (170-mi) reach of the Middle Rio Grande, New Mexico, from Cochiti Dam in Sandoval County, to the headwaters of Elephant Butte Reservoir in Socorro County (Service 1994). The silvery minnow was also introduced into the Rio Grande near Big Bend, Texas, in December 2008 as an experimental, nonessential population under section 10(j) of the ESA. The silvery minnow is a stout minnow, with a small, subterminal mouth, with long pharyngeal dentition with a distinct grinding surface and a pointed snout that projects beyond the upper lip (Sublette et al. 1990). The back and upper sides of the silvery

minnow are silvery to olive, the broad middorsal stripe is greenish, and the lower sides and abdomen are silver. Maximum total length attained in New Mexico specimens is about 90 millimeters (mm) (3.5 inches [in]) (Sublette et al. 1990). Sexual differences are generally not observed except during spawning when the body cavity of ripe females is expanded with eggs (Bestgen and Propst 1994).

In the past, the silvery minnow was included with other species in the genus *Hybognathus* due to morphological similarities. Phenetic and phylogenetic analyses corroborate the hypothesis that it is a distinct valid taxon, and separate from other species of *Hybognathus* (Cook et al. 1992; Bestgen and Propst 1994). It is now recognized as one of seven species in the genus *Hybognathus* in the United States and was formerly one of the most widespread and abundant minnow species in the Rio Grande basin of New Mexico, Texas, and Mexico (Pflieger 1980; Bestgen and Platania 1991). Currently, *Hybognathus amarus* is the only remaining endemic pelagic spawning minnow in the Middle Rio Grande. The speckled chub (*Macrhybopsis aestivalis*), Rio Grande shiner (*Notropis jemezanus*), phantom shiner (*Notropis orca*), and bluntnose shiner (*Notropis simus simus*) are either extinct or have been extirpated from the Middle Rio Grande (Bestgen and Platania 1991).

Legal Status

The silvery minnow was federally listed as endangered under the ESA on July 20, 1994 (58 Federal Register [FR] 36988, see Service 1994). Primary reasons for listing the silvery minnow are described below in the *Reasons for Listing/Threats to Survival* section. The Service designated critical habitat for the silvery minnow on February 19, 2003 (68 FR 8088, Service 2003b). See description of designated critical habitat below. The species is also listed as an endangered species by the State of New Mexico.

Habitat

The silvery minnow travels in schools and tolerates a wide range of habitats (Sublette et al. 1990), yet generally prefers low velocity (less than 10 centimeters per second [cm/s] (0.33 feet per second [ft/s])) areas over silt or sand substrate associated with shallow (less than 40 cm [15.8 in]) braided runs, backwaters, or pools (Dudley and Platania 1997). Habitat for the silvery minnow includes stream margins, side channels, and off-channel pools where water velocities are low or reduced. Stream reaches dominated by straight, narrow, incised channels with rapid flows are not typically occupied by the silvery minnow (Sublette et al. 1990; Bestgen and Platania 1991). Adult silvery minnows are most commonly found in backwaters, pools, and habitats associated with debris piles; whereas, age-0 fish occupy shallow, low velocity backwaters with silt substrates (Dudley and Platania 1997). A study conducted between 1994 and 1996 characterized habitat availability and use at two sites in the Middle Rio Grande, one near Rio Rancho, New Mexico and the other near Socorro, New Mexico. From this study, Dudley and Platania (1997) reported that the silvery minnow was most commonly found in habitats with depths less than 50 cm (19.7 in). Over 85 percent were collected from low-velocity habitats (less than 10 cm/s [0.33 ft/s]) (Dudley and Platania 1997; Watts et al. 2002).

Designated Critical Habitat

The action area for this consultation occurs within designated critical habitat because the mixing zone may occur far downstream of the North Diversion Channel outfall in the Rio Grande (Van Horn 2008). The critical habitat designation extends approximately 252 km (157 mi) from Cochiti Dam in Sandoval County, New Mexico, downstream to the utility line crossing the Rio Grande, which is a permanent identified landmark in Socorro County, New Mexico. The Pueblos of Cochiti, Sandia, Santo Domingo, Santa Ana, and Isleta within the Middle Rio Grande are not included in the designated critical habitat because each Pueblo has management plans to protect the silvery minnow. The remaining portion of the silvery minnow's occupied range in the Middle Rio Grande is designated as critical habitat.

The critical habitat designation defines the lateral extent (width) as those areas including the Rio Grande and riparian zone bounded by existing levees or, in areas without levees, 91.4 m (300 ft) of riparian zone adjacent to each side of the bankfull stage of the Rio Grande. Some developed lands within the riparian zone are not considered designated critical habitat, as they do not contain the appropriate PCEs, and are therefore not essential to the conservation of the silvery minnow. Lands located within the lateral boundaries of the critical habitat designation, but not considered critical habitat include: developed flood control facilities, existing paved roads, bridges, parking lots, dikes, levees, diversion structures, railroad tracks, railroad trestles, water diversion and irrigation canals outside of natural stream channels, the Low Flow Conveyance Channel, active gravel pits, cultivated agricultural land, and residential, commercial, and industrial developments.

The Service determined the PCEs of silvery minnow designated critical habitat based on studies on silvery minnow habitat and population biology. These PCEs include:

1. a hydrologic regime that provides sufficient flowing water with low to moderate currents capable of forming and maintaining a diversity of aquatic habitats, such as, but not limited to the following: backwaters (a body of water connected to the main channel, but with no appreciable flow), shallow side channels (anabranches), pools (that portion of the river that is deep with relatively little velocity compared to the rest of the channel), and runs (flowing water in the river channel without obstructions) of varying depth and velocity, all of which are necessary for each of the particular silvery minnow life history stages in appropriate seasons (e.g., the silvery minnow requires habitat with sufficient peak flows from early spring (March) to early summer (June) to trigger spawning, flows in the summer (June) and fall (October) that do not increase prolonged periods of low or no flow, and relatively constant winter flow (November through February));
2. the presence of eddies created by debris piles, pools, or backwaters, or other refuge habitat within unimpounded stretches of flowing water of sufficient length (i.e., river miles) that provide a variation of habitats with a wide range of depth and velocities;
3. substrates of predominantly sand or silt; and
4. water of sufficient quality to maintain natural, daily, and seasonally variable water temperatures in the approximate range of greater than 1 degree Centigrade (°C) (35 degrees Fahrenheit [°F]) and less than 30 °C (85 °F) and reduce degraded conditions

(e.g., decreased DO, increased pH).

These PCEs provide for the physiological, behavioral, and ecological requirements essential to the conservation of the silvery minnow.

Life History

The species is a pelagic spawner and a female may produce as many as 3,000 to 6,000 semibuoyant, nonadhesive eggs during a spawning event (Platania 1995; Platania and Altenbach 1998). The majority of adults in the wild spawn in about a 1-month period in late spring to early summer (May to June) in association with spring runoff. Platania and Dudley (2000) found that the highest collections of silvery minnow eggs occurred in mid- to late May. In 1997, Smith (1999) collected the highest number of eggs in mid-May, with lower frequency of eggs being collected in late May and June. These data suggest multiple silvery minnow spawning events during the spring and summer, perhaps concurrent with peak flows. Artificial flow spikes have apparently induced silvery minnows to spawn (Platania and Hoagstrom 1996). In captivity, silvery minnow have been induced to spawn as many as four times in a year (Altenbach 2000); however, it is unknown if individual silvery minnow spawn more than once per year in the wild or if multiple spawning events suggested during spring and summer represent the same or different individuals.

The spawning strategy of releasing semibuoyant eggs can result in the downstream displacement of eggs, especially in years or locations where overbank-flooding opportunities are limited. The presence of irrigation water diversion dams (Angostura, Isleta, and San Acacia Diversion Dams) prevents the movement of adults to recolonize habitats upstream of these dams (Platania 1995) and has reduced the species' effective population size to critically low levels (Alò and Turner 2005; Osborne et al. 2005). Adults, eggs, and larvae may also be transported downstream and into to Elephant Butte Reservoir. It is believed that none of these fish survives because of poor habitat conditions and predation from reservoir fishes (Service 2010a).

Platania (2000) found that development of larval fish and hatching of eggs are correlated with water temperature. Eggs of the silvery minnow raised in water at 30 °C (86 °F) hatched in approximately 24 hr while eggs reared in 20 to 24°C (70 to 75 °F)

hatchery-released fish (Service 2010a). Based on estimated length groups for assigning an age class, it is possible that some individuals in the wild survive to be Age-3 fish; however greater than 95 percent of the population in any given year is estimated to comprise Age-0 and Age-1 fish (Service 2010a). In comparison to longevity in the wild, it is not uncommon for captive silvery minnows to live beyond 2 years, especially at lower water temperature. The USGS Columbia Environmental Research Center research station in Yankton, South Dakota, has several silvery minnows in captivity with a maximum age of 11 and that range in size from 46 to 73 mm (1.8 to 2.9 in) standard length (Service 2010a).

The silvery minnow foraging strategy is often demersal (feeding along or near the river substrate) and primarily herbivorous (largely feeding on algae); this is indicated indirectly by the elongated and coiled gastrointestinal tract (Sublette et al. 1990); also Shirey (2004) and Magaña (2009) found diatoms (algae with cell walls made of silica) were a main component of their diet. Additionally, organic detritus, larval insect exuvia, sand, and silt are often filtered from the bottom and ingested (Sublette et al. 1990; Service 1999; Magaña 2009). The presence of this sand and silt in the gut of wild-captured specimens suggests that epipsammic algae (algae growing on the surface of sand such as diatoms) is an important food (Magaña 2009; Service 2010a). Silvery minnow reared in a laboratory have been directly observed grazing on algae in aquaria (Platania 1995; Magaña 2009; Service 2010a).

Population Dynamics

Generally, a population of silvery minnow consists of only two age classes: Age-0 and Age-1 fish (Service 2010a). The majority of spawning silvery minnow is 1 year in age, with 2 year-old fish and older estimated to comprise less than 5 percent of the spawning population (Service 2010a). High mortality of silvery minnows occurs during or subsequent to spawning, consequently very few adults are found in late summer and fall. By December, in general, the majority of surviving silvery minnow are represented by Age-0 fish, those that hatched during the previous spring (Dudley and Platania 2007; Remshardt 2007, 2008).

Platania (1995) found that a single female in captivity could broadcast 3,000 eggs in 8 hr. Females produce 3 to 18 clutches of eggs in a 12-hr period. The mean number of eggs in a clutch is approximately 270 (Platania and Altenbach 1998). In captivity, silvery minnows have been induced to spawn as many as four times in a year (Altenbach 2000). It is not known if they spawn multiple times in the wild. The high reproductive potential of this fish appears to be one of the primary reasons that it has not been extirpated from the Middle Rio Grande. However, the short life span of the silvery minnow and environmental variation increases population instability. For example, when 2 below-average flow years occur consecutively, a short-lived species such as the silvery minnow can be impacted, if not eliminated from drying reaches of the Rio Grande (Service 1999, 2003a, 2010a).

Distribution and Abundance

Historically, the silvery minnow occurred in 3,967 km (2,465 mi) of rivers in New Mexico and Texas. The species was known to have occurred upstream to Española, New Mexico (upstream from Cochiti Lake); in the downstream portions of the Rio Chama and Jemez River; throughout

the Middle and Lower Rio Grande to the Gulf of Mexico; and in the Pecos River from Sumner Reservoir downstream to the confluence with the Rio Grande (Sublette et al. 1990; Bestgen and Platania 1991). The current distribution of the silvery minnow is limited to the Rio Grande between Cochiti Dam and Elephant Butte Reservoir, which amounts to approximately 7 percent of its historical range. In December 2008, 2009, and 2010, silvery minnows were introduced into the Rio Grande near Big Bend, Texas as a nonessential, experimental population under section 10(j) of the ESA (73 FR 74357, Service 2008a). Monitoring of the silvery minnow is being conducted to determine the success of those reintroductions.

The construction of mainstem dams, such as Cochiti Dam and several irrigation diversion dams have contributed to the decline of the silvery minnow (Service 2010a). Cochiti Dam was constructed on the main stem of the Rio Grande in 1973 for flood control and sediment retention (Julien et al. 2005). The construction of Cochiti Dam affected the silvery minnow by reducing the magnitude and frequency of peak flow events and floods that help to create and maintain habitat for the species (Julien et al. 2005). In addition, the construction of Cochiti Dam has resulted in degradation of silvery minnow habitat within the Cochiti Reach downstream. Outflow released from Cochiti Dam is now generally clear, cool, and free of sediment. There is relatively little channel braiding, and areas with reduced velocity and sand or silt substrates are now uncommon (Julien et al. 2005). Cochiti Dam also created a barrier for movement upstream by silvery minnow (Service 2010a). As recently as 1978, the silvery minnow was collected upstream of Cochiti Lake; however surveys since 1983 suggest that the fish is now extirpated from that area (Service 1999, 2010a; Torres et al. 2008).

Substrate immediately downstream of the dam is often composed of gravel and cobble (rounded rock fragments generally 8 to 30 cm [3 to 12 in] in diameter). Farther downstream, the riverbed is gravel with some sand and silt substrate. Tributaries including Galisteo Creek and Tonque Arroyo introduce sand and silt during stormwater runoff to the lower sections of the Cochiti Reach, and some of this sediment is transported further downstream along with flows (Salazar 1998; Service 1999, 2001). The Rio Grande below Angostura Dam becomes a predominately sand-bed river with low, sandy banks in the downstream portion of the Angostura Reach and Isleta Reach (Figure 3).

Long-term monitoring for the silvery minnow in the Middle Rio Grande began in 1993 and has continued annually, with the exception of 1998 (Dudley and Platania 2010). The long-term monitoring of silvery minnow populations has recorded substantial fluctuations (order of magnitude increases and decreases) over time (Figure 4). Silvery minnow catch rates declined two to three orders of magnitude between 1993 and 2003, but then increased three to four orders of magnitude by 2005 and continue to fluctuate (Figure 4). Population density data presented in Figure 4 indicate that silvery minnow catch rates, after declining through the early 2000, had increased by 2005, but by 2010 were again below the population level at the time of its listing as an endangered species in 1994. In 2008 population size was positively correlated with the magnitude and duration of the spring runoff (Dudley and Platania 2008b). The capacity of the species to respond to good hydrologic years (e.g., 2005) is dependent on a variety of factors including the previous year's survivorship, number of adults available to reproduce, good habitat conditions, and fecundity.

Augmentation has likely sustained the silvery minnow population throughout its range over the last decade (Remshardt 2008). Over 1,136,100 silvery minnows have been released since 2002. Hatchery-propagated and released fish supplement the native adult population, most likely prevented extinction during the extremely low water years of 2002 and 2003, and allowed for quicker and more robust population response in all reaches due to improved water conditions observed in recent years (Service 2010a). If the overall average catch rate for Angostura Reach drops to below 0.1 per 100 m^2 (1.2 per 100 ft^2) during October, then augmentation will be reinitiated for this reach the following year (Remshardt 2008). Dudley and Platania (2011) reported the range 0 to 0.7 per m^2 (0 to 7.5 per 100 ft^2) silvery minnow densities found in the Angostura Reach the average density in December 2010 was 0.1 per 100 m^2 (1.2 per 100 ft^2).

During 2001 through 2007, the Angostura Reach was the focus of augmentation efforts; however, beginning in 2008, augmentation shifted to the Isleta and San Acacia Reaches (Remshardt 2010a). The success of these augmentation efforts during a period of 5 years (2008–2012) without intensive stocking is currently being evaluated.

Middle Rio Grande Distribution Patterns

During the early 1990s, the density of silvery minnows generally increased from upstream (Angostura Reach) to downstream (San Acacia Reach). During surveys in 1999, over 98 percent of the silvery minnow captured were downstream of San Acacia Diversion Dam (Dudley and Platania 2002). This distributional pattern can be attributed to downstream drift of eggs and larvae and the inability of adults to repopulate upstream reaches because of diversion dams.

This pattern has changed in recent years. In 2004, 2005, and 2007, catch rates were highest in the Angostura Reach and lower in the Isleta and San Acacia Reaches. Routine augmentation of silvery minnows in the Angostura Reach (the focus of augmentation efforts started in 2001) may partially explain this pattern. Transplanting of silvery minnows (approximately 802,700 through 2009) rescued from drying reaches has also occurred since 2003. It is not possible to quantify the effects of those rescue efforts on silvery minnow distribution patterns (Remshardt 2010b). Good recruitment conditions (high and sustained spring runoff) throughout the Middle Rio Grande during April and May followed by wide-scale drying in the Isleta and San Acacia Reaches from June to September may also explain the shift. High spring runoff greater than 86 m^3/s (3,000 cubic feet per second [cfs]) for 7 to10 days and perennial flow tends to lead to increased nursery habitat and survivorship in the Angostura Reach. In contrast, portions of the Rio Grande south of the Isleta and San Acacia Diversion Dams, have had large stretches of river (48 km [30 mi]) routinely dewatered. Silvery minnows in these areas were subjected to poor recruitment conditions (lack of nursery habitats during low flows) or were trapped in drying pools where they perished.

In 2006, densities of silvery minnows were again highest downstream of the San Acacia Diversion Dam. Spring runoff volumes were exceedingly low in 2006. Flows at the Albuquerque gage never exceeded 65 m^3/s (2,300 cfs) in 2006 (USGS 2010), and likely little nursery habitat was inundated during critical recruitment times.

Distribution patterns for silvery minnows shifted in 2007, 2008, and 2009. In 2007, population monitoring of silvery minnow densities indicated the highest densities occurred in the Angostura Reach. Reports for 2008 indicated high recruitment, at all 20 sampling sites along the Middle Rio Grande, and strong runoff over an extended duration from May to July lead to elevated numbers of this species. Sampling in October 2009, indicated high recruitment, at 19 of the 20 sampling sites. The highest densities were noted to persist in the San Acacia Reach during the population monitoring census in October of 2008 and 2009. The lack of extensive river drying in these years, combined with favorable spring flows, was likely an important factor in this distribution shift from highest densities in the Angostura Reach in 2007 to the San Acacia Reach in 2008 and 2009 (Dudley and Platania 2008a, 2009). During 2010, the silvery minnow was most common in the San Acacia Reach and least common in the Angostura Reach. In October and December 2010, the Isleta and San Acacia Reaches were stocked with hatchery fish, and was apparently the primary cause for the increased silvery minnow density in those reaches (Dudley and Platania 2011).

Reasons for Listing/Threats to Survival

The silvery minnow was federally listed as endangered for the following reasons:

1. regulation of stream waters, which has led to severe flow reductions, often to the point of dewatering extended lengths of stream channel;
2. alteration of the natural hydrograph, which impacts the species by disrupting the environmental cues the fish receives for a variety of life functions, including spawning;
3. both the stream flow reductions and other alterations of the natural hydrograph throughout the year can severely impact habitat availability and quality, including the temporal availability of habitats;
4. actions such as channelization, bank stabilization, levee construction, and dredging result in both direct and indirect impacts to the silvery minnow and its habitat by severely disrupting natural fluvial processes throughout the floodplain;
5. construction of diversion dams fragment the habitat and prevent upstream migration;
6. introduction of nonnative fishes that directly compete with, and can totally replace the silvery minnow, as was the case in the Pecos River, where the species was totally replaced in a time frame of 10 years by its congener the plains minnow (*Hybognathus placitus*); and
7. diminished water quality caused by industrial, municipal, and agricultural discharge also affects the species (Service 1994).

These reasons for listing continue to threaten the species throughout its currently occupied range in the Middle Rio Grande.

Recovery Efforts

Recovery efforts are currently guided by the First Revision of the Rio Grande Silvery Minnow Recovery Plan, which was finalized and issued on February 22, 2010 (75 FR 7625, Service 2010b). The revised Recovery Plan describes recovery goals for the silvery minnow and actions

to complete these (Service 2010a). The three goals identified for the recovery and delisting of the silvery minnow are:

1. prevent the extinction of the silvery minnow in the Middle Rio Grande of New Mexico;
2. recover the silvery minnow to an extent sufficient to change its status on the List of Endangered and Threatened Wildlife from endangered to threatened (downlisting); and
3. recover the silvery minnow to an extent sufficient to remove it from the List of Endangered and Threatened Wildlife (delisting).

Downlisting (Goal 2) of the silvery minnow may be considered when the criteria have been met resulting in three populations (including at least two that are self-sustaining) that have been established within the historical range of the species and have been maintained for at least 5 years.

Delisting (Goal 3) of the species may be considered when the criteria have been met resulting in three self-sustaining populations have been established within the historical range of the species and have been maintained for at least 10 years (Service 2010a).

Conservation and recovery efforts targeting the silvery minnow are also summarized in the revised Recovery Plan and elsewhere (Tetra Tech 2004; Service 2007b; SWCA 2010). These efforts have included habitat restoration activities; research and monitoring of the status of the silvery minnow, its habitat, and the associated fish community in the Middle Rio Grande; and programs to stabilize and enhance the species, such as tagging fish and egg monitoring studies, salvage operations, captive propagation, and augmentation efforts (see www.middleriogrande.com for more details). In addition, specific water management actions in the Middle Rio Grande valley over the past several years have been used to meet river flow targets and March 2003 BO requirements for silvery minnows.

Silvery Minnow Propagation and Augmentation

In 2000, the Service identified captive propagation as an appropriate strategy to assist in the recovery of the silvery minnow. Captive propagation is conducted in a manner that will, to the maximum extent possible, preserve the genetic and ecological distinctiveness of the silvery minnow and minimize risks to existing wild populations.

Facilities at Dexter National Fish Hatchery and Technology Center and the City of Albuquerque's BioPark conduct captive propagation of the silvery minnow. Silvery minnows are held at the Service's New Mexico Fish and Wildlife Conservation Office (FWCO), the Interstate Stream Commission Refugium in Los Lunas, New Mexico, and USGS Columbia Environmental Research Center Lab, Yankton, South Dakota; however, there are no active spawning programs at these facilities.

Since 2002, over 1 million silvery minnows have been propagated and released into the Rio Grande (Remshardt 2010b). Wild gravid adults are successfully spawned in captivity at the City

of Albuquerque's propagation facilities. Eggs are raised and released as larval fish. Marked fish have been released into the Middle Rio Grande by the FWCO since 2002 under an augmentation effort funded by the Middle Rio Grande Endangered Species Collaborative Program. Eggs left in the wild have a very low survivorship, and captive propagation ensures that an adequate number of spawning adults are present to repopulate the river each year. Wild eggs are also collected and reared to maximize the genetic diversity of the minnows released (Remshardt 2008b).

Silvery Minnow Salvage and Relocation

During river drying, the Service's silvery minnow salvage crew captures and relocates silvery minnow. Through 2009, approximately 802,700 silvery minnows have been rescued and relocated to wet reaches, the majority of which were released in the Angostura Reach. Studies are being conducted to determine survival rates for salvaged fish. Caldwell et al. (2009) reported on studies that assessed the physiological responses of wild silvery minnows subjected to collection and transport associated with salvage. The authors examined primary (plasma cortisol), secondary (plasma glucose and osmolality), and tertiary indices (parasite and incidence of disease) and concluded that the effects of stressors associated with river intermittency and salvage resulted in a cumulative stress response in wild silvery minnows. They also concluded that fish in isolated pools experienced a greater risk of exposure and vulnerability to pathogens (parasites and bacteria), and that the stress response and subsequent disease effects were reduced through a modified salvage protocol that applied specific criteria to determine which wild fish are to be rescued from pools during river intermittency (Caldwell et al. 2009).

III. ENVIRONMENTAL BASELINE

Under section 7(a)(2) of the ESA, when considering the effects of the action on federally listed species, we are required to take into consideration the environmental baseline. Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area; the anticipated impacts of all proposed Federal actions in the action area that have already undergone formal or early section 7 consultation; and the impact of State and private actions that are contemporaneous with the consultation in process. The environmental baseline defines the effects of these activities in the action area on the status of the species and its habitat to provide a platform to assess the effects of the action now under consultation.

Status of the Species in the Action Area

Long-term monitoring for the silvery minnow in the Middle Rio Grande began in 1993 and has continued annually, with the exception of 1998 (Dudley and Platania 2010, Figure 4). This includes monitoring of silvery minnow in the action area of the Angostura Reach. The most recent data indicate an average minnow density of 0.1 per 100 m^2 (1.2 per 100 ft^2) within the Angostura Reach during December 2010 (Dudley and Platania 2011).

Post-augmentation monitoring for silvery minnow has been carried out since 2002 (Remshardt and Davenport 2003; Remshardt 2005, 2007, 2008a, 2008b, 2010b). One of the monitoring sites

is within the action area below the North Diversion Channel (River Mile [RM] 193.2) (Remshardt 2010b). Monitoring in the action area showed an increase in numbers of silvery minnow sampled since 2002, with considerable annual and seasonal variation. The most consistent seasonal peak was noted during June and July, following silvery minnow spawning.

Silvery minnow reproductive activity has been documented to occur in May and June each year (Platania and Dudley 2000, 2008b). Silvery minnow egg and larval fish monitoring is has been conducted in the action area. Silvery minnow eggs in the action area ranged from 0 to 0.05 per 100 m^2 (0 to 0.5 per 100 ft^2) and averaged approximately 0.005 per 100 m^2 (0.05 per 100 ft^2) (SWCA 2010).

Several activities have contributed to the status of the silvery minnow and its habitat in the action area, and are believed to affect the survival and recovery of silvery minnows in the wild. These include the current weather patterns, changes to the natural hydrology of the Rio Grande, changes to the morphology of the channel and floodplain, water quality, storage of water and release of spike flows, captive propagation and augmentation, silvery minnow salvage and relocation, ongoing research, and past projects in the Angostura Reach.

Factors affecting the Species Environment within the Action Area

Changes in Hydrology

There have been two primary changes in hydrology because of the construction of dams on the Rio Chama and Rio Grande that affect the silvery minnow: 1) loss of water in silvery minnow habitat, and 2) changes to the magnitude and duration of peak flows.

Loss of Water in Silvery Minnow Habitat

Prior to measurable human influence on the system, up to the 14th century, the Rio Grande was a perennially flowing, aggrading river with a shifting sand substrate (Biella and Chapman 1977). There is now strong evidence that the Middle Rio Grande first began drying up periodically after the development of Colorado's San Luis Valley in the mid- to late 1800s (Scurlock 1998). After humans began exerting greater influence on the river, there are two documented occasions when the river became intermittent during prolonged, severe droughts in 1752 and 1861 (Scurlock 1998). The silvery minnow historically survived low-flow periods because such events were infrequent and of lesser magnitude than they are today. There were also no diversion dams to block repopulation of upstream areas, the fish had a much broader geographical distribution, and there were oxbow lakes, cienegas, and sloughs associated with the Rio Grande that supported fish until the river became connected again.

Water use and management has resulted in a large reduction of suitable habitat for the silvery minnow. Agriculture accounts for 90 percent of surface water consumption in the Middle Rio Grande (Bullard and Wells 1992). The average annual diversion of water in the Middle Rio Grande by the Middle Rio Grande Conservancy District (MRGCD) was 0.7×10^7 m^3 (535,280 acre-feet [af]) for the period from 1975 to 1989 (U.S. Bureau of Reclamation [BOR] 1993). In 1990, total water withdrawal (groundwater and surface water) from the Rio Grande Basin in

New Mexico was $2.3x10^9$ m^3 (1,830,628 af), significantly exceeding input (Schmandt 1993). Water withdrawals have not only reduced overall flow quantities, but also caused the river to become locally intermittent or dry for extended reaches. Irrigation diversions and drains significantly reduce water volumes in the river. However, the total water use (surface and groundwater) in the Middle Rio Grande by the MRGCD may range from 28 to 37 percent (S.S. Papadopulos & Associates, Inc. 2000; Bartolino and Cole 2002). A portion of the water diverted by the MRGCD returns to the river (through drains) and may be diverted from the river again for other uses, sometimes more than once (Bullard and Wells 1992). Although the river below Isleta Diversion Dam may be drier than in the past, small inflows may contribute to maintaining flows.

Since 2001, improvements to physical and operational components of the irrigation system have contributed to a reduction in the total diversion of water from the Middle Rio Grande by the MRGCD. Prior to 2001, average annual diversions were $0.8x10^7$ m^3 (630,000 af) and now they are approximately $0.5x10^7$ m^3 (370,000 af). The change was possible because of the considerable efforts by MRGCD and farmers to reduce crop irrigation, schedule and rotate water diversions among water users, and improve record keeping by installing new gages and automating gates at diversions. The new operations reduce the amount of water diverted; however, this also reduces return flows that previously supported flow in the river. In February 2007, the City and Albuquerque Bernalillo County Water Utility Authority with six conservation groups established a fund that will provide the opportunity to lease water from Rio Grande farmers and have that water remain in the river channel to support the silvery minnow and other beneficial uses of the water. The Pilot Water Leasing Project supports the need for reliable sources of water to support conservation programs as identified by the Middle Rio Grande Endangered Species Collaborative Program.

Groundwater withdrawals also affect flow in the Middle Rio Grande. However, under New Mexico State law, the municipal and industrial users are required to offset the effects of groundwater pumping on the surface water system (BOR 2003).

River reaches particularly susceptible to drying occur immediately downstream of the Isleta Diversion Dam (RM 169), a 8-km (5-mi) reach near Tome (RM 150–155), a 8-km (5-mi) reach near the U.S. Highway 60 Bridge (RM 127–132), and an extended 58-km (36-mi) reach from near Brown's Arroyo (downstream of Socorro) to Elephant Butte Reservoir. Extensive fish kills, including tens of thousands of silvery minnows, have occurred in these lower reaches when the river has dried. It is assumed that mortalities during river intermittence are likely greater than documented levels, for example due to predation by birds in isolated pools (Service 2010a). From 1996 to 2007, an average of 51 km (32 mi) of the Rio Grande dried each year, mostly in the San Acacia Reach. The most extensive drying occurred in 2003 and 2004 when 97 and 110.6 km (60 and 68.7 mi) respectively, were dewatered. Most documented drying events lasted an average of 2 weeks before flows returned. In contrast, 2008 was considered a wet year, with above average runoff and an average monsoon season. As a result, there was no river intermittency and no minnow salvage that year, which was the first time there has been no river drying since 1996.

Changes to Magnitude and Duration of Peak Flows

Water management has resulted in a loss of peak flows that historically triggered the initiation of silvery minnow spawning. The reproductive cycle of the silvery minnow is tied to the natural river hydrograph. A reduction in peak flows or altered timing of flows may inhibit reproduction. Since completion of Elephant Butte Dam in 1916, additional dams have been constructed on the Middle Rio Grande (Scurlock 1998). Construction and operation of these dams, which are either irrigation diversion dams (Angostura, Isleta, San Acacia) or flood control and water storage dams (Elephant Butte, Cochiti, Abiquiu, El Vado), have modified the natural flow of the river. Mainstem dams store spring runoff and summer inflow, which would normally cause flooding, and release this water back into the river channel over a prolonged period. These releases are often made during the winter months, when low flows would normally occur. For example, release of carryover storage from Abiquiu Reservoir to Elephant Butte Reservoir during the winter of 1995–96 represented a substantial change in the flow regime. The Corps consulted with the Service on the release of water from November 1, 1995 to March 31, 1996, during which time 0.1×10^7 m^3 (98,000 af) of water was released at a rate of 9.2 m^3/s (325 cfs). Such releases depart significantly from natural, historical winter flow rates, and can substantially alter the habitat for silvery minnows. In spring and summer, artificially low flow may limit the amount of habitat available to the species and dispersal of the species (Service 1999).

In the spring of 2002 and 2003, an extended drought raised concerns that silvery minnows would not spawn because of a lack of spring runoff. River discharge was artificially elevated through short-duration reservoir releases during May to induce silvery minnow spawning. In response to the releases, significant silvery minnow spawning occurred in all reaches except the Cochiti Reach (Dudley et al. 2005; Service 2010a).

By contrast, spring runoff in 2005 was above average, leading to a peak of over 170 m^3/s (6,000 cfs) at Albuquerque and sustained high flows greater than 85 m^3/s (3,000 cfs) for more than 2 months. These flows improved conditions for both spawning and recruitment. October 2005 monitoring indicated a significant increase in silvery minnows in the Middle Rio Grande compared to 2003 and 2004. In 2006, however, October numbers declined again after an extremely low runoff period and channel drying in June and July (Dudley et al. 2006). October samples that year yielded no age-0 silvery minnows, indicating poor recruitment in the spring. Runoff conditions in 2007 through 2009 were average or above average maintaining a high catch rate.

Mainstem dams and the altered flows they create can affect habitat by preventing overbank flooding, trapping nutrients, altering sediment transport and temperature regimes, reducing and dewatering main channel habitat, modifying or eliminating native riparian vegetation, and creating reservoirs that favor nonnative fish species. These changes may affect the silvery minnow by reducing its food supply; altering its preferred habitat, preventing dispersal, and providing a continual supply of nonnative fish that may compete with or prey upon silvery minnow. Altered flow regimes may also result in improved conditions for other native fish species that occupy the same habitat, causing those populations to expand at the expense of the silvery minnow (Service 1999).

In addition to providing a cue for spawning, flood flows maintain a channel morphology to which the silvery minnow is adapted. The changes in channel morphology that have occurred from the loss of flood flows are discussed below.

Changes in Channel and Floodplain Morphology

Historically, the Rio Grande was sinuous, braided, and freely migrated across the valley floodplain. Changes in natural flow regimes, narrowing and deepening of the channel, and restraints (jetty jacks) to channel migration adversely affected the silvery minnow. These effects result directly from constraints placed on channel capacity by structures built in the floodplain. These anthropogenic changes have and continue to degrade and eliminate spawning, nursery, feeding, resting, and refugia areas required for species' survival and recovery (Service 1993).

The active river channel within occupied habitat is also being narrowed by the encroachment of vegetation, resulting from continued flow reductions and the lack of overbank flooding. The lack of flood flows has allowed nonnative riparian vegetation, such as salt cedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*), to encroach on the river channel (BOR 2001). These nonnative plants are very resistant to erosion, resulting in channel narrowing and a subsequent increase in water velocity. Higher velocities result in fine sediment such as silt and sand being carried away, leaving coarser bed materials such as gravel and cobble. Habitat studies during the winter of 1995 and 1996 (Dudley and Platania 1997), demonstrated that a wide, braided river channel with low velocities resulted in higher catch rates of silvery minnows, and narrower channels resulted in fewer fish captured. The availability of wide, shallow habitats that are important to the silvery minnow is decreasing. Narrow channels have few backwater habitats with low velocities that are important for silvery minnow fry and age-0 fish.

Within the current range of the silvery minnow, human development and use of the floodplain have greatly restricted the width available to the active river channel. A comparison of river area between 1935 and 1989 shows a 52 percent reduction, from 10,764 ha (26,598 acres) to 5,626 ha (13,901 acres) (Crawford et al. 1993). These data refer to the Rio Grande from Cochiti Dam downstream to the "Narrows" in Elephant Butte Reservoir, and includes the action area. Within the same stretch, 378 km (235 mi) of levees occur, including levees on both sides of the river. Analysis of aerial photography taken by BOR in February 1992, for the same river reach, shows that of the 290 km (180 mi) of river, only 1.6 km (1 mi), or 0.6 percent of the floodplain has remained undeveloped. Development in the floodplain also makes it difficult, if not impossible, to send large quantities of water downstream that would create low velocity side channels that the silvery minnow prefers. As a result, reduced releases have decreased available habitat for the silvery minnow and allowed encroachment of nonnative species into the floodplain.

Water Quality

Many natural and anthropogenic factors affect water quality in the Middle Rio Grande, including the action area. Water quality in the Middle Rio Grande varies spatially and temporally throughout its course primarily due to inflows of groundwater, as well as surface water discharges and tributary deliveries to the river (Ellis et al. 1993). Factors that are known to cause poor fish habitat include temperature changes, sedimentation, runoff, erosion, organic loading,

reduced oxygen content, pesticides, and an array of other toxic or hazardous substances. Both point source pollution (pollution discharges from a pipe or other discreet conveyances) and nonpoint source pollution (from diffuse sources such as stormwater runoff) affect the Middle Rio Grande (NMED 2007, 2009, 2010). Major point sources include discharges from wastewater treatment plants (WWTPs) and feedlots. Major nonpoint sources include agricultural activities, such as, fertilizer and pesticide application, livestock grazing; urban stormwater; atmospheric deposition; and mining activities (Ellis et al. 1993).

Effluents from WWTPs contain pollutants that may affect the water quality of the river. It is anticipated that WWTP effluent may be the primary source of perennial flow during extended periods of intermittency in the lower portion of the Angostura Reach. For that reason, the water quality of effluent discharges is extremely important. Near the project area, the largest WWTP discharges are from SWRP, followed by two WWTPs in Rio Rancho and Bernalillo (Bartolino and Cole 2002). Since 1989, ammonia and chlorine have been discharged unintentionally at concentrations that exceed protective levels for the silvery minnow (Passell et al. 2007) as recently as 2011 (Chwirka 2011; Lusk 2011a). In addition to ammonia and chlorine, WWTP effluents may also include cyanide, chloroform, organophosphate pesticides, semivolatile compounds, volatile compounds, heavy metals, and pharmaceuticals and their derivatives, which can pose a health risk to silvery minnows when discharged in concentrations that exceed the protective water quality criteria (Lusk 2003; NMED 2010). Additionally, even if the concentration of a single chemical compound is not harmful by itself, chemical mixtures can be more than additive in their toxicity to silvery minnows (Buhl 2002). Marcus et al. (2010) described the concentrations of chemicals in the Middle Rio Grande that may affect fish health or produce localized mortalities. However, the long-term effects and population level impacts of toxic chemical discharges in the Middle Rio Grande on silvery minnow are not fully known.

Pesticides

Pesticide contamination can occur from agricultural activities, as well as from the cumulative impact of residential and commercial landscaping and other activities (Anderholm et al. 1995). Stormwater runoff, irrigation return, and riverside drain return flows and windblown dust likely contribute a portion of pesticides to the Rio Grande. The presence of pesticides in surface water can depend on the amount applied, timing, location, and method of application. Water quality standards have not been set for many pesticides, and existing standards do not consider cumulative effects of several pesticides in the water at the same time or as part of the food chain. Ong et al. (1991) recorded the concentrations of heavy metals and organochlorine pesticides in water, suspended sediment and bed sediment samples between 1978 and 1988. Several researchers (Anderholm et al. 1995; Abeyta and Lusk 2004a; Langman and Nolan 2005; NMED 2009; Marcus et al. 2010) reported various pesticides in Rio Grande water or sediment samples.

Roy et al. (1992) reported that DDE, a degradation product of DDT, was detected in whole body fish collected throughout the Rio Grande. They suggested that fish in the lower Rio Grande were accumulating DDE in concentrations that may be harmful to fish and their predators. The NMED reported that two sites in the Angostura Reach contained total DDT at levels toxic to fish (Schmitt et al. 2004, see Table 15). Lusk (2011b) analyzed silvery minnow collected in the Rio Grande for DDT residues and found that the sum of DDT residues and metabolites ranged from

8.8 to 30.7 micrograms per kilogram (µg/kg) wet weight. The concentrations of DDT residues in silvery minnow, while elevated, were not above concentrations of concern for lethality (890 µg/kg wet weight), but may be associated with sublethal effects (greater than 5 µg/kg wet weight) particularly if similar DDT residues are found in silvery minnow eggs (Beckvar and Lotufo 2011), or to other fish and those that consume them (Schmitt et al. 2004; Lusk 2011b).

Heavy Metals and other Stormwater Pollutants

The EPA (2010a) reviewed the ambient stormwater water quality data for the Albuquerque MS4 Permit Area (NPDES Permit Number NMS000101. www.epa-otis.gov/otis/. Accessed April 27, 2011). The EPA (2010a) reported lead, zinc, bacteria, and cold temperature exceeded applicable water quality standards. There are no controls in place or proposed to reduce lead and zinc to applicable water quality standards other than BMPs. In their BE, the EPA (2010a) reviewed the accumulation of lead and zinc in fish tissue and sediment. The lack of acute toxicity reported by Bio-Aquatic Testing Inc. (2010) and the lack of concentrations greater than those that are lethal to 50 percent of test animal populations was used in support of EPAs decision that that no additional controls for these heavy metals was needed. The NMED (2010) confirmed that lead and zinc were below levels of concern in the action area during monitoring in 2007 to 2009. The Albuquerque MS4 Permit described additional controls for bacteria (PART VI, Tables II.A, II.B.1, II.B.2, and II.C) (EPA 2010a). Ambient stormwater temperatures exceedances were considered erroneously high and required further quality assurance review to verify those results and therefore, no additional temperature controls were included (EPA 2010a).

Sediment and Sediment Quality

Sediment is inorganic (sand, silt, and clay are used to describe sediment particle sizes) and organic matter deposited below the water column in a river or other water body. It is an important component of fish habitat in the Rio Grande (Service 1999). Sediment suspended in the water column, from erosion and other processes, can be described in terms of suspended sediment concentration (SSC) or as total suspended solids (TSS), but these measurements are not identical (Gray et al. 2000). The method for determining TSS, used in NPDES permitting, has been shown to be biased as sand particles are excluded from the analysis (Gray et al. 2000). Sediment concentrations and suspended sediment loads are important sources of sediment contamination often conveyed by stormwater (Harwood 1995; EPA 2002). EPA (2002) identified a number of pollutants that are more likely to partition into sediment than remain dissolved in the water column, such as heavy metals, certain semivolatile organic compounds such as polycyclic aromatic hydrocarbons (PAHs), PCBs, and organochlorine pesticides. Large precipitation events wash sediment and pollutants that adhere to sediment into the river from surrounding lands through storm drains and intermittent tributaries. Stormwater produces high levels of SSC and TSS, and consequently high levels of contaminants for those constituents that commonly bound to sediment particles, for example, metals, radionuclides, and PCBs (NMED 2009, 2010).

PCBs

The chemicals known as PCBs are mixtures of synthetic organic chemicals with the same basic chemical structure and similar physical properties that range from oily liquids to waxy solids (EPA 2011). No known natural sources of PCBs exist. Because they are nonflammable with properties of chemical stability, high boiling point, and electrical insulation, PCBs were used in hundreds of industrial and commercial applications. Prior to 1974, PCBs were used both for nominally closed applications (e.g., capacitor and transformers, and heat transfer and hydraulic fluids) and in open-end applications (e.g., flame retardants, inks, adhesives, paints, pesticide extenders, plasticizers, surface coatings, wire insulators, and metal coatings) (see ASTDR 2001). While the production of PCBs was banned in 1979, there are many PCB containing applications still in use, which can become sources for PCB in the environment (EPA 2011). PCBs enter aquatic environments from wet and dry atmospheric deposition, river inflows, groundwater flow, and discharges from industrial facilities. Dry and wet deposition may be the most important sources to water bodies such as lakes and large watersheds (Wenning et al. 2010).

PCBs have been detected in the Middle Rio Grande samples from below the North Diversion Channel and in stormwater the San Jose Drain during stormwater runoff events (Yanicek 2006; NMED 2010). PCB concentrations in some of these stormwater samples exceeded New Mexico's water quality criteria for the protection of wildlife as well as human health criteria (NMED 2010). PCBs in suspended sediments (0.09 µg/g) in the Rio Grande at Alameda were 90 times the values for the Rio Grande above the North Diversion Channel. This indicates that stormwater is the likely source of the PCBs (NMED 2010). The NMED (2010) noted a correlation between the concentrations of PCBs in suspended sediment and stormwater discharges, suggesting that management techniques that reduce suspended sediment in stormwater may reduce sediment contamination loads to the Rio Grande. Comparison of sediment PCBs (Yanicek 2006) with PCBs in fish tissue samples found similar patterns collected in the action area (NMED 2010).

All fish collected from the Middle Rio Grande by the NMED (2009) contained detectable PCBs ranging from 12.4 to 120.2 nanograms per gram (ng/g) wet weight. The New Mexico Department of Game and Fish, New Mexico Department of Health, and New Mexico Environment Department (2010) subsequently issued fish consumption advisories to protect the public from PCB ingestion due to health concerns in the action area. Lusk (2011b) reported that all twelve samples of silvery minnow collected from the Middle Rio Grande contained detectable concentrations ranging from 4.7 to 38.2 ng/g wet weight. Olsson et al. (1999) reported skeletal deformities associated with fish injected with 360 ng/g PCBs on a lipid basis. Lusk (2011b) reported that silvery minnow had PCBs concentrations lower than 36 ng/g on a lipid basis. This suggests that PCB-induced deformity would be unlikely in the silvery minnow unless it was more sensitive than the test fish (*Danio rerio*). Compared to upstream, concentrations of PCBs are elevated in stormwater, sediment, and fish collected below the North Diversion Channel mixing zone; however, while the concentrations pose a risk to human health and wildlife, the levels do not exceed current known toxic effect concentrations (Wenning et al. 2011) within the silvery minnow.

Dissolved Oxygen

DO measures the amount of oxygen dissolved in the water column (Benson and Krause 1980). The amount of DO in water depends upon water temperature, atmospheric pressure, and the surface area of water exposed to the atmosphere, and the oxygen byproducts of photosynthesis by aquatic plants (Odum 1956; Bott 1996). The capacity of water to hold oxygen in solution is inversely proportional to the water temperature (Benson and Krause 1980). Increased water temperature lowers the concentration of DO at saturation. Saturation is the maximum quantity of DO that water, in equilibrium with the atmosphere, can contain at a given temperature and pressure (i.e., based on the elevation of the water body). Oxygen is lost from the water column because of respiration and the oxygen demand of substances oxidizing in the water or sediment (Odum 1956; Bott 1996). Diurnal fluctuations in DO concentrations result from photosynthesis in excess of respiration as source of oxygen during the day and at night when photosynthesis ceases respiration consumes oxygen and reduces the DO concentrations in the water column (Ignjatovic 1968; Bott 1996). Low DO, that is termed hypoxia in this BO, occurs when DO concentrations are below those expected at 100 percent saturation of oxygen between the air and water. Critically low DO levels (below 2 mg/L), are termed anoxic in this BO.

DO is critical to the biological community and for the breakdown of organic matter. In fact, DO, at appropriate saturation, is essential to keeping fish and other aquatic organisms alive, and for sustaining their reproduction, development, vigor, immune capacity, behavior, movement, and predator response actions (Hughes 1973; Kramer 1987; Breitburg 1992; Pörtner and Peck 2010). Oxygen depletion in streams and lakes is usually associated with excessive temperature, heavy growth of aquatic plants, algal blooms, or high concentrations of organic matter, or elevated nutrients (EPA 1995). Understanding and modeling DO in rivers helps identify where and when low DO events occurs and allows for the identification of pollutant sources that reduce DO. BMPs that control excess delivery of oxygen demanding substances, sediment, nutrients, and organic matter to the river, and that maintain normal water temperatures, and provide good aeration and habitat are most effective in maintaining DO levels (EPA 1995).

Fish can attempt to compensate for low DO conditions by behavioral responses, such as increased use of aquatic surface respiration, changes in activity level or habitat use, and avoidance behavior, though these activities are known to come at a higher energy cost (Kramer 1987; British Columbia Ministry of the Environment (BCME) 1997). Below some threshold oxygen saturation, fish will be expending excess energy to maintain homeostasis and that some degree of physiological stress will occur (Heath 1995). Ventilation rates are often increased, reduced feeding and movement activity are decreased and increased glycolysis and cortisol release can be induced by short-term low DO conditions (Kramer 1987; Heath 1995; BCME 1997). Eventually fish suffocate at critically low DO concentrations and begin to die. Additionally, hypoxic conditions may also cause a wide range of chronic effects and behavior responses in fish (Downing and Merkens 1957; Kramer 1987; Breitburg 1992).

Sediment Oxygen Demand

The depletion of oxygen from the water overlying the bottom sediment is primarily caused by the decomposition of organic matter in sediments. Sediment oxygen demand (SOD) has been

defined as the rate of oxygen consumption, biologically or chemically, on or in the sediment at the bottom of a water body (Veenstra and Nolen 1991). The primary sources of SOD are often recalcitrant compounds (e.g., iron, manganese, ammonia, sulfides, etc.) in the sediments as well as algae, bacteria, and other sources of organic matter that settle out of the water column, or are resuspended with increased flow (Fillos and Molof 1972; Kreutzberger et al. 1980; Wang 1980; Walker and Snodgrass 1986, Caldwell and Doyle 1995). The sources of these compounds include erosion from stream banks, bed sediment and SSC, particulate organic matter, constituents added from point and nonpoint sources, biotic deposits, and biotic activity. Kreutzberger et al. (1980) reported that low DO in the Milwaukee River was SOD churned up by the stormwater discharges scouring sediment into the water column. Another consequence of low DO conditions is that organic matter can also release ammonia, thereby reducing the habitat quality for fish and their prey (Merkens and Downing 1957; Fillos and Molof 1972; Thurston et al. 1981; Caldwell and Doyle 1995).

Floodplain Flooding

In the Middle Rio Grande, Valett et al. (2005) found that flooding of the riparian forest soils (Rio Grande floodplain or "bosque") increased the rates of respiration during the flood pulse. In floodplains that were infrequently flooded, inundation of the forest resulted in widespread low DO in the floodwaters. For example, Abeyta and Lusk (2004b) reported a fish kill due to low DO in a large stagnant floodplain pool after flooding along the Middle Rio Grande. Contributions from the stagnant floodwaters into the main channel would also be expected to decrease the DO content within the Rio Grande downstream. Depending on how the annual cycle of the flood pulse influences primary productivity, plant respiration, decomposition of woody and other vegetation, and water residence time, floodplains may produce and retain enough organic matter to reduce the DO of floodwaters on an annual basis (Valett et al. 2005; DBS&A 2009). However, these flood events are not necessarily a "natural phenomena" as the flood frequency and depositional character of the Rio Grande floodplain has been substantially changed, and frequently flooded areas did not experience low DO conditions to the same extent as did infrequently flooded areas (Ellis et al. 1998; Valett et al. 2005).

Precipitation events of sufficient intensity can result in increased turbidity, increased or decreased water temperatures, and increased input of oxygen demanding substances (Huggins and Anderson 2005). Conditions in the Rio Grande have led to erosion and sedimentation including natural or anthropogenic-induced variation in water and sediment discharge due to high and low flows, poor land management, flooding, or other activities in the Rio Grande basin (Graf 1994; Scurlock 1998; Julien et al. 2005; Massong et al. 2007). When tributaries and riverbeds are scoured by stormwater runoff, water operations, or other events of sufficient velocity, and sediments are redistributed, the actions of sedimentation and elevated SSC likely creates mixing zones that may scour or smother sessile organisms (algae, bacteria, some invertebrates), or turbidity that shades light levels and reduces algae production, and creates stressful or suffocating conditions for fish at least temporarily until the sediment-water interface is stabilized and DO increases (Huggins and Anderson 2005: Bixby and Burdett 2009). Moderate to large changes in any one of these factors as a result of a single or multiple events that can affect the level of DO in the Rio Grande and potentially adversely affect the silvery minnow.

Petroleum Spills and PAHs

There are concerns about the potential petroleum spills (and other chemicals) from pipelines or during transportation in vehicles or by rail along and across the Rio Grande. Based on information reported in the National Response Center database (http://www.nrc.uscg.mil Accessed April 27, 2011), one spill incident involving crude oil occurred near the action area (upstream). In April 1999, a 41-cm (16-inch) transmission pipeline fitting was ruptured by a backhoe, releasing crude oil into the environment; reports indicated that some might have entered the Rio Grande. Fuels, such as diesel, that are carried by pipelines have documented toxicity to aquatic life due in part to semivolatile compounds. PAHs are known to occur during petroleum spills and may persist in contaminated sediments. These may be transported to fish tissues through foraging on contaminated sediments or prey where they can be toxic to fish (Eisler 1987; Schein et al. 2009). A petroleum pipeline break, if it were to spill into the Rio Grande, has the potential to reduce DO in the water column as well as contaminate the water, and can cause adverse effects on downstream water quality and the silvery minnow (Lusk 2010). However, the lack of available information on past spill events does not allow the estimation of these effects to silvery minnow or forecast future frequency.

Data on PAHs in Rio Grande sediments can be compared to numerical sediment quality criteria (Probable Effect Concentrations [PECs]) proposed by MacDonald et al. (2000). Using sediment PAH concentrations in the Middle Rio Grande compared with PECs guidelines, Marcus et al. (2010) identified heavy metal- and PAH-contaminated sediment as posing the greatest toxicity risks to silvery minnow. PAH compounds have been detected in sediment for decades, and are widespread in the Rio Grande (Levings et al. 1998; NMED 2009; Marcus et al. 2010). PAHs can be associated with petroleum spills, but wet and dry atmospheric deposition combustion is a predominant source in the environment (Eisler 1987). PAHs in sediment are often toxic to aquatic life and may reduce prey populations, and when incorporated into prey or through sediment ingestion can become carcinogenic to fish and other predators (Eisler 1987).

According to MacDonald et al. (2000) most of the PECs provide an accurate basis for predicting toxicity to aquatic life, and a reliable basis for assessing sediment quality in freshwater ecosystems. Levings et al. (1998) found one or more PAH compounds at 14 sites along the Rio Grande with high concentrations found below the City. Using guidelines similar to PECs, the NMED (2009) identified PAHs as sediment contaminants of concern to the silvery minnow in the action area, particularly at Alameda below the North Diversion Channel. Concentrations of naphthalene, an indicator PAH, ranged up to 17 µg/kg wet weight were found in silvery minnow collected from the Middle Rio Grande (Lusk 2011b). Lusk (2011b) did not ascribe any negative health consequences to the concentrations detected except to note that they were moderately elevated. Except for evaluating the PAH concentrations in sediment quality criteria (e.g., PECs), there are few diagnostic criteria for the evaluation of PAHs in silvery minnow tissue or methods of evaluation for potential effects to their prey, and how specifically silvery minnow behavior, habitat, feeding, and health may be affected by their widespread exposure to PAHs in the Middle Rio Grande.

Other Stressors

In addition to the compounds and conditions discussed above, several other constituents are present and affect the water quality of the Rio Grande. These include nutrients such as forms of nitrates and phosphorus, total dissolved solids (salinity), and radionuclides. Pollutants and physical stressors have the potential to affect the aquatic ecosystem and health of the silvery minnow. Other physical stressors can also affect the silvery minnow. For example, as the river dries, pollutants and temperatures tend increase in isolated pools (Caldwell et al. 2009). Toxic pollutants have not eliminated silvery minnow in the Middle Rio Grande, though some localized mortalities have been documented (Marcus et al. 2010). Papoulias et al. (2009) suggested that the amount and variety of stressors in the Middle Rio Grande may be affecting the health of silvery minnow.

Climate Change

"Climate" refers to an area's long-term average weather statistics (typically for at least 20- or 30-year periods), including the mean and variation of surface variables such as temperature, precipitation, and wind. "Climate change" refers to a change in the mean and variability of climate properties that persists for an extended period (typically decades or longer), whether due to natural processes or human activity (Intergovernmental Panel on Climate Change [IPCC] 2007a). Although changes in climate occur continuously over geological time, changes are now occurring at an accelerated rate. For example, at continental, regional, and ocean basin scales, recent observed changes in long-term trends include: a substantial increase in precipitation in eastern parts of North American and South America, northern Europe, and northern and central Asia, and an increase in intense tropical cyclone activity in the North Atlantic since about 1970 (IPCC 2007a); and an increase in annual average temperature of more than 1.1 °C (2 °F) across U.S. since 1960 (Karl et al. 2009). Examples of observed changes in the physical environment include: an increase in global average sea level, and declines in mountain glaciers and average snow cover in both the northern and southern hemispheres (IPCC 2007a); substantial and accelerating reductions in Arctic sea-ice (e.g., Comiso et al. 2008), and a variety of changes in ecosystem processes, the distribution of species, and the timing of seasonal events (e.g., Karl et al. 2009).

The IPCC used Atmosphere-Ocean General Circulation Models and various greenhouse gas emissions scenarios to make projections of climate change globally and for broad regions through the 21st century (Meehl et al. 2007; Randall et al. 2007), and reported these projections using a framework for characterizing certainty (Solomon et al. 2007). Examples include: 1) it is virtually certain there will be warmer and more frequent hot days and nights over most of the earth's land areas; 2) it is very likely there will be increased frequency of warm spells and heat waves over most land areas, and the frequency of heavy precipitation events will increase over most areas; and 3) it is likely that increases will occur in the incidence of extreme high sea level (excluding tsunamis), intense tropical cyclone activity, and the area affected by droughts (IPCC 2007b, Table SPM.2). More recent analyses using a different global model and comparing other emissions scenarios resulted in similar projections of global temperature change across the different approaches (Prinn et al. 2011).

All models (not just those involving climate change) have some uncertainty associated with projections due to assumptions used, data available, and features of the models; with regard to climate change this includes factors such as assumptions related to emissions scenarios, internal climate variability and differences among models. Despite this, however, under all global models and emissions scenarios, the overall projected trajectory of surface air temperature is one of increased warming compared to current conditions (Meehl et al. 2007; Prinn et al. 2011). Climate models, emissions scenarios, and associated assumptions, data, and analytical techniques will continue to be refined, as will interpretations of projections, as more information becomes available. For instance, some changes in conditions are occurring more rapidly than initially projected, such as melting of Arctic sea ice (Comiso et al. 2008; Polyak et al. 2010), and since 2000 the observed emissions of greenhouse gases, which are a key influence on climate change, have been occurring at the mid- to higher levels of the various emissions scenarios developed in the late 1990's and used by the IPCC for making projections (Raupach et al. 2007, Figure 1; Pielke et al. 2008; Manning et al. 2010, Figure 1). The best scientific and commercial data available indicates that average global surface air temperature is increasing and several climate-related changes are occurring and will continue for many decades even if emissions are stabilized soon (Meehl et al. 2007; Church et al. 2010; Gillett et al. 2011).

Changes in climate can have a variety of direct and indirect impacts on species, and can exacerbate the effects of other threats. Rather than assessing "climate change" as a single threat in and of itself, we examine the potential consequences to species and their habitats that arise from changes in environmental conditions associated with various aspects of climate change. For example, climate-related changes to habitats, predator-prey relationships, disease and disease vectors, or conditions that exceed the physiological tolerances of a species, occurring individually or in combination, may affect the status of a species. Vulnerability to climate change impacts is a function of sensitivity to those changes, exposure to those changes, and adaptive capacity (IPCC 2007a; Glick et al. 2011). As described above, in evaluating the status of a species, the Service uses the best scientific and commercial data available, and this includes consideration of direct and indirect effects of climate change. If a species is listed as threatened or endangered, knowledge regarding its vulnerability to, and impacts from, climate-associated changes in environmental conditions can be used to help evaluate expected effects of the action for this biological opinion, as well as to help devise appropriate strategies for species recovery.

While projections from global climate model simulations are informative and in some cases are the only or the best scientific information available, various downscaling methods are being used to provide higher-resolution projections that are more relevant to the spatial scales used to assess impacts to a given species (see Glick et al. 2011). With regard to the area of analysis for the silvery minnow, the following downscaled projections are available.

The New Mexico Office of the State Engineer report (2006) made the following observations about the impact of climate change in New Mexico:

1. warming trends in the Southwest exceed global averages by about 50 percent;
2. modeling suggests that even moderate increases in precipitation would not offset the negative impacts to the water supply caused by increased temperature;

3. temperature increases in the Southwest are predicted to continue to be greater than the global average;
4. there will be a delay in the arrival of snow and acceleration of spring snow melt, leading to a rapid and earlier seasonal runoff; and
5. the intensity, frequency, and duration of drought may increase.

Most of the upper Rio Grande basin is arid or semiarid, generally receiving less than 25 cm (10 in) of precipitation per year (BOR 2011). In contrast, some of the high mountain headwater areas receive on average over 100 cm (40 in) of precipitation per year. Most of the total annual flow in the Rio Grande basin results, ultimately, from runoff from mountain snowmelt (BOR 2011). In the Middle Rio Grande, there is expected earlier peak streamflows, reduced total streamflows, and more water lost to evaporation (Hurd and Coonrod 2007).

Climate change predicts four major effects on silvery minnow habitat: 1) increased water temperature; 2) decreased streamflow; 3) a change in the hydrograph; and 4) an increased occurrence of extreme events (fire, drought, and floods).

Increased water temperature

Kundzewicz et al. (2007) found that of all ecosystems, freshwater ecosystems will have the highest proportion of species threatened with extinction due to climate change. Small changes in water temperature are known to have considerable effects on freshwater fishes by affecting a variety of life history, behavioral, and physiological aspects (Morgan et al. 2001; Carveth et al. 2006). Alterations in the temperature regime from natural background conditions negatively affect population viability, when considered at the scale of the watershed or individual stream (McCullough 1999). Both silvery minnow hatching and larval development are affected by high temperatures (Platania 2000). Primary productivity and oxygen saturation are also affected by higher temperatures. As such, the slivery minnow may be adversely affected by increased water temperature due to climate change.

Decreased streamflow

Consistent with the outlook presented for New Mexico, Hoerling and Eischeid (2007) states that, relative to 1990 through 2005, simulations indicate that a 45 percent decline in streamflow will occur from 2035 through 2060 in the Southwest. Current models suggest a decrease in precipitation in the Southwest (Kundzewicz et al. 2007; Seager et al. 2007) that would lead to reduced streamflows and a reduced amount of habitat for silvery minnow. Streamflow is predicted to decrease in the Southwest even if precipitation were to increase moderately (New Mexico Office of State Engineer 2005; Hoerling and Eischeid 2007). Winter and spring warming causes an increased fraction of precipitation to fall as rain, resulting in a reduced snow pack, an earlier snowmelt, and decreased summer base flow (Regonda et al. 2005; Stewart et al. 2005). Earlier snowmelt and warmer air temperatures can lead to a longer dry season. Warmer air temperatures lead to increased evaporation, increased evapotranspiration, and decreased soil moisture. These three factors could lead to decreased streamflow even if precipitation increased moderately.

The effects of decreased streamflow on the Rio Grande include smaller wetted area; more frequent intermittent or dry conditions; and greater conflicts among water users (Hurd and Coonrod 2007). As such, there will be reduced habitat available for aquatic species. As the river becomes more intermittent, fish isolated in pools may be subject to increased predation from terrestrial predators.

Change in the hydrograph

Another documented effect of climate change is that warming in the Southwest has resulted in a shift of the timing of spring snowmelt (BOR 2011). Stewart et al. (2005) show that timing of spring streamflow in the Southwest during the last 5 decades has shifted so that the major peak now arrives 1 to 4 weeks earlier, resulting in less flow in the spring and summer. They conclude that almost everywhere in North America, a 10 to 50 percent decrease in spring-summer streamflow fractions will accentuate the seasonal summer dry period with important consequences for water supplies, ecosystems, and wildfire risks (Stewart et al. 2005). Enquist et al. (2008) found that 93 percent of New Mexico's watersheds have become relatively drier from 1970 to 2006 and that snowpack in New Mexico's major mountain ranges has declined over the past 2 decades. The timing of peak streamflow from snowmelt in New Mexico is an average of 1 week earlier than in the mid-20th century (Enquist et al. 2008). Watersheds with the greatest declines in snowpack are those that have experienced the greatest drying from 1970 to 2006. Increased winter temperatures can cause more precipitation to fall as rain instead of snow resulting in earlier spring peak streamflow (Regonda et al. 2005). Rauscher et al. (2008) suggest that with air temperature increases of 3 to 5 ºC (37 to 41 ºF), snowmelt runoff in the Southwest could occur as much as 2 months earlier than present. Changes in the hydrograph could potentially alter the native fish assemblages and affect the reproductive success of the silvery minnow that is dependent on river flow pulses to spawn (Platania and Hoagstrom 1996).

Increased occurrence in extreme events

It is anticipated that an increase in extreme events (droughts, floods, fires) will most likely affect populations living at the edge of their physiological tolerances. The predicted increases in extreme temperature and precipitation events may lead to dramatic changes in the distribution of species or to their extirpation or extinction (Parmesan and Matthews 2006). Of these extreme events drought may be most important to the silvery minnow.

As of July 12, 2011, the Middle Rio Grande basin is experiencing severe to extreme drought conditions (University of Nebraska-Lincoln 2010). These conditions result in greater human water use, evaporation, and conflict among water users. The low streamflow conditions after irrigation withdrawals leave the river in an intermittent, drying condition that does not support silvery minnow populations. Thus, we can expect a substantial decline the silvery minnow population this year.

Overall, the predicted effects of climate change are expected to result in degradation of the remaining silvery minnow habitat, with potential adverse consequences on species viability.

Past Projects in the Middle Rio Grande including the Angostura Reach

The Service has issued permits authorizing take for scientific research and enhancement purposes under ESA section 10(a)(1)(A), and incidental take under section 7 for Federal actions. Applicants for ESA section 10(a)(1)(A) permits must also acquire a permit from the State of New Mexico to "take" or collect silvery minnow. Many of the section 10 permits issued by the Service allow take for the purpose of collection and salvage of silvery minnow and their eggs for captive propagation. Eggs, larvae, and adults are also collected for scientific studies to further our knowledge about the species and how best to conserve the silvery minnow. Because of the population decline from 2002 to 2004, the Service has reduced the amount of take permitted for voucher specimens in the wild.

The Service has conducted numerous section 7 consultations on past projects in the Middle Rio Grande. In 2001 and 2003, the Service issued jeopardy biological opinions resulting from programmatic section 7 consultations with BOR and Corps, which addressed water operations and management on the Middle Rio Grande and the effects on the silvery minnow and flycatcher (Service 2001, 2003a). Incidental take of listed species was authorized associated with the 2001 programmatic BO (Service 2001), as well as consultations that tiered off that opinion.

A jeopardy biological opinion was issued on March 17, 2003 (2003 BO), and is the current programmatic biological opinion on water operations for the Middle Rio Grande, and contains one RPA with multiple elements (Service 2003a). These elements set forth a flow regime in the Middle Rio Grande and describe habitat improvements necessary to alleviate jeopardy to both the silvery minnow and flycatcher. In 2005, the Service revised the incidental take statement (ITS) for the 2003 BO using a formula that incorporates October monitoring data, habitat conditions during the spawn (spring runoff), and augmentation (Service 2005b). Incidental take of silvery minnows is authorized with the 2005 BO revised ITS, and now fluctuates on an annual basis relative to the total number of silvery minnows found in October across the 20 population monitoring locations. Incidental take is authorized through consultations tiered off this programmatic BO and on projects throughout the Middle Rio Grande.

Within the Angostura Reach, the Service has conducted various section 7 consultations on past projects, including the following:

- In 1999, the Service consulted with BOR on a restoration project on the Santa Ana Pueblo in an area where the river channel was incising and eroding into the levee system. The second phase of this Rio Grande Restoration Project at Santa Ana Pueblo underwent consultation in 2008, and the Service anticipated that up to 36,688 silvery minnow would be harassed by construction, fill placement in the river, and movement of equipment; no mortality was expected (Service 2008b).
- In 2003, the Service completed consultation with the BOR on the City's Drinking Water Project, which involved the construction and operation of a new surface diversion at Alameda in the action area, conveyance of raw water to a new treatment plant, transmission of treated water to customers throughout the Albuquerque metropolitan area, and aquifer storage and recovery. The Service anticipated that up to 20 silvery minnows would be killed or harmed during construction, up to 25,000

eggs would be entrained each year at the diversion, and up to 7,000 larval fish would be harmed, wounded, or killed during operational activities (Service 2004).

- The Service consulted on habitat restoration projects on the Rio Grande near Albuquerque, including the 2005 Phase I, the 2007 Phase II, and the 2009 Phase IIa projects (Service 2005b, 2007c, 2009) with BOs issued that reviewed the effects on silvery minnows. Incidental take authorized included 190 silvery minnows in 2005 due to harm or harassment, in 2007 the harassment of up to 3,365 minnows and mortality of up to 341 minnows, and in 2009 the harassment of up to 4,094 minnows and mortality of up to 187 silvery minnows.
- In 2006 and 2007, the Service consulted with BOR on the Bernalillo Priority Site Project and the Sandia Priority Site Project for river maintenance activities (Service 2006b, 2006c). The Bernalillo project was anticipated to kill no more than 42 silvery minnows due to channel modification, berm removal, dewatering, and sediment deposition in the river. The most recent consultation on the Sandia Priority Site Project concluded that take of up to 539 silvery minnows, and harassment of 53,853 silvery minnows would occur due to construction activities.
- In 2007, the Service determined through consultation with the Corps on the Rio Grande Nature Center Habitat Restoration Project, that up to 10 silvery minnows would be harassed during construction and that up to 154 silvery minnows would be killed due to entrapment in constructed channels (Service 2007d).
- In 2007, consultation on the Corrales Siphon River Maintenance Project concluded that the harassment of up to 244 silvery minnows would occur during construction, fill placement in the river, and movement of equipment (Service 2007e).
- In 2008, the Service concluded an intra-Service consultation on the Pueblo of Sandia Management of Exotics for the Recovery of Endangered Species Habitat Restoration Project. The Service anticipated that up to 2,449 silvery minnows would be harassed due to construction, and up to 770 killed due to potential entrapment in channels (Service 2008c).
- In 2009, the Service concluded a consultation with the BOR on the Pueblo of Sandia Bosque Rehabilitation Project, which anticipated that up to 85 silvery minnows, would be harassed during the proposed restoration activities, and up to 269 would be killed due to potential entrapment in a restored channel (Service 2009b).
- In 2010, the Service consulted with BOR for a habitat restoration project located on the Pueblo of Sandia. The Service anticipated that take in the form of harassment may affect up to 36,318 silvery minnow due to proposed construction and river crossings, as well as the harassment and mortality of up to six silvery minnows due to potential stranding in restored features after peak flows recede (Service 2010c).
- In 2011, the Service consulted with the Army Corps of Engineers on the Middle Rio Grande Bosque Restoration Project located in Bernalillo and Sandoval Counties. The Service anticipated that up to 6,988 silvery minnows would be harassed due to the proposed construction, and up to 8,471 silvery minnow would be harassed or killed due to potential stranding in restored habitat features (Service 2011a).
- In 2011, the Service consulted with the US Forest Service and the New Mexico State Land Office on a restoration project located in the Albuquerque reach. The Service anticipated that up to 96 silvery minnow would be harassed due to the proposed

construction and up to 9 silvery minnow would be harassed and killed due to potential stranding in restored habitat features (Service 2011b).

Summary of the Environmental Baseline

The remaining population of the silvery minnow is restricted to approximately 7 percent of its historical range. With the exception of 2008, every year since 1996 has exhibited at least one drying event that has negatively affected silvery minnow. The species is unable to expand its distribution because poor habitat quality and Cochiti Dam prevents upstream movement and Elephant Butte Reservoir blocks downstream movement (Service 1999). Augmentation of silvery minnow with captive-reared fish has been ongoing, and monitoring and evaluation of these fish provide information regarding the survival and movement of individuals.

Water withdrawals affect the survival of silvery minnow. The consumption of surface water and shallow groundwater for municipal, industrial, and irrigation uses continues to reduce the flow in the Rio Grande and degrade habitat for the silvery minnow (BOR 2003). The effect of water withdrawals means that discharges from WWTPs and irrigation return flows will have greater importance to the silvery minnow and effect on water quality. Lethal levels of chlorine and ammonia have been released from the WWTPs within the last year. Stormwater discharges appear to contribute to low DO conditions in the Rio Grande that can harm silvery minnow feeding and sheltering activities. In addition, a variety of organic chemicals, heavy metals, and pesticides have been documented in stormwater or wastewaters feeding into the river and that cumulatively contribute to the overall degradation of water and sediment quality.

Various conservation efforts have been undertaken in the past and others are currently being carried out in the Middle Rio Grande for the benefit of the silvery minnow. Population monitoring indicates that densities of this species have increased compared to extremely low levels seen in 2002 and 2003. However, current data show catch rates are lower than levels at the time of its listing as an endangered species in 1994 (Dudley and Platania 2011). The threat of extinction for the silvery minnow continues because of decreased water availability, increased reliance on captive propagation, the degraded, fragmented, and isolated nature of occupied habitat, and the absence of silvery minnow throughout most of its historical range.

IV. EFFECTS OF THE ACTION

Regulations implementing the ESA (50 CFR 402.02) define the *effects of the action* as 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, which will be added to the environmental baseline. Indirect effects are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur. 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. The following section describes the anticipated effects on silvery minnow resulting from the proposed action. Designated critical habitat for the silvery minnow occurs in the action area and therefore, temporary adverse effects are also anticipated, and are described in this section

Effects on Silvery Minnow

Adverse effects to the silvery minnow can be expected from low DO and reduced oxygen saturation resulting from implementation of the proposed action. It is likely that a pulse of Embayment water with low DO would suffocate any silvery minnow unable to escape the plume and surviving juvenile and adult silvery minnow will likely flee the impacted area. The Service interprets the draft Albuquerque MS4 permit conditions as allowing the potential remedy to be fully implemented as late as 5 years from the permit effective date.

Oxygen depletion is usually associated with excessive temperature, heavy growth of aquatic plants, algal blooms, or high concentrations of organic matter and nutrients (EPA 1995). Oxygen depletions in the Middle Rio Grande have been associated with stormwater discharges from tributaries and urban areas, and floodplains inundation with high concentrations of organic matter (Abeyta and Lusk 2004b; Valett et al. 2005; Van Horn 2008; DBS&A 2009; USGS 2011a, b; Lusk 2011b), Fish can attempt to compensate for low DO conditions by behavioral responses, such as increased use of aquatic surface respiration, changes in activity level or habitat use, and avoidance behaviors, though these activities are known to come at a higher energy cost (Kramer 1987; BCME 1997). Below some threshold oxygen saturation, fish will be expending excess energy to maintain homeostasis and that some degree of physiological stress will occur (Heath 1995). Ventilation rates are often increased, reduced feeding and movement activity are decreased and increased glycolysis and cortisol release can be induced by short-term low DO conditions (Kramer 1987; Heath 1995; BCME 1997). Additionally, low DO conditions may also cause a wide range of chronic effects and behavior responses in fish (Downing and Merkens 1957; Kramer 1987; Breitburg 1992).

Buhl (2007, 2011) reported that 50 percent of the test population of silvery minnow larvae (6-days post-hatch in age) died when exposed to water containing DO at 0.7 mg/L (8.7 percent oxygen saturation) during 24- to 96-hr exposures, even when allowed access to the water surface. Buhl (2011) reported that 50 percent of the test population of adult silvery minnow exposed to water containing DO from 0.8 mg/L (6.7 to 13.2 percent oxygen saturation) for 3-hr exposure without access to the water surface. Buhl (2011) reported that the highest DO concentration observed without acute mortality to larval silvery minnow (that had no access to the water surface) was 14.3 mg/L (i.e., at 29.8 percent saturation). Buhl (2011) reported that the highest DO concentration observed without acute mortality to adult silvery minnow (that had no access to the water surface) was 4.4 mg/L (i.e., at 54.3 percent saturation). From these data, we assumed that adult silvery minnow in water at 25.7 °C (78.3 °F) with DO less than or equal to 4.4 mg/L (i.e., at 54.3 percent saturation) will begin to experience mortality as well as experience adverse effects such as changes in ventilation rates, increased surface water respiration, lack of feeding activity, metabolism changes, and the condition or position of the fish is changed so they are at an increased risk of predation. Based on Buhl's (2011) results, DO concentrations at 0.7 mg/L (8.7 percent oxygen saturation) are identified as lethal to 50 percent of larvae silvery minnow, and below 4.4 mg/L (54.3 percent saturation) begins the onset of mortality and other acute adverse effects in adult silvery minnow. Temperature and pressure can affect the solubility of DO in water, in the Middle Rio Grande (as compared to Buhl 2011 temperature and pressure); we used the oxygen saturation values (8.7 and 54.3 percent respectively) to generate effect levels for incidental take later in this BO.

Lusk (2011b) reported DO concentrations effects on the silvery minnow along the Middle Rio Grande, in and below the action area, which were less than 4.4 mg/L for approximately 9.8 days (3.1 percent of the time) in cumulative duration during 313 days of continuous monitoring during 2006 to 2008. The USGS (2011a) also provided DO data from the Rio Grande upstream of the action area collected during 2009 and 2010. They reported concentrations of DO less than 4.4 mg/L occurred for approximately 1 hr (less than 0.02 percent of the time) in duration during 328 days of continuous monitoring. These low DO events in the Rio Grande upstream of the North Diversion Channel appeared to be related to stormwater runoff events from tributaries upstream of the action area. However, DO concentrations measured in the Embayment during 2009 and 2010 (USGS 2011b) were less than 4.4 mg/L for approximately 98 days during 301 days of continuous monitoring. In addition, the Embayment had DO concentrations less than 0.7 mg/L for approximately 21 days during 301 days of monitoring (USGS 2011b). The Embayment had substantially lower DO and greater frequency and duration of low DO events when compared to the Rio Grande.

From 2000 to 2010, the North Diversion Channel mean daily discharge ranged from 0 to 16.6 m^3/s (585 cfs) with an average mean daily flow of 0.3 m^3/s (10 cfs). However, peak flows from the North Diversion Channel range from 0.01 to 206 m^3/s (0.6 to 7,260 cfs) and averaged 21.8 m^3/s (770 cfs) (Kelly and Romero 2003; Kelly et al. 2006; USGS 2011b). During storms, more than 16,035 m^3 (13 af) of low DO water in the Embayment is displaced by stormwater pulses, that is discharged into the Rio Grande, and mixes as the pulse moves downstream. The low DO events in the Rio Grande are associated with the volume of hypoxic or anoxic water in the Embayment, and are often followed by fresh stormwater flow with adequate oxygen saturation as it moves through the North Diversion Channel (DBS&A 2009). The pulse of low DO water travels into the Middle Rio Grande, and is mixed and dispersed by the physical processes of interaction with substrate and dilution through inflow. After the pulse of low DO water travels downstream, it is also replaced by well-oxygenated Rio Grande water.

No mixing zone size estimates were provided in the BE. The EPA (2010b) only describes stormwater discharges from the Albuquerque MS4 permit area as flowing into waters of the Pueblo of Sandia and the Pueblo of Isleta. We used the MacIntyre Method described by EPA and Corps (1988, Appendix C) to estimate mixing zone size with a range of peak flows from the North Diversion Channel and Rio Grande (Appendix A). Depending on a variety of flow assumptions, a maximum mixing distance of up to 14 km (9 mi) was estimated. This is likely the maximum mixing distance stormwater flows from the North Diversion Channel when it flows for 24 hr at 56.6 m^3/s (2,000 cfs) and the Rio Grande is flowing at 14.2 m^3/s (500 cfs). However, the plume of low DO water is not continuous, and this pulse of water is likely to disperse as it interacts with the substrate and other flows that enter the river.

Pulse events are likely to disperse due to interaction with the riverbed, banks, and broader channel in the Rio Grande in the action area, which create longer flow paths and increase dispersion because of larger wetted perimeters that increase the interaction of the water flow with the substrate (Langman 2007). Additionally, the City's SWRP and other tributaries such as Tijeras Arroyo, as well as the Albuquerque and Atrisco Riverside Drains provide dilution water.

The change in flow velocities that occurs at the Isleta Diversion Dam may also affect stormwater plume dispersion in the Middle Rio Grande.

A pulse of Embayment water of 0.1 mg/L DO is likely to increase above 0.7 mg/L within 1 hr of mixing with the Rio Grande. During that hour, the lethally anoxic water (less than 0.7 mg/L) would suffocate any silvery minnow unable to escape the plume. Additionally, surviving juvenile and adult silvery minnow will likely flee the area affected by water containing less DO than 4.4 mg/L in the impact area. Some silvery minnow are expected to exhibit an avoidance response to the low DO events. Avoidance behavior, or fleeing from the disturbance, represents a disruption in normal behaviors and an expenditure of energy that an individual silvery minnow would not have experienced to the same degree in the absence of the proposed action. Such additional energy expenditures reduce the amount that the animal can devote to natural activities, growth, survival and reproduction. However, this form of harassment is expected to be short, with preexposure behaviors expected to resume after fleeing the disturbance by the plume as it mixes, or after replenishment of well-oxygenated Rio Grande water in their habitat.

To summarize the effects to the silvery minnow, there is an initial lethal zone of anoxic water that is displaced by storm water during the first hour of discharge, and that occurs within a maximum distance of 3.9 km (2.4 mi) in length. There is also an impact area where hypoxic water will adversely affect and harass silvery minnow until DO levels in the water increases above 4.4 mg/L (54.3 percent saturation). We expect that this impact area will extend a maximum distance of 14.3 km (8.9 mi) and achieve complete mixing within 20 hr.

The EPA (2010b) describes the proposed action as identifying a plan for the remedy of the low DO conditions to be initiated in 2 months, and submitted in 6 months from the permit effective date, with progress reports from the Applicants submitted to EPA annually thereafter for the duration of the permit or until such time as the stormwater controls eliminate conditions that exceed water quality standards. Available DO data from the Embayment during 2009 and 2010 (USGS 2011b) indicated that the frequency of low DO measurements less than 0.7 mg/L occurred over 20 days and measurements less than 4.4 mg/L occurred over 98.5 days. If the data provided reflects the frequency of low DO events that will occur in the Embayment until the remedial action is implemented, then over the 5-year permit term, hypoxic events less than 4.4 mg/L will occur for 492 days and anoxic events less than 0.8 mg/L will occur for 100 days. However, the frequency of stormwater runoff events that push the low DO water from the Embayment into the Rio Grande occur less often than the total number of days the Embayment contains anoxic water (DBS&A 2009). For example, after the low DO Embayment water is pushed into the Rio Grande it remains at adequate oxygen levels during fresh stormwater events and until conditions again favor rapid oxygen loss (DBS&A 2009). In 2009 and 2010, there were 24 events (14 were less than or equal to 4.4 mg/L and 10 were less than or equal to 0.7 mg/L) where flows in the North Diversion Channel appeared sufficient to move low DO Embayment water into the Rio Grande. This flow discharge frequency was not readily identifiable using daily average flows but rather using monthly plots of DO and peak or cumulative flow discharge events (AMAFCA 2011). Therefore, monitoring low DO concentrations in the Embayment, the Rio Grande downstream along with flows rates that are sufficient to displace the volume of water in the Embayment in the North Diversion Channel and

the daily Rio Grande flow rate will be used to estimating the size of the impact area and the incidental take of silvery minnow.

Although recent monitoring data (December 2010) indicated a silvery minnow density of 0.1 per 100 m^2 (1.2 per 100 ft^2) in the Angostura Reach (Dudley and Platania 2011), the Albuquerque MS4 permit action is for 5 years. Therefore, we evaluated the silvery minnow density in the Angostura Reach from the population monitoring reports for the past 5 years (Dudley and Platania 2007, 2008a, 2009, 2010, 2011). The average silvery minnow density over this period was 5.6 per 100 m^2 (60.1 per 100 ft^2) which we use here as the expected density in the action area during the proposed 5-year action.

Assuming that every low DO event in the Embayment was associated with stormwater discharge, and using the MacIntyre Method and Table 1, we identified 128 different mixing scenarios where up to 7,708 silvery minnows would occur in the impact area (less than 4.4 mg/L DO or 54.3 percent saturation); the average number of silvery minnow affected would be 293. However, Rio Grande discharge volumes and those in the North Diversion Channel would have to vary extensively for the maximum take level to occur; therefore, we anticipated that an average stormwater event frequency would occur during the proposed action for estimating incidental take. If the average number of silvery minnow affected in 14 discharges of low DO stormwater with concentrations greater than 0.7 mg/L (8.7 percent saturation), but less than 4.4 mg/L (54.3 percent saturation), then we expect than, on average, 4,102 (293 times 14) silvery minnow will be harassed from their habitat or sublethally affected in the impact area annually.

Using these same mixing scenarios up to 973 silvery minnows would occur in the lethal zone (less than or equal to 0.7 mg/L DO, 8.7 percent saturation); the average number of silvery minnow affected would be 37. During 10 days of discharges containing less than 0.7 mg/L, then we expect that, on average, 370 (10 times 37) silvery minnow would be killed annually. This low DO water would also continue to mix up to 4.4 mg/L, therefore an additional 2,930 (293 times 10) silvery minnow would be harassed in the impact area annually. Additionally, if the low DO stormwater discharge occurred after spawning in mid- to late May, at concentrations less than 0.7 mg/L, then we expect that, on average, up to 973 silvery minnow larvae, that drift into the mixing zone, would also be killed for each day of low DO discharges.

Under the proposed action, assuming that there will be up to 14 discharges containing hypoxic water (less than 4.4 mg/L) and 10 discharges containing anoxic water (less than or equal to 0.7 mg/L including one event in May) annually into the Middle Rio Grande for 5 years, then up to 1,850 silvery minnow would perish and up to 35,160 silvery minnow would be harassed from designated critical habitat. There are uncertainties associated with these estimates including the frequency and duration of low DO events that mix with the Rio Grande, the water available for dilution during times of drought, its oxygen saturation, and the number of silvery minnow exposed in the mixing zone, that could all increase or decrease the estimated incidental take over time. During this consultation, AMAFCA developed a potential remedial action that could reduce the incidental take (Paulsgrove 2011). If the proposed action with the potential remedy were implemented within 1.5 years, then using the estimates above no more than 1,528 silvery minnow would likely die (37 mortalities per event times 10 events per year times 1.5 years equals 555 plus 1 day of exposure in May that would adversely affect 973 larval silvery

minnow), and no more than a total of 10,548 silvery minnow would likely be harassed by low DO events associated with stormwater discharges through the North Diversion Channel.

As described above, the potential remedial action is expected to be contingent on the Corps CWA 404 permit approval. Therefore, any incidental take associated with that Federal action will be considered in the future. The potential remedial action is expected to have beneficial effects on silvery minnows in the long term by reducing the delivery of anoxic and hypoxic water to their habitat, and depending on the final design, may improve habitat available for use by the silvery minnow for feeding and sheltering.

Effects on Silvery Minnow Designated Critical Habitat

The action area for this project occurs within designated silvery minnow critical habitat. Direct and indirect effects of the proposed action are likely to result on several PCEs of silvery minnow critical habitat. PCEs for critical habitat are described above and include water of sufficient quality to reduce degraded conditions (e.g., decreased DO). The proposed action may have short-term adverse effects on PCEs of silvery minnow critical habitat. Specifically, low DO in the discharge is a water quality condition that degrades designated critical habitat (PCE 4). Hypoxia (less than 4.4 mg/L) has not been commonly observed in the Middle Rio Grande. In the designated critical habitat, Lusk (2011b) observed the occurrence of hypoxia during 3 percent of the times measured, whereas the USGS (2011a) observed the occurrence of hypoxia at less than 0.02 percent of the times measured. Anoxic conditions have not been observed in the Middle Rio Grande (Van Horn 2008; Lusk 2011b; USGS 2011b).

The USGS (2001b) observed hypoxia in the Embayment at approximately 35 percent of the times measured. In addition, the Embayment had DO concentrations less than or equal to 0.7 mg/L (anoxia) for approximately 8 percent of the times measured. While the frequency of stormwater events that push Embayment water into the Rio Grande is low, the likelihood of increased water quality degradation from low DO events is expected to increase in designated critical habitat, if no remedial action is taken. Therefore, the proposed action is likely to adversely affect silvery minnow designated critical habitat. Low DO associated with proposed action will likely affect up to 14.3 km (8.9 mi) downstream, or up to 5 percent of the designated critical habitat, for a limited time.

Using a variety of mixing scenarios, we determined a range of areas that we expect silvery minnows will be harassed by low DO events associated with stormwater discharges from the Embayment that will temporarily affect areas of designated critical habitat ranging from less than 0.4 to 14 ha (1 to 34 acres) and average 0.5 ha (1.3 acres) (Appendix A). We expect that low DO water will travel as a pulse downstream, disperse, and return to background levels after replenishment by well-oxygenated Rio Grande water or as fresh stormwater enters their habitat (DBS&A 2009). We expect designated critical habitat to rapidly return to a functional condition, and remain suitable to serve its recovery role for the silvery minnow. Therefore, as the low DO events that will degrade the water quality that characterizes designated critical habitat will be of short duration, and given the timeline for remedying the low DO occurrence, we find the effects of the proposed action on the function and conservation role of silvery minnow critical habitat relative to the entire designation are not significant. Therefore, we conclude that the PCEs of

silvery minnow critical habitat will continue to serve the intended conservation role for silvery minnows with implementation of the proposed action.

V. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, Tribal, local or private actions that are reasonably certain to occur within the action area considered in this biological opinion (50 CFR 402.02). 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 ESA.

The Service expects the natural and anthropogenic phenomena in the action area will continue to influence silvery minnows as described in the Environmental Baseline. The Service also expects the continuation of habitat restoration projects and research that will benefit silvery minnows in the action area. In addition, we expect cumulative effects to include the following:

- Increased development and urbanization in the historical floodplain may result in reduced conveyance of peak flows because of the threat of flooding damages. Development in the floodplain makes it more difficult, if not impossible, to transport large quantities of water that would overbank and create low velocity habitats that silvery minnow prefer. Development also reduces overbank flooding favorable for the silvery minnow. Gradual changes in the floodplain vegetation from native riparian species to nonnative species (e.g., saltcedar), as well as riparian clearing activities or herbicide treatment for vegetation control and associated with agricultural crops could adversely affect the silvery minnow and its habitat. Silvery minnow larvae require shallow, low velocity habitats for their development. Therefore, encroachment of nonnative species will result in habitat reduction for the silvery minnow.
- Increased consumptive use of surface water including for municipal and private uses will reduce river flow and thereby decrease available habitat for the silvery minnow.
- Increased groundwater pumping will reduce river recharge.
- Increased water contamination associated with WWTP effluent discharges; stormwater runoff from urban areas, runoff from small feedlots and dairies; and residential, industrial, and commercial development, or illegal discharges can contribute to decreased water quality.
- Increased human activities (recreational use and large woody debris removal) that cause habitat disturbance.
- Increased effects of climate change including increases in the long-term averages and variability of temperature, snow cover, precipitation patterns, and the intensity, frequency, and duration of extreme events (droughts, floods, fire, etc.) that may change the distribution and qualities of silvery minnow habitat.

The Service anticipates the continued and expanded degradation of silvery minnow habitat because of these types of activities. Effects from these activities will continue to threaten the survival and recovery of the species by reducing the quality and quantity of minnow habitat.

VI. CONCLUSION

After reviewing the current status of the silvery minnow, the environmental baseline for the action area, the anticipated effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that the issuance of the Albuquerque MS4 Permit (EPA 2010b) is not likely to jeopardize the continued existence of the silvery minnow and not likely to destroy or adversely modify its critical habitat. We expect the level and type of take associated with this action is unlikely to appreciably diminish the population in the action area. We expect harassment of minnows may occur, but the duration and intensity of this effect will be short term, with no long-term effects on silvery minnow behaviors such as breeding, feeding, or sheltering. A small number of mortalities may occur due to suffocation by stormwater containing low DO entering the Rio Grande; however, we do not expect these mortalities to result in any significant long-term effects on the population in the action area, or destroy or adversely modify designated critical habitat.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without 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), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are nondiscretionary, and must be undertaken by EPA so that they become binding conditions of any permit issued, as appropriate, for the exemption in section 7(o)(2) to apply. The EPA has a continuing duty to regulate the activity covered by this incidental take statement. If EPA 1) fails to assume and implement the terms and conditions or 2) fails to require adherence to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, EPA or the Applicants 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 Anticipated

The Service has developed the following incidental take statement based on the premise that the Albuquerque MS4 Permit will be implemented as proposed (EPA 2010b). Take of silvery

minnow is expected in the form of harm and harassment due to the discharge of stormwater pulses that push water with low DO into the Rio Grande. The Service expects that no more than 195 (15 mortalities and 180 harassment) silvery minnow will be incidentally taken because of the proposed action with implementation of the reasonable and prudent measures. If actual incidental take meets or exceeds the predicted level, EPA should reinitiate consultation.

The Service anticipates that take in the form of harassment may affect up to 10,548 silvery minnows due to stormwater containing less than 4.4 mg/L DO and harm of up to 555 silvery minnows due to stormwater containing less than 0.7 mg/L DO. If stormwater discharges containing less than 0.7 mg/L DO occur during the period of May 15 to 31, then up to 973 larval silvery minnow may also die. For a total take due to harm of 1,528 silvery minnows. We base these figures on the best available information on minnow density in the area impacted by the proposed activities (Table 1). Table 1 includes the flow rate of the North Diversion Channel, when the flow cumulatively equals the volume of Embayment water (16,035 m^3 [13 af]), the daily flow of the Rio Grande upstream, and the oxygen concentration measured in the Embayment water prior to a stormwater runoff event sufficient to displace Embayment water, as determined from continuous monitoring. These discharges and DO data are used as a surrogate for the area of critical habitat affected and the number of affected silvery minnow because fish observation during storm events would be unsafe and is unlikely to result in quantifiable observations of harassment. Where oxygen monitoring equipment fail, data from the most recent 24-hr period will be substituted. In the event that flow discharges differ from values in Table 1, then a value should be rounded to the nearest flow value category listed. Incidental take will be quantified for qualifying stormwater events where cumulative flow has equaled or exceeded 16,035 m^3 (13 af) in the North Diversion Channel using the following procedure and information in Table 1:

Step 1. Determine the season of the event. Spring (March 21 to June 20), summer (June 21 to September 22), fall (September 23 to December 20), and winter (December 21 to March 20).

Step 2. Determine the flow rate at the North Diversion Channel Gage (USGS Station 08329900) and the daily discharge rate at the upstream Rio Grande Gage (USGS Station 083296806).

Step 3. Determine the DO concentration and oxygen saturation in the Embayment just prior to onset of stormwater discharge at USGS Gage 083299176.

Step 4. If DO is less than 0.7 mg/L (i.e., if saturation is less than 8.7 percent), then determine the number of silvery minnow killed by summing the number in column S over all events (Table 1). Calculate the number of slivery minnow harassed by summing the number in column T over all events (Table 1). If an event occurs between May 15 and 31 then add the amount in column S to the total number killed.

Step 5. If DO is greater than 0.7 mg/L and less than or equal to 4.4 mg/L (i.e., if oxygen saturation is less than or equal to 54.3 percent), calculate the number of silvery minnow harassed by summing the number in column T over all events (Table 1).

Step 6. If the sum of silvery minnows killed or harassed does not exceed the incidental take statement (1,528 killed; 10,548 harassed), then list all events in a table, the sum the take for all events, submit an annual report to the Service.
If the sum of silvery minnow killed or harassed exceeds the incidental take statement then reinitiate consultation.

Effect of Take

The Service has determined that this level of anticipated take is not likely to result in jeopardy to the silvery minnow. The proposed action is likely to have adverse effects on silvery minnows, but those effects are not anticipated to result in any long-term impacts on the population. The Service notes that this represents a best estimate of the extent of take that is likely during the proposed action. The estimated incidental take may be modified through reconsultation and amendment of the BO if the actual measured parameters differ significantly from those estimated.

Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize impacts of incidental take of the silvery minnow resulting from the proposed action:

1. Implement remedial action on the Embayment to significantly reduce the likelihood and magnitude of low DO discharges into silvery minnow habitat in the Middle Rio Grande.

2. Monitor DO and temperature in the water column in the Embayment and Rio Grande to determine the effectiveness of the remedial action.

Terms and Conditions

Compliance with the following terms and conditions must be achieved in order to be exempt from the prohibitions of section 9 of the ESA. These terms and conditions implement the Reasonable and Prudent Measures described above. These terms and conditions are nondiscretionary. EPA or the Applicants must report to the Service on the implementation of these terms and conditions.

To implement RPM 1, EPA shall:

1. Ensure that the remedial action selected for the North Diversion Channel Embayment is completed within 1.5 years of the Albuquerque MS4 permit effective date.

To implement RPM 2, EPA shall:

1. Ensure that continuous monitoring of DO and temperature in the Embayment and at one location in the Rio Grande downstream of the North Diversion Channel outfall within the action area (e.g., Rio Bravo Bridge) to verify the remedial action is successful for the duration of the permit.
2. Ensure that all data and information necessary to complete Table 1 for all qualifying storm events are provided to the Service. The information on qualifying storm events to be provided includes: date of any qualifying stormwater events, DO value in Embayment, DO value at downstream monitoring station, flow rate in the North

Diversion Channel, daily flow rate in the Rio Grande, and sum of silvery minnows taken.

3. Ensure that annual reports cite or describe all standard operating procedures, quality assurance plans, maintenance, and implementation schedules to assure that timely and accurate water temperature, dissolved oxygen, oxygen saturation, and flow data are collected and reported.
4. Ensure that the Service receives electronic copies of all incidental take, interim, and annual reports described in the Albuquerque MS4 permit no later than March 31 for the preceding calendar year ending December 31. These should be sent to the email address nmesfo@fws.gov or by mail to the New Mexico Ecological Services Field Office, 2105 Osuna Road NE, Albuquerque, New Mexico 87113.
5. EPA, Applicants, and the Service will meet annually (via teleconference) during the permit period to review the remedial action progress, information gathered, and incidental take estimates associated with qualifying storm events.

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 designated critical habitat, to help implement recovery plans, or to develop information. The Service recommends the following conservation activities:

1. Identify suspended solid and sediment sources and transport pathways in the storm runoff events from urban area basins.
2. Encourage the simultaneous or replacement of methods to determine TSS with the more accurate methods to determine SSC.
3. Identify pollutant concentrations on SSC and develop BMPs to reduce SSC containing pollutants effects on silvery minnow habitat.
4. Estimate carbonaceous oxygen demand, SOD, SSC and ammonia concentrations associated with stormwater and their relationship to low DO events in the Rio Grande and potential effects to silvery minnow.
5. Improve mixing model accuracy of stormwater runoff and its effects on DO concentrations in the Middle Rio Grande.
6. Identify the chronic effects or avoidance of low DO concentrations to silvery minnow under a range of water temperatures from 5 to 35 °C (41 to 95 °F).
7. Amend the SWMP to include PCB monitoring according to methods recommended by the NMED (2010) within the North Diversion Channel outfall, San Jose Drain outfall, and the Middle Rio Grande both upstream and downstream of the Albuquerque urban area.
8. Measure PCBs in insect prey of the flycatcher, conduct PCB accumulation studies on the flycatcher or a surrogate, including collection of addled flycatcher eggs by the permittee through Service's issuance of ESA 10(A)1(a) permits, and then analyze them for PCBs and other pollutants.

9. Implement recovery actions identified in flycatcher and silvery minnow recovery plans.
10. Encourage volunteers, educators and classrooms to "adopt-a-watershed" for the stormwater basins that their schools reside in.

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

REINITIATION NOTICE

This concludes formal consultation on the action of issuance of the Albuquerque MS4 Permit. As provided in 50 CFR 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 of silvery minnow is exceeded; 2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this BO; 3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this BO; or, 4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, the EPA shall immediately implement actions necessary to cease any operations from causing such take, pending reinitiation.

Thank you for your concern for endangered species and New Mexico's wildlife habitats. The Service appreciates EPA's coordination efforts associated with this NPDES permit to better understand and fully characterize the effects to federally listed species and their critical habitats. If you have any questions regarding this BO or if we can be of further assistance, please contact Joel D. Lusk of my staff at the letterhead address, by email at joel_lusk@fws.gov, or telephone at (505) 761-4709.

Sincerely,

Wally Murphy
Field Supervisor

cc:
Executive Engineer, AMAFCA, Albuquerque, New Mexico (Attn. K. Daggett)
Stormwater Manager, City Municipal Development, Albuquerque, New Mexico (Attn. R. Penttila)
District Three Engineer, NMDOT, Albuquerque, New Mexico (Attn. R. Rizzi)
Director, Department of Safety and Risk Services, UNM, Albuquerque, New Mexico (Attn. V. Hershberger)
Governor, Pueblo of Sandia, Bernalillo, New Mexico (Attn. S. Bulgrin)
Governor, Pueblo of Isleta, Isleta, New Mexico (Attn. C. Walker)

Director, New Mexico Department of Game and Fish, Santa Fe, New Mexico
Office of the Superintendent, Bureau of Indian Affairs, Southern Pueblos Agency, Albuquerque, New Mexico.
Assistant Regional Director, Ecological Service, Region 2, Albuquerque, New Mexico (Attn. D. Montaño)
Chief, Division of Habitat Conservation/Environmental Contaminants, Region 2, Albuquerque, New Mexico (Attn. L. Wellman)

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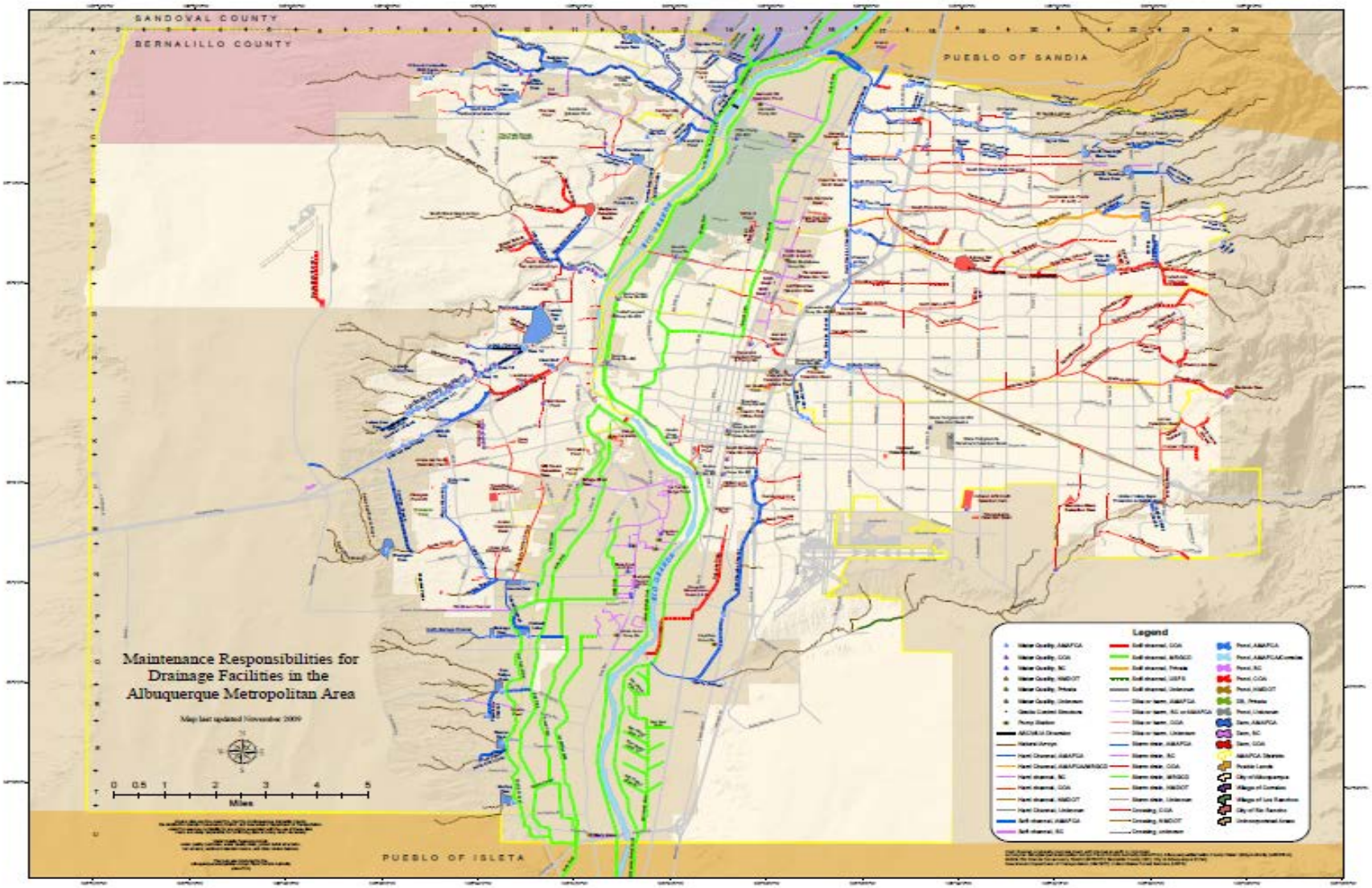

Figure 1. Map of the Albuquerque MS4 Permit Area in Bernalillo County, New Mexico. http://12.23.244.78/amafcapublic/. Accessed April 27, 2011.

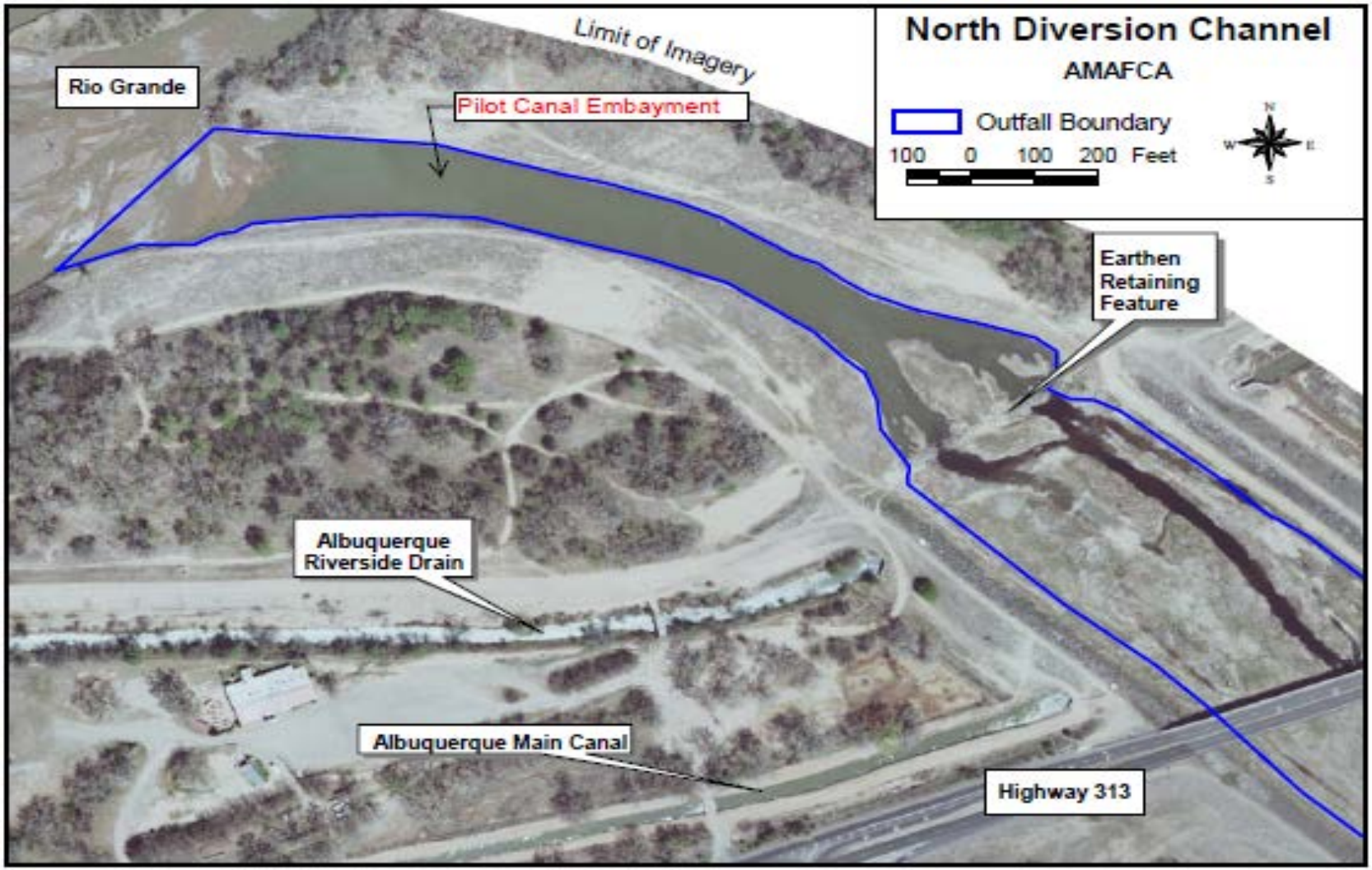

Figure 2. Location of the Pilot Canal Embayment in the North Diversion Channel at confluence of the Rio Grande in Albuquerque Bernalillo County, New Mexico (Image Source: SWCA 2004).

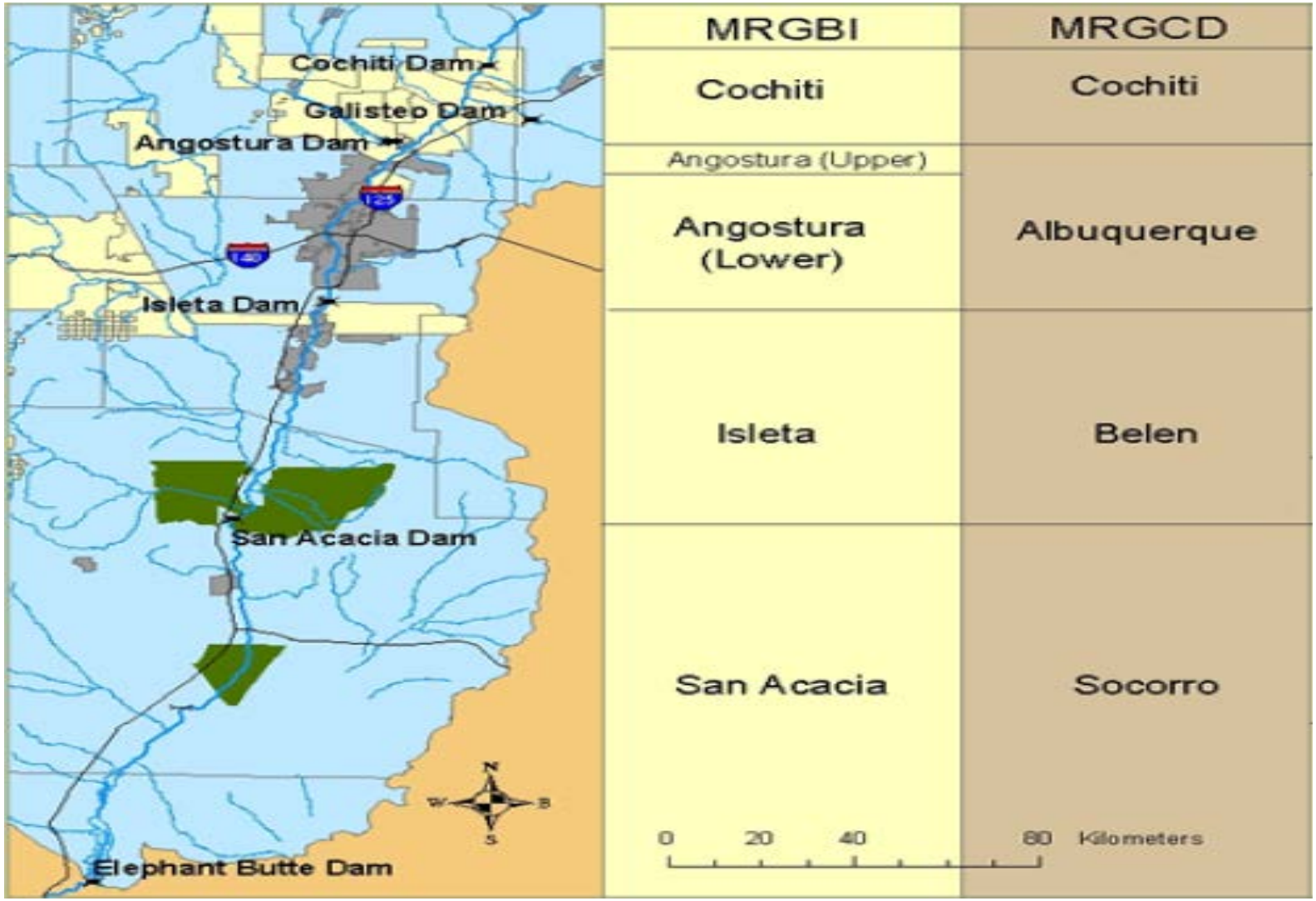

Figure 3. Location of the Angostura Reach in the Middle Rio Grande from Angostura Dam to the Isleta Dam. Major diversion dams and river reach naming conventions by the Middle Rio Grande Bosque Initiative (MRGBI) and the Middle Rio Grande Conservancy District (MRGCD) are identified.

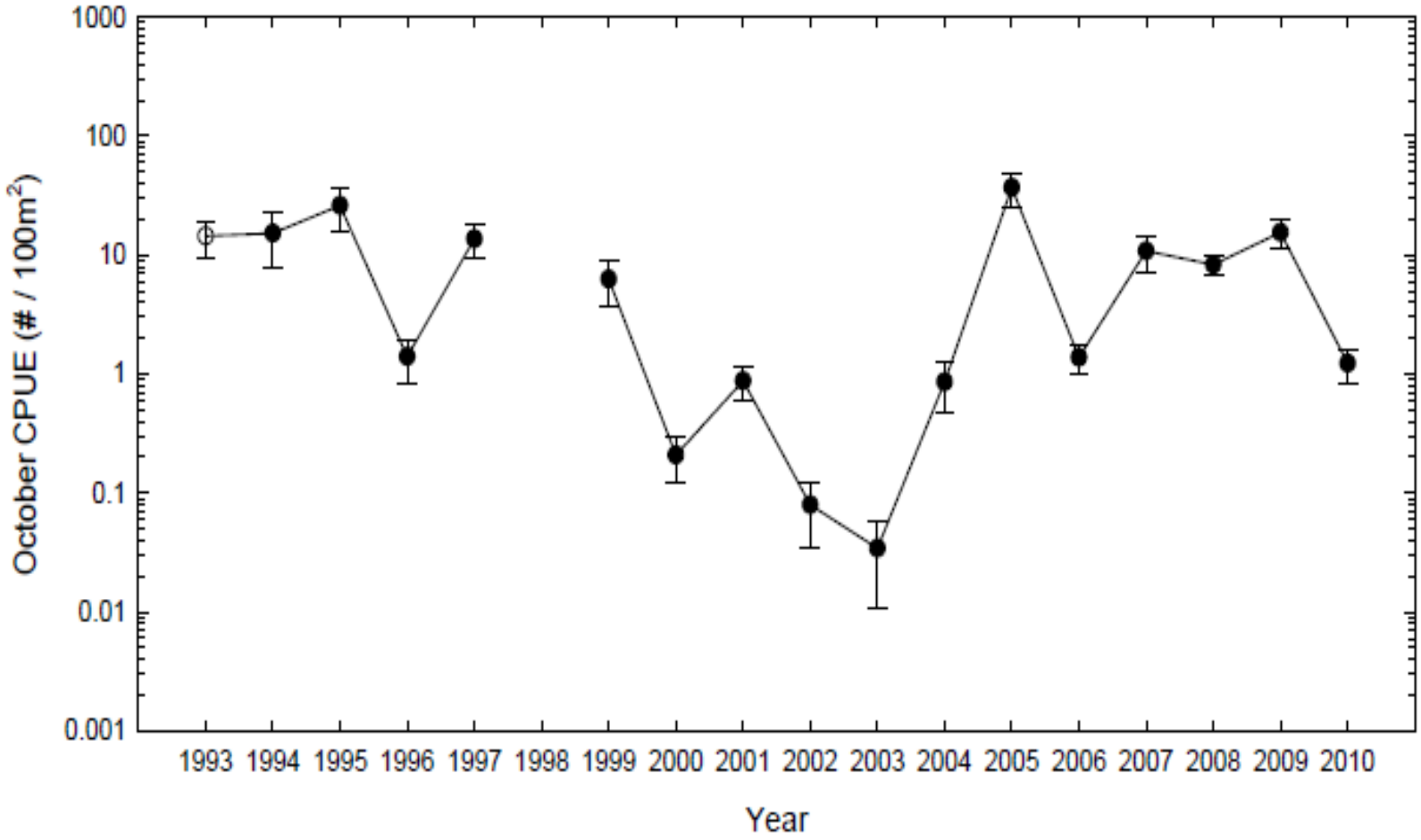

Figure 4. Silvery Minnow Population Monitoring Data (1993-2010) based on October catch per unit effort (CPUE) (values are numbers of silvery minnow caught per 100 m^2) (Dudley and Platania 2010).

Table 1. Incidental take of Rio Grande silvery minnow (RGSM) for stormwater events that equal or exceed cumulative discharge of 16,035 m^3 (13 af) through the North Diversion Channel (NDC) into Rio Grande by season. Area estimated using MacIntyre method (EPA and Corps 1998, Appendix C).

SPRING (March 21 – June 20)

Flow Rate in NDC (cfs)	Daily Flow Rate in Rio Grande (cfs)	Lethal Zone Area (ft^2)	S No. of RGSM killed in Lethal Zone	T No. of RGSM harassed in Impact Area
500	500	1,828	9	67
500	1000	182	1	7
500	1500	58	0	2
500	2000	22	0	1
500	2500	12	0	0
500	3000	7	0	0
500	3500	4	0	0
500	4000	3	0	0
1000	500	14,625	69	532
1000	1000	1,458	7	53
1000	1500	466	2	17
1000	2000	176	1	6
1000	2500	96	0	3
1000	3000	55	0	2
1000	3500	33	0	1
1000	4000	21	0	1
1500	500	49,359	232	1,797
1500	1000	4,922	23	179
1500	1500	1,572	7	57
1500	2000	594	3	22
1500	2500	324	2	12
1500	3000	186	1	7
1500	3500	111	1	4
1500	4000	69	0	3
2000	500	117,000	550	4,259
2000	1000	11,667	55	425
2000	1500	3,726	18	136
2000	2000	1,409	7	51
2000	2500	768	4	28
2000	3000	441	2	16
2000	3500	264	1	10
2000	4000	164	1	6

Table 1. Continued.

SUMMER (June 21 – September 22)			**S**	**T**
Flow Rate in NDC (cfs)	**Daily Flow Rate in Rio Grande (cfs)**	**Lethal Zone Area (ft^2)**	**No. of RGSM killed in Lethal Zone**	**No. of RGSM harassed in Impact Area**
500	500	3,322	15	120
500	1000	331	2	12
500	1500	106	0	4
500	2000	40	0	1
500	2500	22	0	1
500	3000	13	0	0
500	3500	8	0	0
500	4000	5	0	0
1000	500	26,592	122	963
1000	1000	2,652	12	96
1000	1500	847	4	31
1000	2000	320	1	12
1000	2500	175	1	6
1000	3000	100	0	4
1000	3500	60	0	2
1000	4000	37	0	1
1500	500	89,748	411	3,252
1500	1000	8,949	41	324
1500	1500	2,858	13	104
1500	2000	1,081	5	39
1500	2500	589	3	21
1500	3000	338	2	12
1500	3500	203	1	7
1500	4000	126	1	5
2000	500	212,736	973	7,708
2000	1000	21,213	97	769
2000	1500	6,775	31	245
2000	2000	2,561	12	93
2000	2500	1,396	6	51
2000	3000	801	4	29
2000	3500	480	2	17
2000	4000	299	1	11

Table 1. Continued.

FALL (September 23 – December 20) **S** **T**

Flow Rate in NDC (cfs)	Daily Flow Rate in Rio Grande (cfs)	Lethal Zone Area (ft^2)	No. of RGSM killed in Lethal Zone	No. of RGSM harassed in Impact Area
500	500	2,479	12	90
500	1000	247	1	9
500	1500	79	0	3
500	2000	30	0	1
500	2500	16	0	1
500	3000	9	0	0
500	3500	6	0	0
500	4000	3	0	0
1000	500	19,833	92	718
1000	1000	1,978	9	72
1000	1500	632	3	23
1000	2000	239	1	9
1000	2500	130	1	5
1000	3000	75	0	3
1000	3500	45	0	2
1000	4000	28	0	1
1500	500	66,936	311	2,424
1500	1000	6,675	31	242
1500	1500	2,132	10	77
1500	2000	806	4	29
1500	2500	439	2	16
1500	3000	252	1	9
1500	3500	151	1	5
1500	4000	94	0	3
2000	500	158,663	738	5,746
2000	1000	15,821	74	573
2000	1500	5,053	23	183
2000	2000	1,910	9	69
2000	2500	1,041	5	38
2000	3000	598	3	22
2000	3500	358	2	13
2000	4000	223	1	8

Table 1. Continued.

WINTER	(December 21 – March 20)		**S**	**T**
Flow Rate in NDC (cfs)	**Daily Flow Rate in Rio Grande (cfs)**	**Lethal Zone Area (ft^2)**	**No. of RGSM killed in Lethal Zone**	**No. of RGSM harassed in Impact Area**
500	500	1,296	6	47
500	1000	129	1	5
500	1500	41	0	2
500	2000	16	0	1
500	2500	9	0	0
500	3000	5	0	0
500	3500	3	0	0
500	4000	2	0	0
1000	500	10,371	49	378
1000	1000	1,034	5	38
1000	1500	330	2	12
1000	2000	125	1	5
1000	2500	68	0	2
1000	3000	39	0	1
1000	3500	23	0	1
1000	4000	15	0	1
1500	500	35,004	165	1,274
1500	1000	3,490	16	127
1500	1500	1,115	5	41
1500	2000	421	2	15
1500	2500	230	1	8
1500	3000	132	1	5
1500	3500	79	0	3
1500	4000	49	0	2
2000	500	82,971	391	3,020
2000	1000	8,273	39	301
2000	1500	2,643	12	96
2000	2000	999	5	36
2000	2500	545	3	20
2000	3000	313	1	11
2000	3500	187	1	7
2000	4000	116	1	4

Appendix A

Calculations of area impacted and number of silvery minnows affected were made in an Excel spreadsheet, **Appendix A. DO mixing model_NDC_RG.xlsx**.

Column A. Determine season. Spring (March 21-June 20), Summer (June 21-September 22), Fall (September 23-December 20) and Winter (December 21- March20). Water temperature affects oxygen saturation of water (Odum 1956, Ignjatovic 1968). The temperature based phenomena affects all calculations and must be standardized. Lusk (2011) reported that the average water temperatures in the Middle Rio Grande varies by season. Water temperature averages approximately 15 °C in spring, 25 °C in summer, 20 °C in fall, and 10 °C in winter, in the Middle Rio Grande.
Column B. Daily Rio Grande discharge was determined from an upstream gage (USGS Gage 083296806). For ease of table use, each flow was binned into 500 cfs units.
Column C. Flow rates in the North Diversion Channel is determined from a gage upstream of the Embayment (USGS Gage 08329900). For ease of use, each flow was binned according to 500 cfs units.
Column D. River widths for this reach and for different discharges were obtained from Table 4.6 in Mussetter Engineering Inc (MEI) (2008). FLO-2D Model Development - Existing Conditions and Restoration Alternatives 1 to 5 Albuquerque Reach, New Mexico. Report to the U. S. Army Corps of Engineers. Fort Collins, Colorado. http://www.spa.usace.army.mil/FONSI/bosque/Engineering%20Appendix/App%20A_H&H%20Main%20report.pdf . Accessed May 17, 2011.
Column E. Average river depth for this reach and for different discharges were obtained from Table 4.6 in MEI (2008).
Column F. Pressure and temperature adjusted dissolved oxygen (DO) concentration. We used 630 mm Hg barometric pressure based on site elevation and an upstream oxygen saturation of 100 percent. DO was adjusted using the USGS DO website (http://water.usgs.gov/cgi-bin/dotables. Accessed May 17, 2011).
Column G. Lowest DO in the Embayment is from DBS&A (2009). It can be zero but it creates calculation error of division by zero. A small positive value (0.1 mg/L) was used here instead.
Column H. Rio Grande cross sectional area determined using the MacIntyre Method (EPA and Corps 1998, Appendix C).
Column I. Average river velocity for this reach and for different discharges were obtained from Table 4.6 in MEI (2008).
Column J. Rio Grande shear velocity determined using the MacIntyre Method (EPA and Corps 1998, Appendix C.) and slopes for this reach and for different discharges were obtained from Table 4.6 in MEI (2008).
Column K. Rio Grande lateral mixing coefficient determined using the MacIntyre Method (EPA and Corps 1998, Appendix C).
Column L. Lethal DO concentration for silvery minnow. Buhl (2011) reported lethality at 8.7 percent saturation (i.e., 0.7 mg/L at 26 °C in South Dakota at about 1000 ft elevation). To determine 8.7 percent saturation at the Middle Rio Grande site at 25 °C, use 100 percent saturation determined using USGS DO tables (http://water.usgs.gov/cgi-bin/dotables. Accessed May 17, 2011) and multiply by 8.7 percent. Therefore 6.8 mg/L at 25 °C times 0.087 = 0.6 mg/L; 8.6 mg/L at 15 °C times 0.087 = 0.7mg/L; 9.3 mg/L at 10 °C times 0.126 = 1.17 mg/L.
Column M. Mixing zone length for lethality in feet calculated using the MacIntyre Method (EPA and Corps 1998, Appendix C).
Column N. Mixing zone length for lethality in feet converted to miles.
Column O. Mixing zone width for lethality in feet calculated using the MacIntyre Method (EPA and Corps 1998, Appendix C).
Column P. Area of the lethal zone in square feet calculated by multiplying length (N) and width (O).
Column Q. Area of the lethal zone converted to square meters.
Column R. Average density of silvery minnow per 100 m^2 in Angostura Reach from 2006 to 2010.
Column S. Density of silvery minnow per 100 m^2 multiplied by impact area.
Column T. Area of the lethal zone converted to acres. How big an area is lethal to silvery minnow?

Column U. No adverse affect DO concentration for silvery minnow. Buhl (2011) reported the no adverse effect concentration at 54.3 percent saturation (i.e., 4.4 mg/L at 25 °C in South Dakota at about 1,000 ft elevation). To determine 54.3 percent saturation at the Middle Rio Grande site at 25 °C, assume 100 percent saturation and determined using USGS DO tables (http://water.usgs.gov/cgi-bin/dotables. Accessed May 17, 2011) and multiply by 54.3 percent. Therefore 6.8 mg/L at 25 °C times 0.543 = 3.69 mg/L; 9.3 mg/L at 10 °C times 0.543 = 5.05 mg/L.
Column V. Mixing zone length for harassment in feet calculated using the MacIntyre Method (USEPA and Corps 1998, Appendix C).
Column W. Mixing zone length for harassment in feet converted to miles. How far downstream is there harassment?
Column X. Mixing zone width for harassment in feet calculated using the MacIntyre Method (USEPA and Corps 1998, Appendix C).
Column Y. Impact area of harassment in square feet calculated by multiplying length (U) and width (W).
Column Z. Impact area of harassment converted to square meters.
Column AA. Density of silvery minnow per 100 m^2 multiplied by impact area. How many silvery minnow are harassed?