Carlsbad Project Water Operations and Water Supply Conservation

Draft Environmental Impact Statement
September 2005

U.S. Department of the Interior
Bureau of Reclamation
Denver, Colorado, and Albuquerque, New Mexico

New Mexico Office of the State Engineer
Interstate Stream Commission
Santa Fe, New Mexico

Mission Statements

Department of the Interior

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The Office of the State Engineer and the Interstate Stream Commission

To actively protect and manage the water resources of New Mexico for beneficial uses by its people, in accordance with law:

- To investigate, measure, and distribute water in accordance with water rights and interstate obligations,

- To administer a water rights system that lawfully and effectively allocates and reallocates water and adjudicates water rights to meet the needs of New Mexico's growing population, and

- To maximize use of New Mexico's renewable interstate stream apportionments in order to improve the sustainability of New Mexico's water supplies

DRAFT ENVIRONMENTAL IMPACT STATEMENT
CARLSBAD PROJECT WATER OPERATIONS AND WATER SUPPLY CONSERVATION

Prepared by: U.S. Department of the Interior, Bureau of Reclamation
New Mexico Office of the State Engineer, Interstate Stream Commission in cooperation with U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish, Carlsbad Irrigation District, Pecos Valley Artesian Conservancy District, and Eddy County

The Bureau of Reclamation (Reclamation) and the New Mexico Interstate Stream Commission (NMISC) prepared this Carlsbad Project Water Operations and Water Supply Conservation Draft Environmental Impact Statement (DEIS) to assess the potential consequences of proposed changes in Carlsbad Project operations and the implementation of a water acquisition program in the Pecos River basin, New Mexico. This DEIS includes a description of alternative means of implementing the proposed Federal action (alternatives), including a No Action Alternative, and presents an evaluation of the potential environmental, economic, and social consequences that could result from implementing these alternatives. These proposed changes in water operations are designed to conserve the Pecos bluntnose shiner and its designated critical habitat, while conserving the Carlsbad Project water supply.

This DEIS has been prepared in compliance with the National Environmental Policy Act and Reclamation procedures and is intended to serve environmental review and consultation requirements pursuant to Executive Order 11988 (Floodplain Management), Executive Order 11990 (Wetlands Protection), Executive Order 12898 (Environmental Justice), the National Historic Preservation Act (section 106), Endangered Species Act (section 7(c)) and Departmental and Reclamation Indian Trust Asset policies. **The comment period for this DEIS ends on October 31, 2005.**

For further information,
Contact: Marsha Carra, Bureau of Reclamation, Albuquerque Area Office, 555 Broadway NE., Suite 100, Albuquerque, New Mexico 87102. Telephone: (505) 462-3602; FAX: 505-462-3780; E-Mail: mcarra@uc.usbr.gov

Coleman Smith, New Mexico Interstate Stream Commission, PO Box 25102, Santa Fe, NM 87504-5102. Telephone: (505) 476-0551; FAX: (505) 476-0399; E-Mail: coleman.smith@state.nm.us

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Abbreviations and Acronyms

µS/cm	microSiemens per centimeter
AMP	Alternative Management Plan
APE	area of potential effects
ARMS	Archaeological Records Management System
AWA	additional water acquisition
AWN	additional water needed
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BLNWR	Bitter Lake National Wildlife Refuge
BO	Biological Opinion
CADSWES	Center for Advanced Decision Support for Water and Environmental Systems
CAGW	Carlsbad Area Ground Water model
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CID	Carlsbad Irrigation District
CIR	consumptive irrigation requirement
Compact	Pecos River Compact
Corps	U.S. Army Corps of Engineers
CPWA	Carlsbad Project water acquisition
DEIS	draft environmental impact statement
DO	dissolved oxygen
dS/m	deciSiemens per meter
EA	environmental assessment
EC	specific electrical conductance
ECe	electrical conductivity of the saturation extract
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act of 1973, as amended
EUAC	equivalent uniform annual costs
FCP	fish conservation pool
F.I.R.E.	finance, insurance, and real estate
FR	Federal Register
FSI	farmland of Statewide importance
FSID	Fort Sumner Irrigation District
HIC	Hagerman Irrigation Company
HRC	Hydrosphere Resource Consultants
HRS	high-range summer
ID team	National Environmental Policy Act interdisciplinary team
IMPLAN	IMpact analysis for PLANning model
Interior	U.S. Department of the Interior
ITA	Indian trust assets

LRS	low-range summer
mg/L	milligrams per liter
MOA	memorandum of agreement
MPCEIS	Long-Term Miscellaneous Purposes Contract Environmental Impact Statement
MRS	mid-range summer
NED	National Economic Development
NEPA	National Environmental Policy Act of 1969
NGVD 29	National Geodetic Vertical Datum of 1929
NHL	National Historic Landmark
NHPA	National Historic Preservation Act of 1966
NMDA	New Mexico Department of Agriculture
NMED	New Mexico Environment Department
NMFD	New Mexico Energy, Minerals and Natural Resources Department, Forestry Division
NMDGF	New Mexico Department of Game and Fish
NMISC	New Mexico Interstate Stream Commission
NMOSE	New Mexico Office of State Engineer
NMRPTC	New Mexico Rare Plant Technical Council
NMSA	New Mexico Statutes, Annotated
NMWQCC	New Mexico Water Quality Control Commission
NOA	Notice of Availability
NOI	Notice of Intent
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWIS	National Water Information System
PCPI	per capita personal income
PDL	Puerto de Luna
PDSI	Palmer Drought Severity Index
PF	prime farmland
PRDSS	Pecos River Decision Support System
PVACD	Pecos Valley Artesian Conservancy District
RABGW	Roswell Basin Ground Water Model
Reclamation	Bureau of Reclamation
RED	Regional Economic Development
ROD	Record of Decision
ROI	region of influence
RPA	reasonable and prudent alternatives
Service	U.S. Fish and Wildlife Service
shiner	Pecos bluntnose shiner
SHPO	State Historic Preservation Office
Stat.	statute
TDS	total dissolved solids
TPI	total personal income
U.S.C	United States Code
USGS	U.S. Geological Survey
VCP	Vaughn-Crockett pipeline

Executive Summary

Executive Summary

1. Introduction

The Bureau of Reclamation (Reclamation) and the New Mexico Interstate Stream Commission (NMISC) prepared this Carlsbad Project Water Operations and Water Supply Conservation Draft Environmental Impact Statement (DEIS) to assess the potential consequences of proposed changes in Carlsbad Project operations and the implementation of a water acquisition program in the Pecos River basin, New Mexico.

This analysis was carried out to meet requirements of the National Environmental Policy Act (NEPA) and the Endangered Species Act of 1973, as amended (ESA). This DEIS includes a description of alternative means of implementing the proposed Federal action (alternatives) and presents an evaluation of the potential environmental, economic, and social consequences that could result from implementing these alternatives. These proposed changes in water operations are designed to conserve the federally threatened Pecos bluntnose shiner (*Notropis simus pecosensis*) (shiner) and its designated critical habitat, while conserving the Carlsbad Project water supply.

2. Proposed Federal Actions

The proposed Federal actions that require NEPA compliance are changes in Carlsbad Project operations and the implementation of a water acquisition program. As required by NEPA, a No Action Alternative is also analyzed that would continue current Carlsbad Project operations and water acquisition actions.

Carlsbad Project operations include diverting water to storage and releasing water for authorized uses. Sumner Lake is the storage reservoir located immediately upstream of the reach of the river where the shiner is still present. Reclamation has limited opportunities to store and release water in Sumner Lake under its State water rights permit and the Sumner Dam authorization.

Proposed changes in Carlsbad Project operations include bypassing available inflows through Santa Rosa and Sumner Dams to meet target flows or minimum flows as measured at either the Taiban gage (i.e., the Below Taiban Creek Near Fort Sumner gage) or the Near Acme gage. These gages are used to monitor flows in river reaches that have dried in the past. Depending on the alternative, these target flows can be constant or variable by time of year or by to hydrologic conditions. Actions contemplated also include guidance for block releases, use of a fish conservation pool, and implementation of an adaptive management plan.

Because changes in Carlsbad Project operations to benefit the shiner could result in reduction to the available Carlsbad Project water supply, a variety of options for acquiring water to keep the project whole are under consideration. Additional options have been developed to acquire water to directly augment flows and meet target flows at gage locations in reaches of the river where the shiner is present. Both types of water acquisition options include a range of actions that are not fully developed as site-specific proposals. As part of the record of decision (ROD) for this EIS, options that provide Reclamation the tools needed to meet the project purpose and need will be retained and specific proposals developed. Implementation of water acquisition options may require additional permitting, consultations, Congressional authorization, and NEPA analysis. Additional NEPA analysis is expected to include the preparation of documents tiered from this DEIS, such as environmental assessments and categorical exclusions. For some actions, resource-specific field studies, such as cultural and biological resource studies, may be conducted. Entities other than Reclamation may need to implement some of these options. Reclamation actions must be in accordance with its existing Federal and State legal and statutory authorities and obligations, the Pecos River Compact, water rights, and contractual obligations.

3. Purpose of and Need for Action

The purpose of Reclamation's proposed Federal action is to conserve[1] and protect the Pecos bluntnose shiner, a federally threatened fish species, and to conserve the Carlsbad Project water supply.[2] The underlying need for Reclamation action is compliance with ESA and Reclamation's responsibility to conserve the Carlsbad Project water supply.

Reclamation needs to comply with ESA for operation of its Pecos River facilities. Reclamation is proposing changes in operations that benefit the shiner under its existing authorities and are consistent with its ESA section 7(a) (1) obligation to conserve and protect listed species. Within the exercise of its discretionary authority, Reclamation must also continue to avoid jeopardizing the continued

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[1] Conserving the shiner means that Reclamation would ensure that any discretionary action is authorizes, funds, or carries out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. Reclamation would continue to participate in interagency actions to protect federally-listed species and designated critical habitats, within its legal and discretionary authority.

[2] Conserving the Carlsbad Project water supply means delivering the amount of water to the project that would otherwise be available but for changes to operations.

existence of the shiner or destroying or adversely modifying designated critical habitat [ESA section 7(a)(2)].[3]

Reclamation has also elected to keep the Carlsbad Project water supply whole. Without an accompanying program to acquire and provide water, changes to pre-1991 operations would cause reductions to the Carlsbad Project water supply.

4. Alternatives

NEPA requires consideration of a reasonable range of management alternatives that meet the purpose of and need for the proposed action. The joint lead agencies also need to be responsive to issues identified during scoping; need to provide flexibility in order to address issues of uncertainty; and need to meet Federal, State, and local laws, regulations, and agreements.

Reclamation and NMISC developed a No Action Alternative and five action alternatives: (1) Taiban Constant, (2) Taiban Variable, (3) Acme Constant, (4) Acme Variable, and (5) Critical Habitat. Reclamation has selected Taiban Constant as the preferred alternative. This alternative proposes to operate the Carlsbad Project to (1) divert to storage when flows at the Taiban gage are greater than 35 cfs and (2) deliver from storage Carlsbad Project water as contracted for irrigation and consistent with applicable Federal and State laws.

Reclamation has selected the Taiban Constant Alternative as the preferred alternative for this DEIS and for initiation of section 7 consultation under ESA with the Service. Under this alternative, Reclamation proposes to operate the Carlsbad Project to (1) divert to storage when flows at the Taiban gage are greater than 35 cfs, and (2) deliver from storage Carlsbad Project water as contracted for irrigation and consistent with applicable Federal and State laws. This alternative best meets the purpose of and need for the proposed action.

Under the No Action Alternative, Reclamation would continue to manage Pecos River dam operations in accordance with the Final Biological Opinion for the Bureau of Reclamation’s Proposed Pecos River Dam Operations, March 1, 2003 through February 28, 2006, dated June 18, 2003 (BO), Reclamation authorizations, water rights, and contractual obligations. Each action alternative includes common guidance for block releases. The action alternatives include an Adaptive Management Plan that is intended to monitor target flows and net depletions; to establish procedures, mitigative actions, and sources of water when compliance with target flows are threatened; and to respond to new information

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[3] Under section 7(a)(2), a discretionary agency action jeopardizes the continued existence of a species if it “reasonably would be expected, directly or indirectly, to reduce appreciably the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species.”

and changing conditions. Under the action alternatives, Reclamation would cooperate with other agencies in ongoing and future conservation measures, including developing wells and pumping infrastructure for supplementing short-term flows, removing non-native riparian vegetation, participating in channel restoration projects, and other direct and indirect actions to enhance shiner conservation. Reclamation participation would be limited by its authority, and most of these measures would require additional permitting, Congressional authorization, and project-specific NEPA analysis.

Table ES.1 provides a summary of the alternatives, specifies target flows and minimums, and indicates gage locations for monitoring flows. Target flows for the alternatives are either constant or variable by time of year or whether hydrologic conditions are dry, average, or wet. The defined target flows do not preclude enhancing base flows beyond target flows, if additional water is available and the Carlsbad Project water supply is conserved. The Near Acme gage on the Pecos River northeast of Roswell, New Mexico, is currently used to monitor flows in critical habitat for the shiner. Some alternatives include proposals to monitor flows at the Taiban gage. Use of this gage for monitoring may provide more timely and accurate information on river conditions in critical habitat for the shiner and improve the success of maintaining flows.

Table ES.1 Carlsbad Project Water Operations and Water Supply Conservation DEIS alternatives

<table>
<tr><th></th><th colspan="6">Range of flows [1,2]</th><th rowspan="2">Block release protocols</th><th rowspan="2">Other elements</th></tr>
<tr><th></th><th colspan="2">Dry</th><th colspan="2">Average</th><th colspan="2">Wet</th></tr>
<tr><th>Alternative</th><th>Nonirrigation season target flows</th><th>Irrigation season target flows</th><th>Nonirrigation season target flows</th><th>Irrigation season target flows</th><th>Nonirrigation season target flows</th><th>Irrigation season target flows</th><th>Time of year, magnitude, frequency, duration, ramp down</th><th>Water acquisition, shiner conservation and management measures, adaptive management</th></tr>
<tr><td>Taiban Constant</td><td>35 cfs Taiban</td><td>35 cfs Taiban</td><td>35 cfs Taiban</td><td>35 cfs Taiban</td><td>35 cfs Taiban</td><td>35 cfs Taiban</td><td rowspan="5">Time of Year: On CID[3] request. Avoid releases during 6 weeks around August 1.
Magnitude: On CID request and to maximize efficiency.
Frequency: On CID request, but a minimum of 14 days between block releases.
Duration: 15-day maximum per release.
Ramp down: No ramp down required.</td><td rowspan="5">Within Reclamation's authorities, acquire water for the Carlsbad Project and for the shiner using respective “A” list options. Maintain fish conservation pool. Implement Adaptive Management Plan (AMP). Continue existing shiner management measures and cooperate with others in shiner conservation measures.</td></tr>
<tr><td>Taiban Variable</td><td>35 cfs Taiban</td><td>45 cfs, -5, +10 Taiban</td><td>35 cfs Taiban</td><td>45 cfs, -5, +10 Taiban</td><td>35 cfs Taiban</td><td>45 cfs, -5, +10 Taiban</td></tr>
<tr><td>Acme Constant</td><td>35 cfs Acme</td><td>35 cfs Acme</td><td>35 cfs Acme</td><td>35 cfs Acme</td><td>35 cfs Acme</td><td>35 cfs Acme</td></tr>
<tr><td>Acme Variable</td><td>35 cfs Acme</td><td>12 cfs Acme</td><td>35 cfs Acme</td><td>24 cfs Acme</td><td>35 cfs Acme</td><td>48 cfs Acme</td></tr>
<tr><td>Critical Habitat</td><td>35 cfs Taiban minimum</td><td>Critical habitat kept wet; avoid intermittency Acme</td><td>35 cfs Taiban minimum</td><td>5 cfs Acme</td><td>35 cfs Taiban minimum</td><td>10 cfs Acme</td></tr>
</table>

Table ES.1 Carlsbad Project Water Operations and Water Supply Conservation DEIS alternatives

	Range of flows [1,2]						Block release protocols	Other elements
	Dry		Average		Wet			
No Action (current operations, based on current BO)	35 cfs Acme	Upper critical habitat kept wet; avoid intermit-tency Acme	35 cfs Acme	20 cfs Acme	35 cfs Acme	35 cfs Acme	**Same as other alternatives except**: Time of year: No stipulation to avoid releases during 6 weeks around August 1. Duration: Maximum of 65 days per year.	**Same as other alternatives except**: AMP is not specifically included. Water would continue to be acquired from current sources, and new sources would be developed.

[1] Target flows are based on the Final Biological Opinion for the Bureau of Reclamation's Proposed Pecos River Dam Operations, March 1, 2003, through February 28, 2006, dated June 18, 2003 (BO) (U.S. Fish and Wildlife Service [Service], 2003).
[2] Dry hydrologic condition: Effective Brantley storage is less than 75,000 acre-feet.
Average hydrologic condition: Effective Brantley storage is greater than 75,000 acre-feet and less than 110,000 acre-feet.
Wet hydrologic condition: Effective Brantley storage is greater than 110,000 acre-feet.
[3] CID = Carlsbad Irrigation District

Under all action alternatives, additional water would be acquired to ensure that the Carlsbad Project water supply would be conserved. Options for acquiring water for both the Carlsbad Project water supply (Carlsbad Project water acquisition [CPWA] options and for augmenting flows for the shiner were screened (additional water acquisition [AWA] options) and developed for analysis in this DEIS. These water acquisition options include five general categories: water right purchase and retirement, water right lease and retirement, change in cropping patterns, development of well fields, and Fort Sumner Irrigation District (FSID) gravel pit pumping. The options are not linked to specific alternatives, but instead represent a suite of potential sources for water acquisition. Some water acquisition options may need to be implemented by entities other than Reclamation.

Table ES.2 presents the "A" list of 16 CPWA options. The "A" list is further refined by recognition that the amount of water generated by the option would not be fully effective in replacing depletions to the Carlsbad Project water supply. For example, the purchase and retirement of FSID water rights make water available far upstream of the Carlsbad Project, and less than the full amount of water generated at FSID would be available farther downstream because of conveyance losses. Table ES.3 presents the "A" list of AWA options. The table includes the final combined total score, the amount of potentially available water, and the projected cost. The table describes the AWA options that could be implemented to provide water within 3 years. Additional NEPA analysis may be required for some options and may include the preparation of documents tiered from this DEIS, such as environmental assessments and categorical exclusions. For some options, resource specific field studies (cultural and biological resource studies) may be conducted.

Table ES.2 "A" list: equally weighted ranking of CPWA options

Rank	Designation[1]	Option name/ description	Reclamation authority	Amount available (consumptive acre ft/year)[2]	Average CPWA efficiency to CID[3]	Average effective CPWA (acre ft/year)	Combined total score (no units)	Adjusted EUAC[4] ($/acre-ft/year)
1	Q1-SR	Develop well field: Seven Rivers	No authority to construct facilities, but authority to acquire water for the Carlsbad Project.	10,000	67%	6,700	77.0	433
2	Q1-BV	Develop well field: Buffalo Valley	No authority to construct facilities, but authority to acquire water for the Carlsbad Project.	10,000	58%	5,800	76.0	455
3	D-1B	Surface water right purchase: Roswell area	Yes – for Carlsbad Project uses.	1,600	55%	1,300	74.0	180
4	E-1B	Surface water right lease: Roswell area	Yes – for Carlsbad Project uses.	1,600	55%	1,300	73.0	165
5	D-1A	Surface water right purchase: FSID	Yes – for Carlsbad Project uses.	1,000	23%	300	72.0	431
6	D-1BX	Surface water right purchase: Roswell area	Yes – for Carlsbad Project uses.	1,600	55%	1,300	72.0	252
7	L-3	Changes to cropping patterns: CID[5] (very low water use crop)	Yes – for Carlsbad Project uses.	10,500	100%	10,500	71.5	182
8	E-1A	Surface water right lease: FSID	Yes – for Carlsbad Project uses.	1,000	23%	300	71.0	396
9	D-1C	Surface water right purchase: CID	Yes – for Carlsbad Project uses.	3,150	100%	3,150	71.0	99
10	E-1C	Surface water right lease: CID	Yes – for Carlsbad Project uses.	3,150	100%	3,150	70.0	91
11	D-1AX	Surface water right purchase: FSID	Yes – for Carlsbad Project uses.	1,000	23%	300	70.0	603

Table ES.2 "A" list: equally weighted ranking of CPWA options

Rank	Designation[1]	Option name/ description	Reclamation authority	Amount available (consumptive acre ft/year)[2]	Average CPWA efficiency to CID[3]	Average effective CPWA (acre ft/year)	Combined total score (no units)	Adjusted EUAC[4] ($/acre-ft/year)
12	D-1CX	Surface water right purchase: CID	Yes – for Carlsbad Project uses.	3,150	100%	3,150	69.0	139
13	L-2	Changes to cropping patterns: CID[5] (low water use crop)	Yes – for Carlsbad Project uses.	8,800	100%	8,800	66.5	249
14	L-1	Changes to cropping patterns: CID[5] (average of all water use amounts)	Yes – for Carlsbad Project uses.	8,900	100%	8,900	65.5	206
15	L-4	Changes to cropping patterns: CID[5] (medium water use crop)	Yes – for Carlsbad Project uses.	6,000	100%	6,000	64.5	209
16	U	FSID gravel pit pumping	Unknown – construction may be considered operations and maintenance, but do have the authority to acquire water for the Carlsbad Project.	300	74%	222	62.0	13

[1] Options designated with an "X" represent the option with the same designation but with an escalated cost of 40% to account for market pressures.

[2] Amount presented for all water rights acquisition options is the Consumptive Irrigation Requirement (CIR). The CIR is the amount of irrigation water, exclusive of precipitation, stored soil moisture or groundwater needed consumptively for crop production.

[3] Note that “amount available” column multiplied by efficiency in this column does not yield effective offset. Only diverted amounts (convert from CIR amount by multiplying by 3 acre-feet/acre and dividing by 2.1 acre-feet/acre) can be multiplied by efficiencies in this column to determine effective offset.

[4] EUAC was “adjusted” to account for CPWA option efficiencies.

[5] The changes to cropping patterns were based on conversion of 5,000 acres of alfalfa to the crops with the indicated level of water.

Table ES.3 "A" list AWA options

Designation[1]	Option name	Reclamation authority	Combined total score	Amount available (consumptive acre-feet/year)	EUAC ($/acre-feet/year)
A-1	Surface water right purchase: CID	Yes – for Carlsbad Project uses	75.5	3,150	99
A-2	Surface water right purchase: FSID	Yes – for Carlsbad Project uses	73.5	1,000	99
A-1X	Surface water right purchase: CID (additional 40-percent inflation)	Yes – for Carlsbad Project uses	73.5	3,150	139
B-1	Surface water right lease: CID	Yes – for Carlsbad Project uses	72.5	3,150	91
A-2X	Surface water right purchase: FSID (additional 40% inflation)	Yes – for Carlsbad Project uses	71.5	1,000	139
B-2	Surface water right lease: FSID	Yes – for Carlsbad Project uses	70.5	1,000	91
I	FSID gravel pit pumping	Unknown – construction may be considered operations and maintenance, but do have the authority to acquire water for the Carlsbad Project	63.5	300	10
J-2	Fort Sumner area large-capacity well field	No authority to construct facilities, but authority to acquire water for the Carlsbad Project	62.0	1,384	150
J-1	Fort Sumner area small-capacity well field	No authority to construct facilities, but authority to acquire water for the Carlsbad Project	61.0	500	164
D-1C	Changes to cropping patterns: CID (very low water use crop)	Yes – for Carlsbad Project uses	60.0	10,500	128
D-1A	Changes to cropping patterns: CID (average of all water use amounts crop)	Yes – for Carlsbad Project uses.	60.0	8,900	144
D-1D	Changes to cropping patterns: CID (medium water use crop)	Yes – for Carlsbad Project uses	60.0	6,000	147
D-1B	Changes to cropping patterns: CID (low water use crop)	Yes – for Carlsbad Project uses	60.0	8,800	175
D-2	Changes to cropping patterns: FSID (small grain)	Yes – for Carlsbad Project uses	59.0	3,375	158
A-4	Surface water right purchase: Puerto de Luna area	Yes – for Carlsbad Project uses	57.5	110	99
A-4X	Surface water right purchase: Puerto de Luna area (additional 40-percent inflation)	Yes – for Carlsbad Project uses	55.5	110	139
B-4	Surface water right lease: Puerto de Luna area	Yes – for Carlsbad Project uses	54.5	110	91
D-4	Changes to cropping patterns: Puerto de Luna area (very low water use crop)	Yes – for Carlsbad Project uses	47.5	360	168

[1] Options designated with an "X" represent the option with the same designation but with an escalated cost of 40% to account for market pressures.

5. Environmental Consequences

The proposed Federal action could potentially affect water resources; water quality; agricultural soil and land resources; biological resources, including special status species; regional economy; recreation, cultural resources; Indian trust and treaty assets (ITA); and environmental justice. The analysis of the effects of the alternatives on these resources focused on selected *indicators*. A resource indicator is a particular measure of a resource used to assess impacts on the overall resource. Table ES.4 (at the end of this summary) summarizes the impacts of the alternatives on the resource indicators analyzed in this DEIS.

5.1 Water Resources

The following indicators were selected to evaluate water resources: (1) flow frequency at the Near Acme gage, (2) Carlsbad Project water supply, (3) flows at the New Mexico-Texas State line, (4) CPWA option efficiencies.

The analysis indicates higher flows would occur more frequently under the alternatives with higher target flows, but the associated target flows cannot be met as frequently. Model results show that intermittency (flows of 0 cfs) occurs less frequently under every alternative than under the pre-1991 baseline. Differences in the frequency of intermittency among the alternatives are quite small and may be considered insignificant. The analysis indicates that the highest average annual net depletions to both the Carlsbad Project water supply and to State-line flows would occur under the Acme Constant and Acme Variable Alternatives, and the lowest net depletions would occur under the Taiban Constant and Critical Habitat Alternatives. There is a strong correlation between an alternative's net depletions to the Carlsbad Project water supply and the magnitude of its target flows. There is a similar correlation between an alternative's net depletions to State-line flows and the magnitude of its target flows.

5.2 Water Quality

The analysis indicates that specific electrical conductance (EC), the selected indicator of water quality, would be lower under the Acme Constant and Acme Variable Alternatives and higher under the Critical Habitat Alternative and the Taiban Variable Alternative than the under No Action Alternative. However, model results indicate that any effects on EC resulting from bypass flows would be eliminated once the CPWA options are in place. As a result, changes in Carlsbad Project operations would have no net effect on water quality.

Changes in Carlsbad Project operations would not affect the five reaches of the Pecos River in the study area that are listed as impaired for sedimentation/siltation under the Clean Water Act or the reasons for their listing. Likewise, the four Carlsbad Project reservoirs are listed as impaired for excessive mercury concentrations in fish tissue would not be affected by changes in Carlsbad Project operations.

The Pecos River from Sumner Dam to Brantley Reservoir is classified as supporting a warmwater fishery. This reach of the Pecos River is listed under the Clean Water Act as fully supporting of all classified uses. In addition to a warmwater fishery, the river is classified for irrigation, livestock watering, wildlife habitat, and secondary contact recreation, i.e., contact that does not involve full body immersion in the water. None of these uses should be adversely affected by changes in Carlsbad Project operations.

5.3 Agricultural Soil and Land and Resources

The following indicators were selected to evaluate agricultural soil and land resources: (1) soil erosion potential (mainly wind erosion), (2) soil quality (mainly soil salinity), (3) land quality, as measured by the acres of lands meeting criteria for national prime farmland (PF) and the acres of lands meeting criteria for farmlands of Statewide importance (FSI), and (4) acres of land infested with noxious weeds and plants (mainly salt cedar).

Greater evaporative transmission losses associated with the No Action Alternative and all the action alternatives would tend to lead to a smaller water supply and a higher salinity of the irrigation water at the Carlsbad Irrigation District (CID) diversion structure at Avalon Dam into the CID main canal compared to conditions since the construction of Brantley Reservoir.

In the absence of water acquisition options, the result would be substantial adverse impacts (e.g., greater soil salinity, reduced crop yields) to CID soil and land resources. Many CID lands barely meet the criteria for national PF, and any decrease in the quantity or increase in the salinity of the irrigation water would raise soil salinity above the threshold of 4 deciSiemens per meter (dS/m) EC of the saturation extract (ECe) for PF in many areas. Higher soil salinity also would lead to smaller crop yields and encourage abandonment of some marginal lands. In dry and average hydrologic conditions, water quality (salinity) also would deteriorate during the critical early spring crop establishment period, a major adverse impact on CID.

This analysis of the alternatives is based on full water acquisition options to make up for any depletions to CID and provide for an early spring block release to reduce the salinity in Brantley Reservoir for crop establishment. These water acquisition options have the effect of “spreading” the impacts on the land and resources over the entire Pecos River Valley downstream from the Guadalupe County northern boundary line. The principal adverse impact would be the loss of PF due to water right purchase and retirement of lands from irrigation. Impacts to soil quality should be minimal as long as the retired lands are reseeded to perennial grasses. The impacts also could be minimized by targeting marginal and unproductive lands for retirement rather than prime farmlands.

5.4 Biological Resources

The following broad indicators were selected to evaluate biological resources: (1) terrestrial and flood plain ecosystem components (including wetlands, riparian vegetation, and wildlife), (2) riverine aquatic ecosystem components, (3) reservoir aquatic ecosystem components, (4) special status species that occur within the study area, especially the Pecos bluntnose shiner and the interior least tern, and (5) critical habitat within the study area.

No additional impacts on terrestrial, flood plain, and wetland ecosystem components, including special status species inhabiting terrestrial ecosystems, are expected under any alternative because no changes are expected in overbank flooding or bank erosion. Carlsbad Project water acquisition options may occur on upland habitats and would have direct impacts to terrestrial vegetation.

For riverine aquatic ecosystem components, analysis shows that in the reach from Santa Rosa Reservoir to Sumner Lake, no change is expected under any alternative because of stable base inflow conditions. In the reach from Sumner Lake to Brantley Reservoir, model results show that intermittency occurs under all alternatives with bypass flows, with little difference among the alternatives. With AWA options and adaptive management guidance, impacts could be eliminated or mitigated to levels that would be better than under the No Action Alternative. These flexibilities would be extremely important for protecting Pecos bluntnose shiner populations during the irrigation season in dry and average hydrologic conditions.

The analysis of reservoir aquatic ecosystem components shows that the minimum, average, and maximum pool elevations of Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoirs each are very similar under all the alternatives. Additionally, measures of variation in pool elevations were very similar and indicate that little difference would be expected in elevations over time. Because of the similarities, effects to the habitats of reservoir fishes or their spawning areas would be comparable under all alternatives.

For the interior least tern, impacts of all action alternatives would be expected to be very similar to those of the No Action Alternative. Generally, impacts to other special status species would be minimal.

5.5 Regional Economy

Several indicators were selected to evaluate impacts on the regional economy: (1) change in value of regional output produced in the study area, (2) change in regional income, and (3) change in regional employment.

Impacts to the regional economy associated with changes in Carlsbad Project operations could occur as a result of water right purchases/leases (and associated land retirement or fallowing) and changes in cropping patterns. These impacts are the result of changes in net farm revenues and input expenditures associated with changes in agricultural production. Most of these changes in agricultural production would lead to negative regional economic impacts. Some positive impacts also could occur as a result of land or lease payments made to farmers adversely affected by land use changes.

Regional economic impacts are estimated to be less under the Taiban Constant Alternative, the Taiban Variable Alternative (45 cfs), and the Critical Habitat Alternative than under the No Action Alternative. The estimated upper range of regional economic impacts under these three alternatives are $1.6 million in total value of output lost and losses of about 21 jobs per year compared to the pre-1991 baseline. The high range of impacts is $0.5 million in additional value of output and creation of 7 jobs each year compared to the No Action Alternative.

Some positive impacts are associated with each action alternative as a result of lump-sum land retirement or lease payments and compensation for lost farm revenues as a result of changes to cropping patterns. These are **one-time impacts,** not recurring negative annual impacts. The greatest one-time positive impacts would occur under the Acme Constant Alternative, followed by the Acme Variable Alternative, the Taiban Variable Alternative, and the Taiban Constant and Critical Habitat Alternatives.

5.6 Recreation

The following indicators were selected to evaluate recreation: (1) recreation visitation and associated expenditures at Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir and (2) recreation along the Pecos River.

The action alternatives are expected to have negligible to minor impacts on recreation. That is, recreation use of the reservoirs and the Pecos River is expected to vary from year, perhaps drastically, but the different operating regimes for the system would not, in and of themselves, be the cause of major changes in use from year to year.

5.7 Cultural Resources

The following indicators were selected to evaluate changes to cultural resources: (1) the presence or potential for cultural resources that may be eligible for listing on the *National Register of Historic Places* (NRHP) or locations that are important to Native American or other traditional communities in areas affected by the action, (2) changes in riverflow and reservoir storage levels and fluctuation where there is a potential for directly disturbing resources, increasing access to resources, or exposing submerged resources and (3) ground-disturbing activities such as drilling, trenching, grading, or construction where resources may be present; modifications to historic water retention or conveyance infrastructure; or loss or abandonment of historic structures associated with water acquisition options.

The changes in Carlsbad Project operations proposed under all of the alternatives would result in negligible impacts to cultural resources. Sites in the immediate vicinity of the river or in flood zones have been subject to past disturbances, reducing the likelihood of their intact preservation. Proposed flow levels, flow fluctuations, and changes in reservoir storage would be within the range of normal river and reservoir operations and would not be expected to exacerbate erosion of archaeological resources or exposure of submerged resources. The potential for these kinds of impacts is greater from natural drought cycles and flood events.

Water acquisition options could be associated with negligible to major impacts on cultural resources due to ground-disturbing activities, modification of historic infrastructure, loss or abandonment of historic structures. In all cases, the implementation of these options would require further consideration of cultural resource impacts and completion of the National Historic Preservation Act, section 106 process for actions that are Federal undertakings. Depending on the option, the identification, evaluation, effects determination, and resolution of adverse effects through the section 106 process could require extensive additional fieldwork and the possibility of project redesign to avoid resources. Impacts would be expected to be reduced to negligible or minor in most cases.

5.8 Indian Trust and Treaty Assets

The following resource indicator was selected to evaluate Indian trust and treaty assets (ITAs): (1) the potential for the action to affect Indian real property, physical assets, or intangible property rights.

No ITAs have been identified in consultation with tribes and the Bureau of Indian Affairs. There are no reservations or ceded lands in the region of influence. Because resources are not believed to be present, no impacts are anticipated to result from the alternatives or from water offset and acquisition options, but contact w.

5.9 Environmental Justice

The location of any negative regional economic or social impacts associated with each alternative is difficult to determine because the location of retired/fallowed land or land with changes to cropping patterns cannot be predicted with any certainty. However, environmental justice concerns would be raised if any alternative results in impacts that are primarily imposed on irrigated land or recreation in Guadalupe County. Likewise, there could be an environmental justice impact if acequias are retired since many of these systems support lands owned by Hispanic farmers. Acquiring acequia water would require consensus of the acequia community, which is unlikely; therefore, such an impact would have a low chance of occurring.

The analysis of agricultural economic impacts indicates the greatest potential negative regional impacts are associated with the Acme Constant and Acme Variable Alternatives. The recreation analysis indicates minimal impacts under each alternative, although "somewhat less" recreation is expected to occur under the Taiban Constant and Taiban Variable Alternatives. Therefore, the possibility of potential environmental justice concerns is greatest under these two alternatives.

5.10 Environmental Commitments

This section provides the environmental commitments that may be implemented with the selection of any of the alternatives. These commitments generally are intended to avoid, mitigate, or compensate for adverse environmental effects that would otherwise occur.

Water acquisition programs: The Carlsbad project water acquisition options and the additional water acquisition options are incorporated as common actions to all alternatives. These options will be implemented as needed to help meet target flows and to conserve the Carlsbad Project water supply. All options that involve water or land leasing or purchasing would be conducted on a willing-seller basis.

Adaptive management plan (AMP): The AMP (appendix 1) is incorporated as common to all alternatives. Uncertainty is an unavoidable component of restoring and managing natural systems. To help address uncertainty, the AMP will be implemented to guide how management actions should be adjusted over time based on results of monitoring. In short, the AMP provides guidance for monitoring EIS targets, addressing actions to be taken for targets that are at risk of being missed, and addressing changing conditions in the future management of river operations by modifying operations within established parameters. The AMP provides a framework to ensure that the selected alternative satisfies the requirements of the EIS and the purpose of and need for the proposed action.

Agricultural lands: To minimize soil erosion, any retired farmlands should be reseeded to perennial grasses. This could require short-term maintenance in order to obtain adequate cover. In retiring lands, marginal or unproductive lands should be targeted rather than prime farmland.

Land disturbance: Any activities that disturb the land would follow best management practices including soil stabilization (e.g., mulching and watering), revegetation, and noxious weed control. Appropriate environmental studies would be conducted to comply with laws and regulations. These could include archeological surveys, biological surveys, Native American consultation, and hazardous waste assessments.

6. Cumulative Impacts

Cumulative impacts are "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of which agency (Federal or non-Federal) or person undertakes such actions"(40 Code of Federal Regulations section 1508.7). There are numerous past, present, and reasonably foreseeable actions in the study area; however, the analysis focused on actions that may have a continuing, additive, and significant relationship to the effects of the proposed action.

6.1 Water Resources

The most apparent significant cumulative impact to water resources in the study area results from the Settlement Agreement. Because this project also uses agricultural land retirement as a solution to water resource supply problems, it will additionally impact farmers in the basin. Water conservation projects may augment the Carlsbad Project water supplies and help increase State-line flows, but the level of this conservation may reach a point of diminishing returns and, in fact, may introduce new net depletions if taken too far (losses from rising ground-water tables). Other projects, such as restoration and water salvage activities along the river, are small, and will not have a significant cumulative impact on water resources in the basin because of their limited size.

6.2 Water Quality

Overall, many of the cumulative actions strive to increase or maintain water flows in the river, which would have a beneficial net effect on water quality. Likewise, less agricultural use of water could reduce salinity as less drain and tailwater would enter the Pecos River system. Conversely, any future development in the basin likely would degrade water quality as a result of increased waste loadings to the river. Only activities directly related to agricultural development would likely be considered cumulative to the Carlsbad Project operations addressed in this DEIS.

6.3 Agricultural Soil and Land Resources

The only significant cumulative adverse impact of the actions considered in this DEIS and the other related actions on agricultural soils and lands would be a reduction in the acreages of prime farmland (PF) and farmland of statewide importance (FSI) in New Mexico.

6.4 Biological Resources

The net cumulative effect to biological resources generally would be positive as most of the listed projects are focused on increasing flows for Pecos River Compact delivery purposes and the Carlsbad Project water supply. Higher and more reliable base inflows would benefit aquatic ecosystems throughout the study area. Current riparian ecosystems and the species dependent upon the habitats provided likely would not benefit from the listed projects. However, long-term benefits might be realized through the removal of non-native phreatophytes that would allow for possible reestablishment of native vegetated communities and associated wildlife species.

6.5 Regional Economy

The continuing trend in the region for land fallowing, retirement, and changes to cropping patterns has a cumulative negative impact to local economies. Without specific data on where lands would be retired or fallowed, a cumulative assessment of long-term losses in economic output and employment is crop value loss and job loss is uncertain. Assuming the Long-Term Miscellaneous Purposes Contract and Settlement Agreement would result in the combined retirement of about 22,000 to 23,000 acres, economic impacts would range from about $14.4 to $16.8 million in the total value of regional output lost annually and the losses of 187 to 218 jobs annually. These impacts represent less than 1 percent of the total value of regional output and less than one-half of 1 percent of employment in the six-county economic impact area. Other actions would serve to either mitigate this impact, such as increased oil and gas production and new developments, including the cheese factories. Other actions, such as the closure of Cannon Air Force Base, could increase the net adverse impact to the regional economy.

6.6 Recreation and ITAs

There are no cumulative impacts of the proposed action on recreation or Indian trust and treaty assets in relation to other projects or programs (ongoing or reasonably foreseeable future actions) in the Pecos River basin.

6.7 Cultural Resources

Although few surveys have been conducted to confirm their presence, it is likely that there are many unrecorded cultural resources that could be impacted by this project or ongoing or reasonably foreseeable future actions. The changes in Carlsbad Project operations (block releases, target flows, reservoir levels) proposed under all of the alternatives would result in negligible effects to cultural resources. The effects of water acquisition options are unknown, but could be similar to those resulting from ongoing or reasonably foreseeable future regional actions in type, intensity, timeframe and general location. Implementation of the water acquisition options and many of the regional actions would be subject to further consideration under Federal and/or State cultural resource statutes and regulatory protections. Some regional actions would not be subject to further cultural resource consideration. The intensity of cumulative impacts is unknown because of uncertainty about water acquisition options and the cultural resource impact, but it is anticipated that cumulative impacts are possible because of the additive effect and the location and timing of other regional actions.

6.8 Environmental Justice

A continuing trend of ongoing and proposed programs to fallow, retire, or change farming practices exists within the Pecos River basin. The exact location of where retirement or fallowing would occur cannot be predicted with certainty; however, the majority is expected to occur within CID and Fort Sumner Irrigation District, where a large percentage of the irrigated acreage is located. To the extent that some land retirement could also occur in Guadalupe County, there could be some cumulative impacts that would affect low-income or minority populations.

7. Summary of Impacts Table

Table ES.4 summarizes the impacts of the alternatives on the resource indicators analyzed in this DEIS.

Table ES.4 Summary of impacts of alternatives on resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Water Resources						
Difference in percent of time modeled flows of 10 cfs at the Near Acme gage are exceeded	10 percent more frequently than under pre-1991 baseline	3 percent less frequently than under No Action	3 percent less to 4 percent more frequently than under No Action	7 percent more frequently than under No Action	5 percent more frequently than under No Action	2 percent less frequently than under No Action
Difference in percent of time modeled flows of 20 cfs at the Near Acme gage are exceeded	19 percent more frequently than under pre-1991 baseline	10 percent less frequently than under No Action	8 to 9 percent less frequently than under No Action.	10 percent more frequently than under No Action	3 percent more frequently than under No Action	6 percent less frequently than under No Action

Table ES.4 Summary of impacts of alternatives on resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Difference in percent of time modeled flows of 30 cfs at the Near Acme gage are exceeded	24 percent more frequently than under pre-1991 baseline	23 percent less frequently than under No Action	23 percent less frequently than under No Action.	8 percent more frequently than under No Action	0.6 percent more frequently than under No Action	23 percent less frequently than under No Action
Difference in frequency of modeled intermittency at the Near Acme gage	0.3 percent less frequently than under pre-1991 baseline	0.04 percent less frequently than under No Action	0.08 to 0.3 percent less frequently than under No Action	0.3 percent less frequently than under No Action	0.3 percent less frequently than under No Action	0.1 percent more frequently than under No Action
Additional water needed (AWN) to meet target flows	Average of 2,900 acre-feet per year more than under pre-1991 baseline	Average of 720 acre-feet per year more than under pre-1991 baseline	Average of 1,400 to 4,200 acre-feet per year more than under pre-1991 baseline	Average of 9,500 acre-feet per year more than under pre-1991 baseline	Average of 5,300 acre-feet per year more than under pre-1991 baseline	Average of 620 acre-feet per year more than under pre-1991 baseline
Modeled average annual depletions (net depletions) to Carlsbad Project water supply	Average of 1,600 acre-feet per year greater than under pre-1991 baseline	Average of 1,200 acre-feet per year greater than under pre-1991 baseline	Average of 1,200 to 1,700 acre-feet per year greater than under pre-1991 baseline	Average of 3,900 acre-feet per year greater than under pre-1991 baseline	Average of 3,000 acre-feet per year greater than under pre-1991 baseline	Average of 1,200 acre-feet per year greater than under pre-1991 baseline
Modeled average annual flows at the New-Mexico State line	1,200 acre-feet per year lower than under pre-1991 baseline	440 acre-feet per year lower than under pre-1991 baseline	690 to 1,600 acre-feet per year lower than under pre-1991 baseline	2,100 acre-feet per year lower than under pre-1991 baseline	1,600 acre-feet per year lower than under pre-1991 baseline	530 acre-feet per year lower than under pre-1991 baseline
Water Quality						
EC	EC as much as 900 µS/cm higher in Brantley Reservoir and more than 300 µS/cm higher in CID; higher EC in all year types, but highest in dry year, lowest in wet year. Impacts would be moderate, localized, and long-term.	Slightly higher EC in wet year, but higher than under No Action in other year types. Impacts would be minor, localized, and long-term.	Higher EC in dry years and lower EC in normal and wet years at high and intermediate target flows; lower EC in wet years and higher EC in normal and dry years at lowest target flows. Impacts would vary with target flows, but overall would be minor, localized, and long-term.	Lower EC in normal and dry years, but higher in wet years when EC is generally lower. Impacts would be moderate, localized, and long-term.	No change in EC in wet year, but lower EC in normal and dry years, highest EC in dry years. Impacts would be moderate, localized, and long-term.	Higher EC in all year types, Impacts would be minor, localized, and long-term.
Agricultural Soil and Land Resources						
Overall resource	Minor localized adverse impacts to agricultural soil and land resources compared to pre-1991 baseline	Minor adverse impacts compared to No Action	Minor adverse impacts compared to No Action	Minor adverse impacts compared to No Action, mainly because of greater land retirement	Minor adverse impacts compared to No Action	Minor, mitigatable impacts compared to No Action

Table ES.4 Summary of impacts of alternatives on resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
			Biological Resources			
Terrestrial and flood plain ecosystem components	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Riverine aquatic ecosystem components: Santa Rosa Reservoir to Sumner Lake	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	No change The lack of AWA options and adaptive management guidelines would not provide the management flexibility necessary to offset these potential impacts.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under No Action. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under No Action. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under No Action. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under No Action. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. Same as No Action. AWA options would not reduce or eliminate intermittency as under other action alternatives.
Riverine aquatic ecosystem components: Brantley Dam to New Mexico-Texas State line	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Reservoir aquatic ecosystem components	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action

Table ES.4 Summary of impacts of alternatives on resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Pecos bluntnose shiner	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir
Regional Economy						
Change in annual value of regional output ($)	- 350,000 to - 2,165,000	+ 88,000 to + 525,000	+ 88,000 to + 525,000 **to** - 22,000 to - 131,000	- 504,000 to - 3,149,000	- 307,000 to - 1,902,000	+ 88,000 to + 525,000
Change in annual regional income ($)	- 27,000 to - 871,000	+ 7,000 to + 211,000	+ 7,000 to + 211,000 **to** -2,000 to + 53,000	- 39,000 to - 1,267,000	- 24,000 to - 766,000	+ 7,000 to - 211,000
Change in regional employment (jobs)	-0.3 to -28.1	+0.1 to +6.8	+0.1 to +6.8 **to** 0.0 to -1.7	-0.5 to -40.8	-0.3 to -24.7	+0.1 to +6.8
Recreation						
Reservoir recreation and impacts	No change	Approximately the same as No Action	Approximately the same as No Action	Approximately the same as No Action	Approximately the same as No Action	Approximately the same as No Action
River recreation and impacts	No change	Less recreation use implies less recreation related spending and lower net benefits than No Action	Less recreation use implies less recreation related spending and lower net benefits than No Action	More recreation use implies more recreation related spending and higher net benefits than No Action	More recreation use implies more recreation related spending and higher net benefits than No Action	Approximately the same recreation use implies approximately the same recreation related spending and approximately the same net benefits as No Action
Cultural Resources						
Presence or potential for significant cultural resources	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Riverflow and reservoir storage levels and fluctuation where resources could be disturbed	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action

Table ES.4 Summary of impacts of alternatives on resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Ground-disturbing activities, modification, loss, or abandonment of historic structures	No change	Unknown. Least amount of AWN. Lower potential to exercise water acquisition options which could affect cultural resources.	Unknown. Low AWN. Lower potential to exercise water acquisition options which could affect cultural resources.	Unknown. Most AWN. Highest potential to exercise water acquisition options which could affect cultural resources.	Unknown. High AWN. Higher potential to exercise water acquisition options which could affect cultural resources	Unknown. Low AWN. Lower potential to exercise water acquisition options which could affect cultural resources.
Indian Trust and Treaty Assets						
Potential to affect Indian real property, physical assets, or intangible property rights	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action

EC = specific electrical conductance, AWN = additional water needed, µS/cm = microSiemens per centimeter

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Attachment

Biological Assessment of Proposed Carlsbad Project Water Operations and Water Supply Conservation (pending)

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Appendices

Chapter 1

Purpose of and Need for Action

Chapter 1
Purpose of and Need for Action

1. Introduction

The Bureau of Reclamation (Reclamation) and the New Mexico Interstate Stream Commission (NMISC) prepared this Carlsbad Project Water Operations and Water Supply Conservation Draft Environmental Impact Statement (DEIS) to assess the potential consequences of proposed changes in Carlsbad Project operations and the implementation of a water acquisition program in the Pecos River basin, New Mexico. (See map 1.1.) This analysis was carried out to meet requirements of the National Environmental Policy Act of 1969 (NEPA) and the Endangered Species Act of 1973, as amended (ESA). This DEIS includes a description of alternative means of implementing the proposed Federal action (alternatives) and presents an evaluation of the potential environmental, economic, and social consequences that could result from implementing these alternatives. These proposed changes in water operations are designed to conserve the Pecos bluntnose shiner (*Notropis simus pecosensis*) (shiner) and its designated critical habitat, while conserving the Carlsbad Project water supply.

What is the Carlsbad Project?

Carlsbad Irrigation District (CID) operates the Carlsbad Project to provide water for water users who are members of CID. The Secretary of the Interior authorized the Carlsbad Project for the purpose of irrigation in 1905.

Reclamation owns the Carlsbad Project dams and reservoirs, and CID operates the dams and reservoirs. Carlsbad Project operations include diverting to storage and releasing water to deliver project water to CID water users.

In 1987, the U.S. Fish and Wildlife Service (Service) listed the shiner, a small minnow, as a threatened species under ESA and designated two noncontiguous river reaches, totaling approximately 101 miles of the Pecos River, as critical habitat (52 *Federal Register* [FR] 5295-5303). Critical habitat is a geographical area occupied by the species at the time it is listed, on which are found those physical and biological features essential to the conservation of the species and which may require special management considerations or protection. The shiner population is currently restricted to about 194 miles of river between Fort Sumner State Park and Brantley Reservoir. Threats identified in the listing package included “restricted flow from reservoirs, water diversion for irrigation, siltation, and pollution from agricultural activities along the river.” Subsequent to the listing, additional information has been gathered to assess these threats.

Biologists generally agree that the greatest immediate threat to the shiner is intermittent flows between the lower boundary of the upper critical habitat and the U.S. Geological Survey (USGS) Near Acme gage near Roswell (Service, 2003; Kehmeier et al., 2004). Intermittency is an interruption in connected flows or temporary drying of the river. Reclamation believes that its discretionary actions do not cause the intermittency that has occurred since 1998, and that diversion to storage of water or block releases for the Carlsbad Project do not cause the intermittent conditions near the Near Acme gage that have occurred since 1998. In 1998, the Carlsbad Project began bypassing water when the water was available and was needed to provide continuous flow to the river. Intermittency near the Near Acme gage and the upper critical habitat has been caused by diversion of water downstream from Sumner Dam for irrigation and by the ongoing drought. Section 5, "Background," includes a discussion of Pecos River water rights and operations and their influence on intermittency.

Why is an EIS Being Prepared?

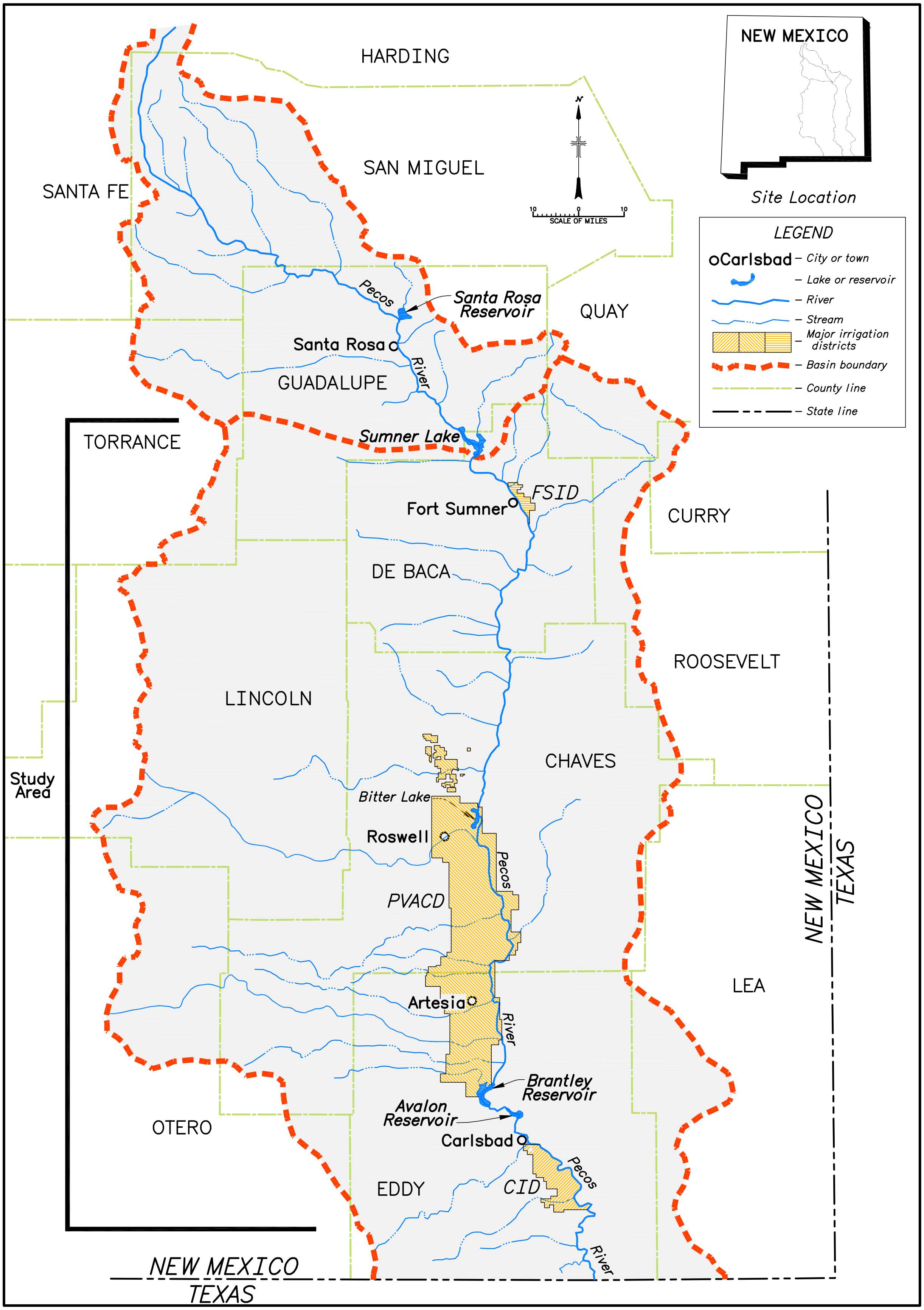
Under NEPA, an environmental impact statement (EIS) must be prepared for a major Federal action. Major Federal actions include new and ongoing activities that have the potential for significant impacts. The proposed action is a major Federal action based on the level of anticipated impacts associated with measures to conserve the Pecos bluntnose shiner and the Carlsbad Project water supply. This EIS documents potential impacts of the proposed action.

Private partnerships constructed water storage, canals, and diversion structures along the Pecos River in the late 1880s near Carlsbad, New Mexico. In 1905, the Secretary of the Interior authorized the original Carlsbad Project under the Reclamation Act of 1902. The Federal Government purchased and rehabilitated the existing irrigation system and constructed and maintained new facilities throughout the twentieth century. The Carlsbad Irrigation District (CID) is a political subdivision of the State of New Mexico created to deliver irrigation water to its members. CID has since repaid its obligation, and the Federal Government has transferred title for much of the distribution infrastructure to CID. Reclamation owns the project dams and reservoirs but contracts with CID for their operation. Reclamation holds Carlsbad Project storage rights for the beneficial use of CID members in accordance with various contracts between Reclamation and CID. Carlsbad Project beneficial use is downstream from the designated critical habitat.

2. Proposed Federal Actions

The proposed Federal actions that require NEPA compliance are changes in Carlsbad Project operations and the implementation of a water acquisition program. As required by NEPA, a No Action Alternative is also analyzed, which would continue current Carlsbad Project operations and water acquisition actions.

Carlsbad Project operations include diverting water to storage and releasing water for authorized uses. Sumner Lake is the storage reservoir located immediately



Map 1.1 Pecos River basin location map

upstream of the reach of the river where the shiner is still present. Reclamation has limited opportunities to store and release water in Sumner Lake under its State water rights permit and the Sumner Dam authorization, as described in Section 5, "Background."

Proposed changes in Carlsbad Project operations include bypassing available inflows through Santa Rosa and Sumner Dams to meet target flows or minimum flows as measured at either the Taiban gage (i.e., the Below Taiban Creek Near Fort Sumner gage) or the Near Acme gage. These gages are used to monitor flows in river reaches that have dried in the past. Depending on the alternative, these target flows can be constant or variable by time of year or by hydrologic condition, as defined in chapter 2. Actions contemplated also include guidance for block releases, use of a fish conservation pool, and implementation of an adaptive management plan.

Because changes in Carlsbad Project operations to benefit the shiner could result in reduction to the available Carlsbad Project water supply, a variety of options for acquiring water to keep the project whole are under consideration. Additional options have been developed to acquire water to directly augment flows and meet target flows at gage locations in reaches of the river where the shiner is present. Both types of water acquisition options include a range of actions described in

Key Terms and Concepts

Beneficial use: Uses of water including agricultural, commercial, industrial, and recreational that do not constitute waste. In New Mexico, continuous beneficial water use is needed to maintain a water right.

Block release: High-volume, high-velocity releases of water from a dam.

Bypassing: Allowing water to flow downstream, rather than diverting it for irrigation or storage.

Critical habitat: Critical habitat is a geographical area occupied by the species at the time it is listed, on which are found those physical and biological features essential to the conservation of the species and which may require special management considerations or protection.

Conservation pool: An amount or allocation of water held in a reservoir.

Discretionary actions: Actions that are within the scope of the agency's legal and statutory authority.

Fish conservation pool: In this case, an allocation of storage in either Santa Rosa Reservoir or Sumner Lake, which is designated specifically for the benefit the shiner by maintaining flows or avoiding intermittency.

Target flows: A specific goal for streamflow as measured at a gage location. Target flows are a goal, and they do not preclude higher flows or the possibility that target flows would not be met 100 percent of the time.

Gage: A specific monitoring location on a stream where systematic observations of hydrologic data are obtained.

Intermittency: An interruption in connected flows or temporary drying of reaches of the river.

Pecos bluntnose shiner: A small fish that is native to the Pecos River that has been designated as a threatened species.

Water right: A property right to put surface or ground water to beneficial use. Water in New Mexico belongs to the public and is subject to appropriation by the New Mexico State Engineer.

chapter 2 that are not fully developed as site-specific proposals. As part of the Record of Decision (ROD) for this EIS, options that provide Reclamation the tools needed to meet the purpose of and need for the proposed action will be retained and specific proposals will be developed. Implementation of water acquisition options may require additional permitting, consultations, congressional authorization, and NEPA analysis. Additional NEPA analysis is expected to include the preparation of documents tiered from this DEIS, such as environmental assessments (EA) and categorical exclusions. For some actions, resource-specific field studies, such as cultural and biological resource studies, may be conducted. Entities other than Reclamation may need to implement some of these options. Reclamation actions must be in accordance with its existing Federal and State legal and statutory authorities and obligations, the Pecos River Compact (Compact), water rights, and contractual obligations.

3. Purpose of and Need for Action

The purpose of Reclamation's proposed Federal action is to conserve[1] and protect the Pecos bluntnose shiner, a federally threatened fish species, and to conserve the Carlsbad Project water supply.[2] The underlying need for Reclamation action is compliance with ESA and Reclamation's responsibility to conserve the Carlsbad Project water supply.

Reclamation needs to comply with ESA for operation of its Pecos River facilities. Reclamation is proposing changes in operations that benefit the shiner under its existing authorities and are consistent with its ESA section 7(a)(1) obligation to conserve and protect listed species. Within the exercise of its discretionary authority, Reclamation must also continue to avoid jeopardizing the continued existence of the shiner or destroying or adversely modifying designated critical habitat [ESA section 7(a)(2)].[3]

[1] Conserving the shiner means that Reclamation would ensure that any discretionary action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. Reclamation would continue to participate in interagency actions to protect federally listed species and designated critical habitats, within its legal and discretionary authority.

[2] Conserving the Carlsbad Project water supply means delivering the amount of water to the project that would otherwise be available but for changes to operations.

[3] Under section 7(a)(2), a discretionary agency action jeopardizes the continued existence of a species if it "reasonably would be expected, directly or indirectly, to reduce appreciably the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species."

Reclamation has also elected to keep the Carlsbad Project water supply whole. Without an accompanying program to acquire and provide water, changes to pre-1991 operations would cause reductions to the Carlsbad Project water supply.

4. Lead, Cooperating, and Participating Agencies

Reclamation and NMISC are the joint lead agencies for preparing this DEIS. The joint lead agencies are responsible for all decisions involving preparation of the DEIS and issues arising during the NEPA process. NEPA decision documents, such as the ROD, are the responsibility of the lead Federal agency, and the final decision on alternatives and options is made solely by Reclamation.

The mission of Reclamation is to manage, develop, and protect water and related resources in an environmentally and ecologically sound manner. Reclamation diverts to storage and delivers Carlsbad Project water to CID and owns Sumner, Fort Sumner Irrigation District (FSID) Diversion, Brantley, and Avalon Dams.

NMISC administers interstate stream compacts, oversees interstate litigation, and cooperates in the planning of Federal water projects. The New Mexico Office of the State Engineer (NMOSE) administers water rights in the State, including the apportionment, measurement, and distribution of water. Together, NMISC and NMOSE conduct investigations of water supply, and protect, conserve, and develop the underground and stream systems of the State. NMISC is responsible for ensuring that the State of New Mexico meets its water delivery requirements to Texas, as measured at the State line, in order to ensure compliance with the 1948 Pecos River Compact, the 1988 *Texas* v. *New Mexico* U.S. Supreme Court Amended Decree, and the 2003 Settlement Agreement.

In addition to NMISC, other Federal, State, and local agencies were invited to be part of the NEPA process. The role of cooperating agencies is defined in 40 Code of Federal Regulations (CFR) 1508.5 and includes agencies that have special expertise or legal jurisdiction with respect to the environmental impact. By formal agreement, cooperating agencies include the U.S. Army Corps of Engineers (Corps), Service, New Mexico Department of Game and Fish (NMDGF), CID, Pecos Valley Artesian Conservancy District (PVACD), and Eddy County. Other agencies participating in the NEPA process include Chaves County, Chaves County Flood Control District, DeBaca County, FSID, Guadalupe County, and the Pecos Valley Water Users Organization. The involvement of these agencies in the DEIS has varied, but all have been given the opportunity to participate in the NEPA interdisciplinary team (ID team), the DEIS review committee, and technical workgroups. The ID team meets regularly as a forum to communicate and update representatives of the technical workgroups, authors, and the cooperating and participating agencies on DEIS progress and issues. The review committee has no decisionmaking role, but it is a forum for formally reviewing DEIS documentation and for coordinating and exchanging information among the lead agencies, cooperating or participating agencies, and important stakeholders. Technical workgroups provide scientific and task support to the ID team.

5. Background

This section describes the study area, a brief history of Reclamation's involvement on the Pecos River and the Carlsbad Project, changes in Pecos River water operations, authorities and institutional constraints, compliance with ESA, and the current operational decisionmaking process.

5.1 Study Area

Carlsbad Project water operations are located in the Pecos River basin from the "Above Santa Rosa Lake" gage to the "At Red Bluff" gage near the New Mexico-Texas State line (map 1.1). The study area includes the river channels of the Pecos River, major inflow tributaries, water conveyance infrastructure, and the reservoir pools of storage facilities. It includes portions of Guadalupe, De Baca, Chaves, and Eddy Counties. Reclamation facilities include Sumner Dam, FSID Diversion Dam, a portion of the FSID Main Canal, Brantley Dam, and Avalon Dam. The Corps owns Santa Rosa Dam. CID and FSID own a network of laterals, drains, and other distribution infrastructure. Actions considered under the alternatives would occur in the immediate vicinity of these facilities and the river, primarily in the reach from Sumner Dam to Brantley Reservoir.

Water acquisition options are located throughout the entire basin. They include lands where water rights may be leased or purchased, cropping patterns may be changed, or new infrastructure may be constructed. Options currently under consideration extend north to Puerto de Luna and south to the border with Texas. Lands east and west of the river in the FSID, CID, Puerto de Luna, Roswell, Seven Rivers, and Buffalo Valley areas are considered for water acquisition options.

Some of the resource analyses include a broader study area. For example, economic impacts are assessed at the county level, where changes in the amount of irrigated land may affect the local economy.

5.2 Water Development History in the Pecos River Basin

Water development in the Pecos River basin, New Mexico, has a long history. Before the 1880s, there had been acequias and small-scale water diversion projects at several locations, mostly in the upper Pecos River basin. Acequias are the traditional irrigation ditch systems that allow water to be diverted to fields. Coronado observed irrigation agriculture from Pecos Pueblo to Puerto de Luna in 1540. A well-established acequia system was in place at Anton Chico, north of the study area, in the 1840s. In the early 1860s, the U.S. Army built ditches and identified 2,000 acres of land to be farmed by Navajo and Mescalero Apache Indians who had been relocated to Fort Sumner. The relocation was a failure, but

Chronology of Key Events in the Pecos River Basin

- 1800s – Precursors to CID develop dams, canals, and diversion structures
- 1905 – The Secretary of the Interior authorized the Carlsbad Project under the Reclamation Act of 1902
- 1907 – Avalon Dam reconstructed
- 1908 – Renovations made to McMillan Dam
- 1918 – FSID organized
- 1932 – PVACD formed
- 1932 – CID organized
- 1932 – Hope Decree confirmed water rights for Carlsbad Project
- 1935 – Alamogordo Dam (currently called Sumner Dam) authorized under the Flood Control Act of 1935 and completed in 1937
- 1949 – Congress approves Pecos River Compact between New Mexico and Texas
- 1972 – Congress authorized Brantley Project to replace McMillan Dam and Reservoir
  1980 – Corps constructs Santa Rosa Dam
- 1987 – Reclamation completes Brantley Dam and Reservoir
- 1987 – Service lists Pecos bluntnose shiner as a threatened species with critical habitat
- 1988 – U.S. Supreme Court Amended Decree
- 1991 – McMillan Dam breached and reservoir drained
- 1991 – Service issues jeopardy determination for Pecos bluntnose shiner
- 1997 – Reclamation initiates NEPA process in cooperation with other agencies
- 1998 – Reclamation initiates the bypassing inflows through Santa Rosa and Sumner Dams
- 2002 – Forest Guardians complaint submitted in U.S. District Court
- 2002 – Notice of Intent (NOI) to prepare this EIS published in the *Federal Register*
- 2003 – Settlement Agreement among NMISC, CID, Reclamation, and PVACD

portions of the land continued to be farmed after the fort was abandoned in 1868. In the 1880s, several companies and individuals began to explore means to divert larger amounts of water from the Rio Hondo and the Pecos River. The most ambitious of these was the Pecos Valley Irrigation and Improvement Company, which constructed several major water conveyance and dam projects from Roswell to the future CID area, including the Northern Canal, Hondo Reservoir, Avalon Dam and Reservoir, the Southwestern and Southeastern Canals, the Pecos Land and Water Company Canal, and McMillan Dam. After a major economic depression, failure of the Avalon Dam in 1893, and losses of productive land due to problems with salinity and irrigation practices, the company went bankrupt. Avalon Dam was rebuilt, but failed again in 1904. At that time, the Federal Reclamation Service (later named the Bureau of Reclamation) took control of most of these water development projects on the lower Pecos River and Rio Hondo (Bell, 1997; Shomaker, 2003).

In the Fort Sumner area, claims on the water from the old fort system were appropriated by the territorial engineer in 1903 and later developed by the Fort Sumner Land and Development Company. In 1906, the company finished construction of a diversion dam, the first section of the canal, and the head gates. However, the company was plagued by financial trouble, and FSID was organized in 1918 for the purpose of acquiring and operating the irrigation facilities. FSID continued to have problems with system infrastructure and financing and sought help from the State to construct drains and from Reclamation to rehabilitate the diversion works. However, the water users' inability to bear the financial burden of repayment to Reclamation hindered project approval for many years. In 1947, Reclamation developed a plan for rehabilitating the Fort Sumner Irrigation Project, which included building a new diversion dam, rebuilding the main canals, and improving the drainage system. The Secretary of the Interior approved the plan, and President Harry S. Truman approved a congressional act authorizing the Fort Sumner Project under Public Law (P.L.) 192-483. Most of the project construction was completed within 3 years, although Reclamation has assisted FSID in subsequent maintenance projects. Reclamation has retained ownership of the diversion dam (Bell, 1997).

Ground water from the San Andres Formation of the artesian aquifer was developed early in the twentieth century for homes and farms in the Roswell area. It was recognized by 1906 that this aquifer contributed flow to the Pecos River, and the pressure in the aquifer had declined significantly by 1925 (Shomaker, 2003). In the late 1920s, wells were also being developed in a shallow aquifer in river alluvium, which also affected riverflows. At the urging of local interests, the New Mexico State Engineer undertook administration of the Roswell Underground Water Basin. As a result of this action, PVACD was formed in 1932. PVACD has purchased and retired water rights, closed wells, and promoted improvements to irrigation efficiency. Some of the water for irrigated lands in the PVACD area were, and still are, supplied by the Hagerman Canal (formerly known as the Northern Canal). The Hagerman Canal diverts water from the Rio Hondo east of Roswell and has been owned by the Hagerman Irrigation Company (HIC) since 1907. HIC supplies farmers with a combination of diverted surface water and ground water pumped from the artesian aquifer by HIC-owned supplemental wells (Shomaker, 2003).

5.3 Reclamation and the Carlsbad Project

The Reclamation Act of 1902 authorized construction of irrigation projects in arid and semiarid lands in the Western United States. General authority over these projects was assigned to the Secretary of Interior, with project administration oversight by Reclamation. Proceeds from sales of public lands were placed into a fund to provide local irrigation districts with low-interest, or no-interest, loans for financing water storage and distribution systems.

The Secretary of Interior authorized the Carlsbad Project in 1905 for the purpose of irrigation. Reclamation’s predecessor agency, the Federal Reclamation Service, acquired and rehabilitated the existing facilities of the Pecos Valley Irrigation and Improvement Company. Avalon Dam was reconstructed in 1907, and major renovations were made to McMillan Dam in 1908. Further improvements were made to the system infrastructure, including reconstructing the Pecos River Flume; lining canals; and installing innovative dam gates, concrete control gates, and spillway structures. Farmers participating in the Carlsbad Project formed the Pecos Water User’s Association, which became CID in 1932.

For several decades, Carlsbad Project water users pushed for the construction of a new reservoir to provide additional storage. President Franklin Roosevelt approved Alamogordo (now known as Sumner) Dam in 1935. The Flood Control Act of 1935 specified that Alamogordo Dam and Reservoir were to be used first for irrigation, followed by flood control, river regulation, and other beneficial uses. New Deal programs provided capital and labor to construct these projects, to improve McMillan Dam, and to raise the height of Avalon Dam by 6 feet.

There were continuing leakage and siltation problems at McMillan Dam. Studies by Reclamation in the 1960s concluded that major floods could exceed the dam's spillway capacity, resulting in floodwaters overtopping the dam's crest. Reclamation concluded that McMillan Dam and Reservoir should be replaced with a new structure. The Congress authorized the Brantley Project (P.L. 92-514) in 1972 "for the purposes of irrigation, flood control, fish and wildlife, and recreation, and for the elimination of the hazards of failure of McMillan and Avalon Dams." Brantley Dam and Reservoir were completed in 1987. McMillan Dam was breached, and the reservoir was drained in 1991 (Bogener, 1993; Shomaker, 2003).

5.4 Pecos River Water Sources and Use

Surface water in the Pecos River is derived from precipitation in the form of snowmelt and monsoon season rainfall and from ground-water inflows. The headwaters of the Pecos River are in the Sangre de Cristo Mountains, located in the northern part of the basin. Substantial flows also enter the river from tributaries with their origins in the Sacramento and Guadalupe Mountains. Amounts of snowmelt and runoff from precipitation can vary greatly from year to year. Ground water also enters the system along reaches between the Below Santa Rosa Dam to Near Puerto de Luna gages, between the Near Acme to Near Artesia gages, and directly into Brantley Reservoir from Major Johnson Springs. Ground-water inflows are more consistent in annual volume, but some of the inflows are naturally more saline than precipitation sources (Thomas, 1963).

Water that is diverted for agriculture and applied to a crop is not completely used by the plants. Some water is lost to percolation to deep aquifers. The portion of the water that is either used by the plant (transpired) or evaporated is the amount of consumptive use. The unused water or return flow can directly drain back into the river (return flow) or can seep into shallow ground-water aquifers. Throughout the study area, the shallow aquifers and rivers are generally well connected; the return flow will eventually make it back to the river, where it becomes available for downstream diversion and use. Consequently, ground-water pumping affects base inflows to the river from the shallow aquifers connected to the river system (Fort and McGucken, 2003).

Surface water diversions have the immediate effect of reducing surface flows, but the extracted volume is partially replaced by return flow. Water is commonly diverted several times. Return flows are usually more saline than native river waters because salts are concentrated when water is removed through transpiration. Salts also can accumulate due to fertilizer application and soil leaching. As such, repeated diversions and returns result in increased salinity in the river downstream (Fort and McGucken, 2003; Thomas, 1963).

Agriculture accounts for more than 83 percent of the surface and ground-water diversion in the Pecos River basin and more than 80 percent of all anthropogenic consumptive use. Agriculture consumes more than 69 percent of the surface water used in the Pecos River basin, and evaporation consumes another 28 percent. All other sectors combined use less than 3 percent of the consumed surface water in the basin (Wilson, 2003).

Carlsbad Project Water Rights

- Reclamation cannot impair senior water rights in operating the Carlsbad Project.
- Water stored in Carlsbad Project reservoirs can only be used for authorized purposes and applied to beneficial use.
- Reclamation is legally obligated to deliver water stored for irrigation to the water users for use on the lands to which the statutes apply in accordance with the water rights and contracts.

5.5 Pecos River Compact

The Compact is an interstate agreement between New Mexico and Texas that was approved by the Congress in the Act of June 9, 1949. The Compact apportions Pecos River water between the two States and defines the required State-line delivery as the senior right on the Pecos River system. In the Compact, New Mexico agreed to maintain the flows to Texas equivalent to the quantity of water Texas received under the river basin's developed conditions in 1947. The 1988 U.S. Supreme Court Amended Decree reaffirmed the seniority right of State-line delivery, while applying the principle of prior appropriation within New Mexico. New Mexico is prohibited from having a net shortfall condition in its deliveries to Texas and must pay for water with water (no monetary payments are allowed). A net shortfall condition must be remedied within 9 months of its determination.

5.6 Pecos River Water Rights

Federal law provides that Reclamation obtain water rights for its projects through purchase, lease, or contract and administer its projects pursuant to State law relating to the control, appropriation, use, or distribution of water used in irrigation unless the State laws are inconsistent with express or clearly implied congressional directives. Water can only be diverted to storage and delivered by the Carlsbad Project for authorized purposes for which Reclamation has asserted or obtained a water right in accordance with section 8 of the Reclamation Act of 1902 and applicable Federal law. Reclamation must operate the Carlsbad Project in a manner that does not impair senior water rights. Reclamation has an obligation to deliver water to the Carlsbad Project water users in accordance with the water rights and contracts between Reclamation and the water users (which may be through a water district). Water lawfully stored in Carlsbad Project reservoirs can only be used for Carlsbad Project purposes to the extent that the water is applied to beneficial use within the Carlsbad Project.

The beneficial interest in the Carlsbad Project water right is by the water users who put the water to beneficial use. Reclamation and CID have storage and diversion rights. CID has distribution rights, and water users have water rights. In New Mexico, as in most Western States, a water right is obtained through appropriation, followed by application within a reasonable time to beneficial use. Appropriation is an amount of water legally set apart or assigned to a particular purpose or use. Application is putting the water to use. Under New Mexico law, actual application of the water to the land is required to perfect a water right for agricultural use. Federal law concerning Reclamation projects, which is consistent with New Mexico law, also provides that the use of water acquired under the Reclamation Act of 1902 "shall be appurtenant [connected] to the land irrigated, and beneficial use shall be the basis, measure, and the limit of the right" (43 United States Code [U.S.C.] section 372). Beneficial use is determined in accordance with State law to the extent that it is not inconsistent with congressional directives. The authorities and the contracts with the United States create and define the extent of the water users' rights. Thus, Reclamation is legally obligated to deliver water stored for an irrigation purpose to the water users for use on the lands to which the statutes apply.

In establishing the Carlsbad Project, Reclamation purchased water rights from the existing private irrigation system and filed with the territorial engineer for additional water rights. These filings and rights have been adjusted from time to time to accommodate new facility construction, but, essentially, the Carlsbad Project operates under the same rights that had been obtained by 1906. The Hope Decree, Number 712, Equity, May 8, 1933, adjudicated to the United States water rights to divert and store for the Carlsbad Project based upon irrigation use. Water is stored in Carlsbad Project reservoirs for the purpose of irrigation. The Hope Decree also defined the rights and priority to use surface waters of the Pecos River from the headwaters in the Sangre de Cristos to Avalon Dam. The decree did not address connected ground water, which affects flows to senior surface water right holders.

FSID has a direct flow diversion right with a priority date of March 18, 1903. Reclamation owns FSID Diversion Dam, but FSID operates it according to the diversion procedure of its senior water right. FSID's right to divert up to 100 cubic feet per second (cfs) of the Pecos River's natural flow is senior to Carlsbad Project's right to divert to storage at Santa Rosa Dam or at Sumner Dam. FSID has no storage right. In addition to its right to divert from the river during the irrigation season, FSID also has the right to divert for two 8-day periods during the nonirrigation season. Therefore, Reclamation cannot divert water to storage if it is needed to meet FSID's senior diversion water right. FSID's water right was established prior to Reclamation's involvement with FSID and was never transferred to the Federal Government.

Puerto de Luna and Anton Chico acequias have water rights that are senior to FSID's, and some river pumpers downstream also have senior rights on the Pecos River. HIC has surface rights from the Rio Hondo and South Springs and ground-water rights to pursue those surface water sources. These wells provide most of the water used by HIC, but they continue to divert surface water from the Rio Hondo, a tributary of the Pecos River.

As described previously, surface flows of the Pecos River are interrelated with ground-water sources. This is especially true in the Roswell area, where wells were developed in the Roswell artesian and shallow aquifers early in the last century. Water rights that are junior to those held by CID are diverted from ground-water sources. Wells tapping those aquifers reduce base inflow and affect downstream users. Because of the time required for ground water to return to the river, the enforcement of priority water rights on the Pecos River would be very difficult because water could not be easily quantified or immediately delivered to downstream users or to Texas for Compact deliveries.

5.7 Carlsbad Project Operations

Pecos River facilities used to divert Carlsbad Project water to storage and to release water for beneficial use are Santa Rosa Dam and Reservoir, Sumner Dam and Lake, Brantley Dam and Reservoir, and Avalon Dam and Reservoir. Santa Rosa Reservoir, Sumner Lake, and Brantley Reservoir are operated for irrigation and flood control storage. The Corps administers flood control operations, and Reclamation manages irrigation operations.

In 1980, Carlsbad Project water storage rights were transferred from Sumner Lake to Santa Rosa Reservoir (owned by the Corps) to allow more flood control capacity at Sumner Lake. The total storage capacity of the reservoirs is approximately 500,000 acre-feet, which includes the allocation for Carlsbad Project water and the flood pool. The Carlsbad Project is limited to 176,500 acre-feet of storage by the Compact. The different reservoirs also are constrained by individual conservation storage limits for Carlsbad Project water. The conservation storage limits in Santa Rosa Reservoir, Sumner Lake, and Avalon Reservoir change each year, based on estimated sediment deposition since the last survey. Sediment is surveyed every 10 years by the Corps for Santa Rosa and by Reclamation for the other facilities. Reclamation transmits all requests from CID for release of Carlsbad Project water from Santa Rosa Reservoir to the Corps.

CID prefers to store most of its water in the upstream reservoirs and to move water in block releases. Generally, upstream storage is thought to reduce losses to evaporation, but evaporative losses at Sumner Lake may be higher than at Brantley Reservoir. Upstream storage also allows CID the flexibility to capture storm water runoff in Brantley Reservoir. In a block release, a large amount of water is released from Santa Rosa or Sumner Dam. Block releases are the most efficient way to move water downstream. If a small amount of water is released or if water is released slowly, a larger percentage of the delivery is lost to evaporation or subject to other losses in transit. If too large of a percentage of the delivery is lost, a release becomes wasteful and violates State law. The timing of water operations is generally determined by agricultural demand, but water is sometimes released for reasons of conservation storage limits, flood control, and dam safety. If pool elevations exceed designated conservation pool volumes, additional inflows into the reservoir cannot be diverted to storage and must be bypassed through the dam. Flood conditions are relatively rare and seldom

Key Concepts in Carlsbad Project Operations

- Water from storms and snowmelt is diverted from the river for direct use or is stored in reservoirs.
- Water rights and priority affect virtually all aspects of the allocation of water to users.
- Reclamation delivers Carlsbad Project water allocations to CID for irrigation use.
- Upon CID request, block releases are made to deliver water efficiently to CID (Brantley Reservoir).
- Operations must be conducted within the structure of existing water rights and Reclamation authorities. Reclamation is limited by Federal and State laws.
- In order to provide flows for the shiner, Reclamation bypasses Carlsbad Project water when available. Because this is a less efficient way to deliver water, Reclamation has obtained replacement water from other sources.
- This DEIS analyzes the environmental effects of **changes in Carlsbad Project** operations. These changes include a range of proposed target flows, as well as options for acquiring additional water for the Carlsbad Project deliveries to CID and for use to benefit the shiner upstream.

dictate flow releases. If designated flood pool elevations are exceeded, flood operations are initiated.

Each month during the irrigation season, which extends from March 1 through October 31, CID determines an allotment for its farmers based on current conditions. When Brantley Reservoir does not have enough water in storage and farmers need water for irrigation in areas around Carlsbad, a block release is made from Sumner Dam to move water to Brantley Reservoir for distribution. Early season releases prior to April 1 may be made to improve the water quality at Brantley Reservoir.

Before the Service listed the shiner as a threatened species in 1987, the Carlsbad Project was operated by Reclamation solely as required by irrigation need, flood control, the Pecos River Compact, existing water diversion rights, and other agreements. In 1989, in a one-time event to test the safety of the newly constructed Brantley Dam, water was released in a block release from Santa Rosa Reservoir and Sumner Lake from the period of April 10 to June 6. The Service requested a consultation in 1990 concerning the impact Pecos River dam operations were having on federally listed threatened and endangered species. Reclamation formally submitted a biological assessment in 1991. The consultation resulted in a jeopardy determination.

To comply with ESA and still meet its other obligations, Reclamation has adjusted both irrigation season and nonirrigation season operations. Important among many changes in operations is the bypassing of some Carlsbad Project water through Santa Rosa and Sumner Dams to augment flows for the shiner. Because bypasses are less efficient than block releases, Reclamation has obtained water from other sources and delivered that water into the Pecos River to conserve the Carlsbad Project water supply.

5.8 FSID Water Operations

FSID water operations are relevant to this DEIS because FSID's senior diversion right affects the discretionary actions available to Reclamation to conserve the shiner. FSID irrigation usually begins on March 1. However, if FSID chooses to use its winter diversion water rights in conjunction with the beginning of its irrigation season diversion rights, bypasses could start a full 2 weeks earlier. FSID's flexibility in irrigation planning is limited because it has no storage rights. Before the construction of Sumner Dam in 1937, FSID's entitlement was simply the first 100 cfs of the natural riverflow at the diversion dam. After construction of Sumner Dam, FSID was entitled to the natural riverflow up to 100 cfs as measured at the Near Puerto de Luna gage upstream of Sumner Lake. After Santa Rosa Dam was constructed in 1980, FSID's entitlement was set every 2 weeks based on a computation by NMOSE for the average natural riverflow during the previous 2 weeks and capped at 100 cfs. If the 2-week average shows no flows in excess of FSID's water right, Reclamation cannot divert to storage or bypass any inflows. Thus, during the irrigation season when the natural flow of the river may be reduced, FSID can continue to divert up to its entitlement and Reclamation has fewer discretionary actions available to it for providing flows to conserve the shiner. In recent years, FSID's diversion of the natural flow has been a major cause of low flows and river drying during the irrigation season (Reclamation, 2002).

FSID also has a pump-back operation that allows it to reuse its entitlement. In the pump-back operation, FSID pumps flows directly out of return canals before they reach the river and reapplies that water to nearby farmland within the district.

5.9 Compliance with ESA

Section 7 of ESA outlines the procedures for Federal interagency cooperation to conserve federally listed species and designated critical habitats. To comply with ESA, an analysis of the effects of any discretionary Federal action must be conducted in consultation with the Service. Each Federal agency has an obligation to ensure that any discretionary action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or destroy or adversely modify its critical habitat unless that activity is exempt pursuant to ESA.

Under section 7(a)(2) of ESA, a discretionary agency action jeopardizes the continued existence of a species if it "reasonably would be expected, directly or indirectly, to reduce appreciably the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of the species." If a discretionary agency action is jeopardizing a species, the agency must stop the action or adapt it through reasonable and prudent alternatives (RPAs), which must be within the scope of the agency's legal authority.

Under section 7(a)(1) of ESA, Reclamation also has an obligation to conserve and protect listed species. Section 7(a)(1) alone does not give Reclamation additional authority to undertake any particular action, regardless of its potential benefit for endangered species. Whether undertaken as section 7(a)(1) conservation activities or as RPAs subsequent to section 7(a)(2) compliance, any Reclamation action for endangered species purposes must be within the agency's existing authority.

Reclamation does not possess the authority and discretion to:

- Eliminate FSID's right to divert
- Undertake new construction
- Release water from storage for any other purpose than irrigation
- Purchase water to maintain habitat for the shiner
- Construct or modify habitat for the shiner
- Establish storage space for anything other than irrigation
- Restrict CID's right to Carlsbad Project storage space
- Restrict CID's right to divert

As described previously, consultations between Reclamation and the Service in 1991 on Pecos River operations resulted in a jeopardy determination. The Service formulated RPAs that governed many aspects of river operations and required an interagency research and monitoring program to determine the hydrologic and biologic needs of the shiner.

From the 1990 through 1998 irrigation seasons, operations at Sumner Dam resumed with the following changes. Flows above FSID's diversion right were diverted to storage, and block releases continued to be used to deliver water stored in upstream reservoirs to Brantley Reservoir. From 1992 through 1997, experimental operations were conducted to collect data for the development of a hydrologic model and studies of shiner habitat. These experimental operations included winter bypasses from Santa Rosa Reservoir and Sumner Lake for analyzing the efficiency of low flows and block releases that included ramp-up and ramp-down periods for evaluating the effect of these transitional flow periods on shiner habitat and conveyance efficiencies.

One of the RPAs from the jeopardy opinion directed Reclamation to develop a computer model of the river. The model was to be developed for analyzing the effect of changes in operations on the various affected resources. The model was developed with the RiverWare software application developed at the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado at Boulder. An application was developed for the Pecos River that represents all the key processes in the basin and simulates operational policy for the system.

After the 1992-97 study period, Reclamation resumed consultations with the Service. In subsequent years, Reclamation has continued to consult with the Service and has implemented recommendations governing the aspects of the operations where there is discretionary Federal involvement or control. In 1998, the Carlsbad Project began bypassing water when the water was available and was needed to provide a continuous river. Intermittency near the Near Acme gage and the upper critical habitat has been caused by diversion of water downstream from Sumner Dam for irrigation and by the ongoing drought.

ESA compliance on current operations is guided by the Final Biological Opinion for the Bureau of Reclamation's Proposed Pecos River Dam Operations, March 1, 2003, through February 28, 2006, dated June 18, 2003 (BO). Conditions of the BO are described in greater detail in chapter 2 under section 4.1, "No Action Alternative." As detailed in the BO, the Service found that the water operation proposal "is not likely to jeopardize the continued existence of the shiner, and is not likely to destroy or adversely modify the shiner's designated critical habitat." The conclusion was based on the premise that Reclamation's proposed action would, at a minimum, maintain flowing water through critical habitat even during dry years and that in average-to-wet years, additional water would be bypassed for the shiner. The primary focus is to avoid intermittency throughout the river in all years. Reclamation believes that its discretionary actions do not cause the intermittency that has occurred in recent years. The Service anticipated that there would be incidental take of shiner resulting from block releases during the spawning season, but based on the assumption that the river would be kept whole, determined that the level of anticipated take would not likely jeopardize the shiner or destroy or adversely modify critical habitat (Service, 2003).

The Relationships Among the Biological Assessment, Biological Opinion, and DEIS

As required under section 7 of the Endangered Species Act of 1973, as amended, Reclamation is required to consult with the Service regarding project impacts on federally listed species and designated critical habitats. As part of consultation, when there is the potential for project effects on a listed species, the Federal agency prepares a **biological assessment** that evaluates potential effects of the agency action on the listed species. The Service subsequently prepares a **biological opinion** based on information contained in the biological assessment and the Service's knowledge of the project and affected species. Decisions made during consultation process will be incorporated into the final EIS and Record of Decision.

A biological assessment of Reclamation's proposed action is being prepared concurrently. Formal consultation began in August 2005 with the submittal of a draft biological assessment to the Service. Reclamation will seek a long-term BO for long-term operation of the Carlsbad Project. During the time that Reclamation and the Service are in formal consultation, the DEIS also will undergo public review and comment.

5.10 NEPA Study History

In 1997, Reclamation initiated a NEPA process in cooperation with NMISC, the Service, the Corps, NMDGF, and CID to consider long-term changes in operations to protect the shiner. Progress on an environmental assessment was constrained by the continued development of the RiverWare software, the lack of specific details of water acquisition, and the need to verify biological conclusions regarding the needs of the shiner.

Reclamation determined that an EA would be inadequate to address the complicated issues and potential impacts resulting from changes in Carlsbad Project operations. The proposed level of NEPA analysis was elevated to a programmatic EIS to avoid the constraints associated with uncertainty and insufficient data. Reclamation decided to include the water acquisition program within the Federal action being considered, thereby coupling the provision of acquiring water with proposed operational changes that result in a new depletion. Reclamation proceeded with plans to initiate the DEIS and informed the cooperating agencies of its intentions in fall 1999. Reclamation formally invited NMISC to serve as a joint lead agency, and both agencies developed a memorandum of agreement for conducting the study. In 2002, the Forest Guardians submitted a complaint in U.S. District Court, citing the failure of Reclamation and the Corps to comply with the requirements of ESA and NEPA (U.S. District Court, 2002). A settlement was reached based on a court-ordered schedule for completion of the DEIS and final EIS.

In 2002, Reclamation and NMISC developed an approach for environmental review of proposed Pecos River basin activities. Reclamation and NMISC decided to prepare an EIS for Reclamation's Carlsbad Project water operations and water acquisition (i.e., the Carlsbad Project Water Operations and Water Supply Conservation EIS), and another for a miscellaneous purposes contract that would allow NMISC to use Carlsbad Project water for purposes other than irrigation (the Long-Term Miscellaneous Purposes Contract EIS [MPCEIS]). The purpose of the MPCEIS is to allow NMISC to release project water from Avalon Dam to ensure that Pecos River Compact delivery requirements are met. The project water would come from lands within CID boundaries that NMISC owns or leases or through other acquisitions of water rights.

The Notice of Intent (NOI) to prepare the Carlsbad Project Water Operations and Water Supply Conservation DEIS was published in the *Federal Register* on October 4, 2002. This study is following a court-ordered schedule based on settlement of the Forest Guardians' complaint that requires issuance of a DEIS to the public by September 1, 2005, a final EIS by June 1, 2006, and a ROD by August 1, 2006 (U.S. District Court, 2004). The NOI to prepare the MPCEIS was published in the *Federal Register* on January 20, 2004. Reclamation and NMISC are conducting both EIS processes concurrently and are coordinating the environmental analyses.

6. Related and Ongoing Actions

This section describes related and ongoing activities relevant to this DEIS. It begins with a list of the legislated authorities and responsibilities of Federal agencies managing projects and lands. The next section lists major statutes and regulatory requirements involved with the management of natural and human environment. The third section describes the relationship between the actions contemplated in this DEIS and other regional programs, projects, and activities of Reclamation and NMISC.

6.1 Authorities and Agreements

Table 1.1 includes the legislative authorizations for Reclamation activities and major Pecos River agreements that are directly relevant to the DEIS.

Table 1.1 Relevant legislative laws, agreements, and authorizations

Law, agreement, or authorization	Description
Reclamation Act of June 17, 1902 (43 U.S.C. section 391)	Authorized construction of irrigation projects in the West. Assigned authority over these projects to the Secretary of Interior, with project administration oversight by Reclamation.
Carlsbad Project Authorization November 28, 1905	The Secretary of the Interior authorized purchase and rehabilitation of Pecos Irrigation and Improvement Company facilities.
Hope Decree of 1933	Defined the rights and priority to use surface waters of the Pecos River from the headwaters to Avalon Dam (CID, FSID, HIC, acequias, and river pumpers). The decree did not address connected ground water, which affects flows to senior surface water right holders.
Alamogordo (Sumner) Dam Authorization, November 6, 1935, Emergency Relief Appropriations Act of 1935 (funding)	Authorized funding and construction of Alamogordo (Sumner) Dam.
Flood Control Act of 1935	Specified that Alamogordo Dam and Reservoir were to be used first for irrigation, followed by flood control, river regulation, and other beneficial uses.
Reclamation Project Act of 1939 (53 Statute [Stat.] 1187)	Allowed authorization of projects for multiple purposes, the costs to be shared among the various beneficiaries so that the projects would be economically viable.
Pecos River Compact of 1948	Apportions the waters of the Pecos River between New Mexico and the downstream neighboring State of Texas and requires that New Mexico not deplete, by man's activities, the flow of the river at the State line below a quantity of water available to Texas under the river basin's developed conditions in 1947, known as the "1947 condition."
Fort Sumner Project Authorization, under P.L. 81-192, 63 Stat. 483, July 29, 1949	Authorized Reclamation to rehabilitate the Sumner Diversion Dam and other facilities.
Brantley Project Authorization, P.L. 92-514, October 20, 1972	Authorized construction of Brantley Dam and Reservoir for multiple purposes as a replacement for McMillan Dam.
Reclamation Reform Act of 1982 (43 U.S.C. sections 390aa to zz-1)	Increased the acre limit that an individual or legal entity can irrigate with water from a Federal project from 160 acres to 960 owned or leased acres.

Table 1.1 Relevant legislative laws, agreements, and authorizations

Law, agreement, or authorization	Description
U.S. Supreme Court Amended Decree, Pecos River Compact, 1988	Established that a shortfall in deliveries to Texas had occurred and affirmed State-line delivery as the senior right on the Pecos River system, while applying the principle of prior appropriation within New Mexico. New Mexico is prohibited from having a net shortfall condition in its deliveries to Texas and must pay for water with water (no monetary payments are allowed). A net shortfall condition must be remedied within 9 months of its determination.
Reclamation Recreation Management Act of 1992 (P.L. 102-575)	Provided uniform policies regarding recreation developments, fish and wildlife enhancements, cost sharing of Federal multipurpose water resource projects, and other purposes.
Transfers of Certain Carlsbad Project Lands to CID (P.L. 106-220, on June 21, 2000	Transferred title to nearly 6,200 acres of Carlsbad Project lands to CID, including irrigation, drainage features, and a maintenance facility. Does not include Sumner Dam and Lake or Brantley and Avalon Dams and Reservoirs.
Final Biological Opinion for the Bureau of Reclamation's Proposed Pecos River Dam Operations, March 1, 2003 through February 28, 2006	Defined target flows, block release protocols, and other RPAs and conservation recommendations currently in place to avoid jeopardy from Reclamation actions on the Pecos River.

6.2 Regulatory Requirements

In addition to NEPA, several other Federal statutes involve management of resources within the study area. These laws and Executive orders were designed to restore, protect, and preserve the natural resources (for example, air, water, land, fish, and wildlife) and cultural resources (for example, historic and prehistoric sites) of the United States. In addition, several laws protect the rights of Native Americans to express, believe, and exercise religious practices. Federal statutes that guided the NEPA development process include the following:

- American Indian Religious Freedom Act of 1978 (P.L. 95-341; 42 U.S.C. 1996)
- Archaeological and Historic Preservation Act of 1974 (16 U.S.C. sections 1531-1543)
- Archeological Resources Protection Act of 1979 (P.L. 96-95; 16 U.S.C. 470aa-470ll)
- Clean Air Act of 1970 (42 U.S.C. 7401 et seq.; 40 CFR parts 50-87)
- Clean Water Act (33 U.S.C. sections 1251-1387)
- Endangered Species Act of 1973 (P.L. 93-205; 16 U.S.C. 1531 et seq.)

- Farmland Protection Policy Act (P.L. 97-98; 7 U.S.C. 4201)
- Fish and Wildlife Coordination Act of 1958 (P.L. 85-624)
- Historic Sites, Buildings, and Antiquities Act of 1906 (16 U.S.C. sections 431-433)
- Migratory Bird Treaty Act (16 U.S.C. 703-712), as amended
- National Historic Preservation Act of 1966 (P.L. 95-515; P.L. 102-575; 16 U.S.C. 470)
- Executive Order 11593, Protection and Enhancement of the Cultural Environment, May 13, 1971 (36 FR 8921)
- Executive Order 11988, Flood Plain Management, May 24, 1977 (42 FR 26951)
- Executive Order 11990, Protection of Wetlands, May 24, 1977 (42 FR 26961
- Executive Order 11991, Protection and Enhancement of Environmental Quality, March 5, 1970 (35 FR 4247)
- Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, February 11, 1994 (59 FR 7629)
- Executive Order 13007, Indian Sacred Sites, May 24, 1996 (61 FR 26771)
- Executive Order 13112, Invasive Species, February 3, 1999 (64 FR 6183)

6.3 Required Compliance Actions and Permits

Table 1.2 lists required consultations, compliance actions, and permits that are anticipated as part of preparing the EIS or implementing the decisions of the EIS. The acquisition of additional water for the Carlsbad Project water supply or for the shiner may require additional NEPA compliance work and additional permitting and consultation as these actions become better defined.

Table 1.2 Required consultations, compliance actions, and permits applicable to EIS preparation and implementation

Consultation/ permit	Agency/ organization	Description
ESA (section 7 consultation)	U.S. Fish and Wildlife Service	Consultation under section 7 of ESA is required to determine if the project will adversely affect threatened or endangered species or designated critical habitat. Effects on the shiner and other listed species are addressed in a BO. Reclamation will prepare a biological assessment for the preferred alternative and for related actions that could affect listed species.
Permits pursuant to sections 402, 404 of the Clean Water Act	U.S. Army Corps of Engineers (also reviewed by the Service and the New Mexico Environment Department)	Section 404 permitting may be required for options that involve construction or discharge of material into wetlands and other waters of the U.S. National Pollutant Discharge Elimination System (section 402) permitting may be required for options that require discharge.
Environmental Protection Agency (EPA) DEIS review	U.S. Environmental Protection Agency	The DEIS will be filed with EPA, which will review the environmental impacts and rate the adequacy of the DEIS. EPA provides review comments to the Corps on any section 404 permit applications during the public scoping period and assesses compliance with section 309 of the Clean Air Act.
Section 106, National Historic Preservation Act Compliance	New Mexico Historic Preservation Division (State Historic Preservation Office)	Reclamation is required to consult with the State Historic Preservation Office regarding the effects of the project on historic properties (sites eligible for listing on the *National Register of Historic Places*) and to mitigate any adverse effects on these sites. The section 106 process also requires the agency to allow the Advisory Council on Historic Preservation the opportunity to comment on any adverse effects on historic properties.
Permits for water storage, place of use, or point of diversion	New Mexico Office of the State Engineer	Project actions, such as the fish conservation pool and water acquisition options, may require permits to change water storage, type of use, or points of diversion.

6.4 Relationship to Other Reclamation and NMISC Regional Activities

Reclamation and NMISC are currently conducting other projects and NEPA actions in the Pecos River basin. Selected relevant projects and actions are briefly described. Cumulative impacts of these activities and related projects and other relevant past, present, and reasonably foreseeable projects in the region are described in Chapter 5, "Cumulative Impacts."

6.4.1 Settlement Agreement

The Settlement Agreement was executed by NMISC, CID, Reclamation, and PVACD on March 25, 2003, to settle ongoing litigation in the Pecos River basin and to provide a mechanism to ensure long-term compliance with the Pecos River Compact and U.S. Supreme Court Amended Decree. The Settlement Agreement includes an acquisition program that authorizes NMISC to purchase up to 6,000 acres of land and water rights in CID and up to 12,000 acres of land and water rights upstream of Brantley Dam, which includes PVACD and FSID. Additionally, per the Settlement Agreement, the State will construct or purchase a well field(s) capable of producing 15,750 acre-feet of water per year.

6.4.2 MPCEIS

As discussed under Section 5.10, “NEPA Study History,” pursuant to the Settlement Agreement, Reclamation and NMISC are conducting an EIS on the execution of a long-term contract with CID to allow NMISC to use water up to 50,000 acre-feet per year for miscellaneous purposes and the subsequent conversion and delivery of the water for purposes other than irrigation. The MPCEIS is being conducted concurrently with this EIS and, as scheduled, would be completed first.

6.4.3 Carlsbad Project Vegetation Management Program

An environmental assessment/biological assessment was prepared for the Carlsbad Project Vegetation Management Program; a Finding of No Significant Impact was signed in September 2004. This program consists of research and treatment components, both targeting salt cedar and other invasive plants. The research component includes studies of biological agents, herbicides, mechanical methods, revegetation, and herbicide residue.

6.4.4 Water Resources Conservation Program

This program, established in 1991 by section 72-1-2.2, New Mexico Statutes Annotated (NMSA) 1978, called for NMISC to purchase, retire, and place in a State water conservation program adequate water rights over a period of years to increase the flow of water in the Pecos River and to diminish the impact of depletions of the streamflow from human activity and, therefore, meet the State’s future obligations under the Pecos River Compact and the U.S. Supreme Court Amended Decree.

6.4.5 Active Water Resource Management Program

In response to legislation (section 72-2-9.1, NMSA 1978), the State Engineer adopted Rules and Regulations for Active Water Resources Management on December 30, 2004. The regulations are designed to establish a framework for NMOSE to supervise the physical distribution of water and to administer the available water supply by priority date or alternative administration, as appropriate. These State-wide rules and regulations provide that, when necessary, junior water rights that would otherwise be curtailed will be able to temporarily acquire senior water rights from owners participating in the water rights marketplace in an expedited manner. Ultimately, rules and regulations specific to the Pecos River basin will be drafted and promulgated.

7. Issues Summary

Scoping is a public process designed to determine the alternatives and issues to be addressed in a NEPA document. The scoping process for this DEIS began on

October 4, 2002, with the publication of the NOI in the *Federal Register*. To inform parties interested in the DEIS about the location of scoping meetings and the opportunity to comment, Reclamation developed a distribution list and mailed a newsletter to more than 200 contacts. Newspaper advertisements and a press release were also issued to notify the public of the project, to announce the four public scoping meetings, to request public comments, and to provide contact information. A display advertisement and legal notice also were published in several newspapers, and a legal notice was placed in the *Albuquerque Journal.*

Reclamation held public scoping meetings in Santa Rosa, Fort Sumner, Carlsbad, and Roswell, New Mexico. These meetings provided an opportunity for the public to receive information, ask questions, and provide input. Factsheets about the project were distributed. Comments from the public and agencies focused on the ecology of the shiner, streamflow requirements, impacts on property owners, impacts on farmers, impacts on industries dependent on the river, water rights, watershed management, accuracy of data, and dam operations. More detailed information on the results of scoping is included in Chapter 6, “Consultation and Coordination.”

The framework for describing the affected environment and for assessing impacts is based on Reclamation guidance, input from stakeholders and technical specialists, scoping, and the potential for study area resources to be affected by proposed changes in Carlsbad Project operations and water acquisition options. The affected environment for the study area described in chapter 3 includes the following resources:

- Water resources
- Water quality
- Agricultural soil and land resources
- Biological resources
- Regional economy
- Recreation
- Cultural resources
- Indian trust and treaty assets
- Environmental justice

Technical specialists and workgroups prepared work plans for each resource to identify resource issues and impact indicators and to guide the impact analysis process. Resource issues relate to potential effects, risks, or hazards on the resource within the affected environment. Resource indicators are a measurement or qualitative assessment of the degree of change resulting from the alternative or option.

8. Document Organization

This DEIS consists of six chapters, described as follows.

Chapter 1 describes the purpose of and need for the proposed Federal action, cooperating agencies, project background, related and ongoing activities, and a summary of issues.

Chapter 2 describes the process used to formulate alternatives, the alternatives considered in detail, the alternatives considered but eliminated from detailed study, and Reclamation's preferred alternative. It also includes a description of the options for acquiring water for the Carlsbad Project water supply, options for providing additional water upstream to conserve the shiner, and a summary comparison of alternatives and impacts.

Chapter 3 describes the current condition of resources within the study area that would be affected by the alternatives and water acquisition options if they were implemented.

Chapter 4 describes and analyzes the environmental impacts of the alternatives and water acquisition options on study area resources. It also describes the relationship between short-term uses of the environment and long-term productivity and provides an assessment of irreversible and irretrievable commitment of resources. Chapter 4 also lists the environmental commitments that may be implemented with the selection of any of the alternatives.

Chapter 5 describes relevant past, present, and reasonably foreseeable projects and their cumulative impacts on study area resources.

Chapter 6 describes the scoping and public participation process that was conducted during the preparation of this DEIS. It also describes coordination with Federal, State, and local agencies; Native American groups; and private organizations.

The document also includes a distribution list, list of preparers, references cited, and a glossary, as well as several appendices with relevant supporting information.

Chapter 2

Alternatives

Chapter 2
Alternatives

1. Introduction

This chapter describes the alternatives developed by the Bureau of Reclamation (Reclamation) and the New Mexico Interstate Stream Commission (NMISC) for conserving the Pecos bluntnose shiner (shiner) and Carlsbad Project water supply. Alternative development was guided by the National Environmental Policy Act of 1969 (NEPA), Reclamation planning regulations, input from public and agency scoping, and the efforts of technical workgroups established for this draft environmental impact statement (DEIS).

This chapter presents the process used to develop and screen the alternatives, the elements of the No Action and action alternatives, and the process of defining and screening Carlsbad Project water acquisition (CPWA) options and additional water acquisition (AWA) options for the Carlsbad Project water supply and for the shiner, respectively. This chapter also provides a summary comparison of the alternatives and their impacts.

NEPA requires consideration of a reasonable range of management alternatives that meet the purpose of and need for the proposed action (40 Code of Federal Regulations [CFR] 1505.1(e)). The joint lead agencies also need to be responsive to issues identified during scoping; need to provide flexibility in order to address issues of uncertainty; and need to meet Federal, State, and local laws, regulations, and agreements. The alternatives include specific actions to be taken to meet the purpose of and need for the proposed action. Reclamation also developed a suite of options for acquiring water that is also needed to meet the project purpose and need. These options are not tied to particular alternatives. Not all elements of the water acquisition options can be precisely defined and analyzed. Implementation of options may require additional permitting, consultations, congressional authorization, and NEPA analysis. Additional NEPA analysis is expected to include the preparation of documents tiered from this DEIS, such as environmental assessments and categorical exclusions. For some actions, resource-specific field studies (cultural and biological resource studies) may be conducted. Entities other than Reclamation may need to implement some of these options. Reclamation actions must be in accordance with its existing Federal and State legal and statutory authorities and obligations, the Pecos River Compact (Compact), water rights, and contractual obligations. Figure 2.1 shows the alternative and water acquisition option development process.

Alternative and Option Development Process

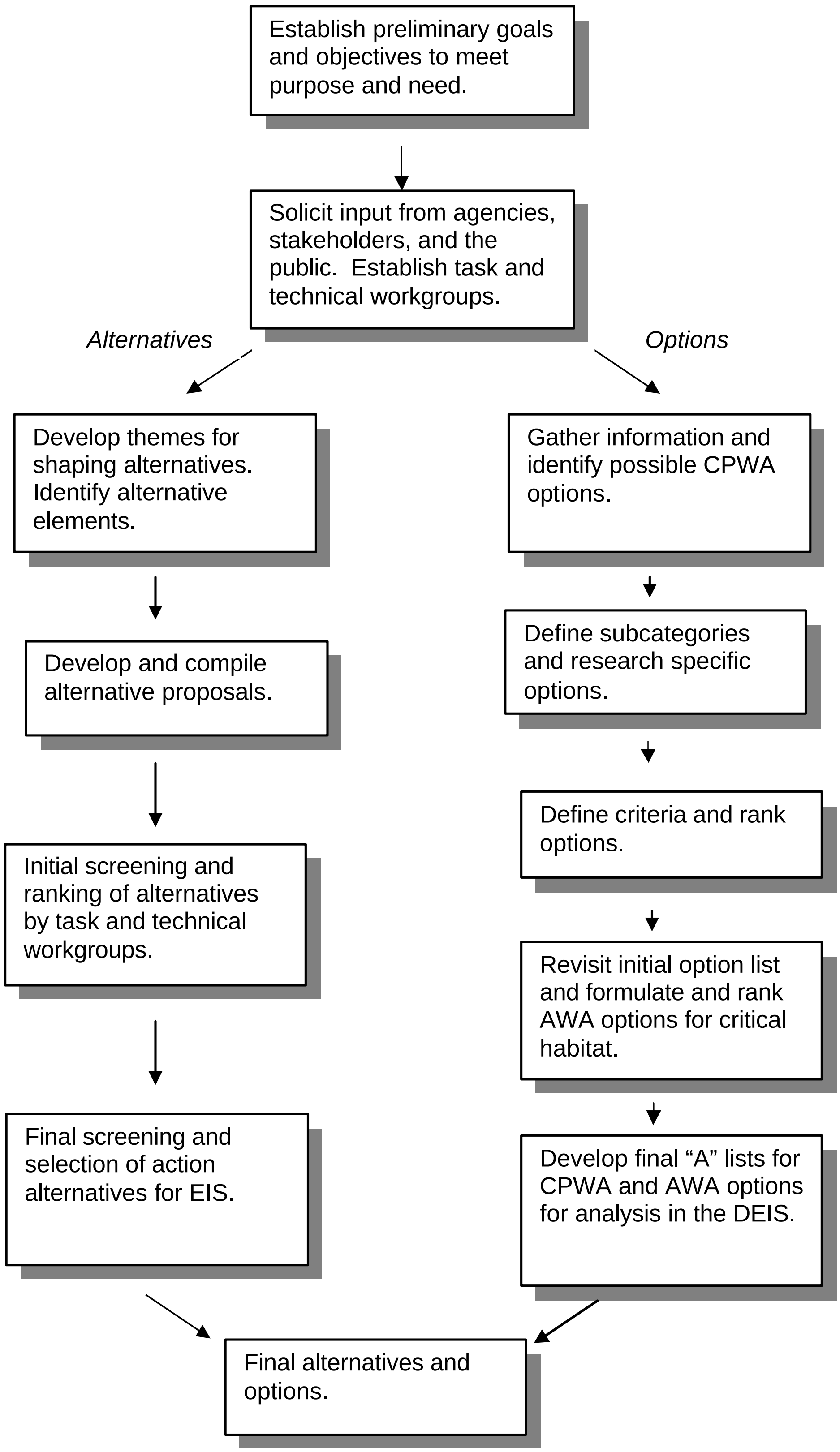


Figure 2.1 Alternative and option development process.

2. Alternative Development Process

Reclamation and NMISC developed the alternatives through a systematic process that used public input, research and recommendations from technical workgroups, and professional judgment. The process began with consideration of the dual purposes of the proposed action: (1) Reclamation’s proposed changes in Carlsbad Project operations to conserve the shiner and (2) implementation of a water acquisition program to conserve the Carlsbad Project water supply. Comments were solicited from cooperating and participating agencies, resource specialists, and the public on how to meet these purposes and the range of issues to be analyzed in the DEIS. Public scoping meetings were held in Santa Rosa, Fort Sumner, Carlsbad, and Roswell, New Mexico. Issues and alternatives identified in scoping and agency meetings in 1999 for the earlier proposed environmental assessment also helped direct the early alternative development process.

In October 2002, an alternatives development workgroup was formed with representatives and technical specialists from the cooperating agencies to fully consider all concepts and suggestions in formulating alternatives. During its first meeting, the alternatives development workgroup established a process for developing alternatives that included defining goals and objectives, establishing preliminary alternative themes, refining the themes into alternatives, establishing other actions required to finalize the alternatives, determining the viability of each alternative by comparing it to the goals and objectives, and moving forward to analyze the viable alternatives.

The workgroup first defined preliminary goals and objectives to meet the purpose of and need for the proposed action. The goals cited by the workgroup were to protect and conserve the shiner through management of water operations and other measures and to ensure that these actions do not impair the Carlsbad Project water supply. The alternatives development workgroup outlined the following objectives:

- To conserve the shiner
- To eliminate additional depletions
- To bypass flows for the benefit of the shiner, when possible
- To act in accordance with existing Reclamation authorities governing dam operations and the release and use of Carlsbad Project water
- To avoid impacting Fort Sumner Irrigation District (FSID) water users
- To comply with New Mexico State water law and water rights appropriation

- To acquire water rights from willing sellers
- To comply with storage limits
- To comply with the Endangered Species Act of 1973, as amended (ESA) for other species

The alternatives development workgroup considered several preliminary themes for shaping the alternatives. Initial alternative themes included higher target flows, current target flows, modified pre-1991 operations, natural hydrograph, and shiner habitat needs. Technical workgroups were assigned to refine the parameters and specific components of each preliminary alternative theme. The technical workgroups expended considerable effort in exploring these themes, but, ultimately, the alternatives development workgroup determined that the alternatives should focus on water operations and target flows. For example, the attempt to define an alternative designed around shiner habitat needs requires a better understanding and agreement on habitat needs than is possible at this point and may be limited by the range of actions available to the responsible agencies. Target flows and the rules for block releases became the primary variables among the preliminary alternatives considered. Table 2.1 outlines the range of elements that were considered in developing the preliminary alternatives.

Concurrently, a water offset options group was formed to gather information and evaluate possible options for augmenting the Carlsbad Project water supply. Modifying operations and bypassing flows through Santa Rosa and Sumner Dams to benefit the shiner have increased channel transmission losses. Typically, the most efficient way to move water through the river channel is to release a large volume of water quickly from a dam in what is called a “block release.” Maintaining a slow, steady flow, such as a low-flow bypass, is less efficient in delivering Carlsbad Project water to the Carlsbad Irrigation District (CID) than a high-flow block release.

The purpose of and need for the proposed action requires conserving the Carlsbad Project water supply; thus, additional water needs to be acquired. These options are called Carlsbad Project water acquisition or CPWA options. The water offset options group also looked at proposals for direct water acquisition to augment riverflows to conserve the shiner, herein referred to as additional water acquisition or AWA options. The water offset options group worked independently of the alternatives development process to consider these options and to provide Reclamation with information on the relative merits of each. The effects of CPWA and AWA options are analyzed to the extent possible in this DEIS, but some options may require further analysis and permitting to be implemented. These options were developed without seeking a definitive determination of the authority of Reclamation or other agencies for their implementation. Reclamation, like all agencies, is limited to implementing actions that are within its authority. NEPA, however, requires consideration of all reasonable alternatives within or outside the jurisdiction of the Federal agency (40 CFR 1502.14). New authorities could be sought, or other entities may be able to acquire water using options analyzed here. The water offset options group screening processes are described in greater detail in Section 8, “CPWA Options Development Process.”

Table 2.1 Preliminary alternative elements

Element	Issues and variables
Flow	Target flows versus minimum/maximum flows
Flow	Target flows versus range of target flows
Flow	Variable target flows by season: irrigation/nonirrigation
Flow	Variable target flows by wet/dry/average hydrologic period
Flow	Target flows: ranging from 0 to 72 cubic feet per second (cfs) at Near Acme and Taiban gages
Block releases	Duration of individual releases
Block releases	Duration of releases per season
Block releases	Frequency: number of days between releases
Block releases	Delivery efficiency targets
Block releases	Magnitude of releases: ranging up to 1,400 cfs
Block releases	Block release ramp up/ ramp down: ranging from none to complex prescriptions
Block releases	Spawning spikes: releases timed to encourage fish spawn
Block releases	Season/time of year: restrictions by season, time of year
Habitat/conservation measures	Removal of non-native riparian vegetation
Habitat/conservation measures	Channel restoration: 15 miles south of Artesia, Bitter Lake
Habitat/conservation measures	Fish conservation pool: establish a pool to benefit the shiner and use wells at Seven Rivers to replace Carlsbad Project water used
Habitat/conservation measures	Use pumps upstream of Near Acme gage
Habitat/conservation measures	Diversion to storage
Habitat/conservation measures	Buy or lease land to allow water to remain in the river or ground- water system

2.1 Alternative Formulation and Evaluation Criteria

Alternative proposals suggested through public scoping, or developed by cooperating agencies and stakeholders, were compiled into a master alternative development matrix. The matrix included the full range of alternative elements that had been identified by the alternatives development workgroup and was a comprehensive list of alternatives that had been proposed by May 2003. Corrections and additions were made after an initial distribution to the study’s interdisciplinary team and the alternative development, hydrology, biology, and

What are CPWA and AWA Options?

CPWA and AWA options are two sets of proposals for adding water to the Pecos River. **Carlsbad Project water acquisitions** provide water to the Carlsbad Project for use in CID in compensation for depletions incurred as a result of changes in operations. **Additional water acquisitions** provide additional flows to meet target flows upstream where the shiner are found, to avoid intermittency in the river, and, at a minimum, to keep flows in the critical habitat.

water acquisition option workgroups for a preliminary review. After this review, the matrix included 28 potential alternatives (Reclamation, 2005).

Workgroups internally developed screening or ranking criteria to apply to this master alternative development matrix. The hydrology workgroup ranked each alternative on the basis of estimated net depletions associated with prescribed block release patterns and target flows designed to benefit the shiner. Net depletions are the additional depletions caused by a modification to operations. These additional depletions were determined against an established baseline scenario that is based on pre-1991 operations.

The biology workgroup screened the alternatives on the basis of the following criteria. An alternative was considered viable if it:

- Proposed appropriate target flows, or range of flows, that would manage water to avoid intermittency, to the extent possible, and protect and conserve the shiner and its critical habitat.

- Allowed, to the extent possible, the cessation of block releases of irrigation water for CID 4 to 6 weeks in July and August of each year to protect young-of-year fish (currently understood to be the peak time for the shiner to spawn).

- Did not suggest the manipulations of irrigation block releases that result in additional net depletions without it being demonstrated that there is a meaningful biological reason to do so (Reclamation, 2003).

Each criterion was given equal weight and applied in its respective category. If any one criterion caused the alternative to fail in its category, the biology workgroup eliminated the alternative from further consideration.

The water offset options group did not provide a formal screening process for the alternatives. Group members concluded that alternatives should first address the conservation needs of the shiner based on biological considerations, followed by a determination of the potential depletions from hydrologic considerations. The role of the water offset options group was to propose and assess options for acquiring water to address net depletions, determine their potential costs, and quantify the amount of water that could be realized. The group did not attempt to determine a maximum available offset amount because this would most properly be a management decision based on balancing the flow requirements for conserving the shiner with the availability of funding and the environmental consequences of water acquisition options.

Representatives of the workgroups initially screened each alternative during meetings of the alternatives development workgroup. Additional alternatives were proposed to combine similar proposals and to address issues identified in this initial screening. A formal screening of all alternatives by the hydrology and biology workgroups followed; the formal screening resulted in a consensus alternatives list of five action alternatives and the No Action Alternative.

Section 5, "Alternatives Considered But Not Analyzed in Detail," provides additional discussion of alternatives and alternative elements that were considered but not further analyzed. Reclamation formulated the final suite of alternatives by restoring an alternative that had been previously combined with others.

2.2 Summary of Alternatives

Table 2.2 provides a summary of the final alternatives, specifies target flows and minimum flows, and indicates U.S. Geological Survey (USGS) gage locations for monitoring flows. Target flows for the alternatives are either constant or variable by time of year or by whether hydrologic conditions are dry, average, or wet. The defined target flows do not preclude enhancing base inflows beyond target flows, if additional water is available and the Carlsbad Project water supply is conserved. The Near Acme gage on the Pecos River northeast of Roswell, New Mexico, is currently used to monitor flows in critical habitat for the shiner. (See map 2.1.) Some alternatives include proposals to monitor flows at the Taiban gage (located ½ mile downstream from the confluence of the Pecos River with Taiban Creek). Use of this gage for monitoring may provide additional information on river conditions in the critical habitat for the shiner and improve the success of maintaining flows.

Under all action alternatives, additional water would be acquired to ensure that the Carlsbad Project water supply would be conserved. Options for acquiring water for both the Carlsbad Project water supply and for augmenting flows for the shiner were screened, and "A" lists for each option were developed for analysis in this DEIS. Sixteen "A" list CPWA options and 18 "A" list AWA options were identified and are listed in sections 8 and 10, respectively, of this chapter. Some of the options are the same action but have been developed using a different

Why is a Determination of Hydrologic Condition Needed?

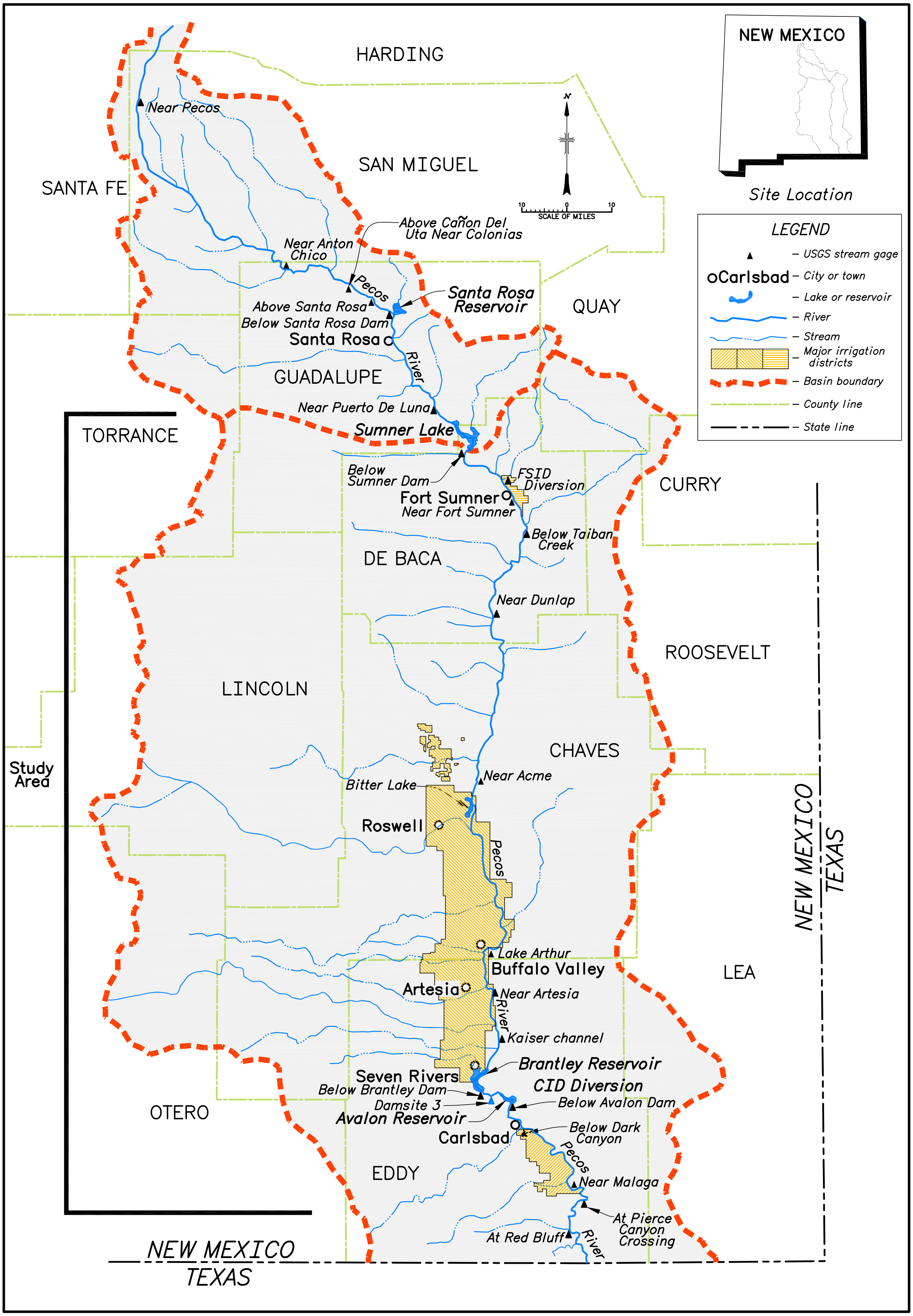
The formula for determining hydrologic conditions is derived from the Final Biological Opinion for the Bureau of Reclamation's Proposed Pecos River Dam Operations, March 1, 2003, through February 28, 2006, dated June 18, 2003 (BO) (Service, 2003). To better manage river operations, an assessment of the current hydrologic condition is used to help ensure that water is available to maintain target flows. For this DEIS, the No Action, Acme Variable, and Critical Habitat Alternatives vary target flows based on dry, average, or wet hydrologic conditions.

cost estimate for acquiring water. These options are not linked to specific alternatives but, instead, represent a suite of potential sources for water acquisition. The effects of each of the “A” list options are analyzed to the extent possible, but many would require further analysis to implement. Entities other than Reclamation may need to implement some of the options.

Table 2.2 Carlsbad Project Water Operations and Water Supply Conservation DEIS alternatives

	Range of flows[1]						Block release protocols	Other elements
	Dry		Average		Wet			
Alternative	**Nonirrigation season target flows**	**Irrigation season target flows**	**Nonirrigation season target flows**	**Irrigation season target flows**	**Nonirrigation season target flows**	**Irrigation season target flows**	**Time of year, magnitude, frequency, duration, ramp down**	**Water acquisition, shiner conservation and management measures, adaptive management**
Taiban Constant	35 cfs Taiban	35 cfs Taiban	35 cfs Taiban	35 cfs Taiban	35 cfs Taiban	35 cfs Taiban	**Time of Year**: On CID request. Avoid releases during 6 weeks around August 1. **Magnitude:** On CID request and to maximize efficiency. **Frequency:** On CID request, but a minimum of 14 days between block releases. **Duration:** 15-day maximum per release. **Ramp down:** No ramp down required.	Within Reclamation's authorities, acquire water for the Carlsbad Project and for the shiner using respective “A” list options. Maintain fish conservation pool. Implement Adaptive Management Plan (AMP). Continue existing shiner management measures and cooperate with others in shiner conservation measures.
Taiban Variable	35 cfs Taiban	45 cfs, -5, +10 Taiban	35 cfs Taiban	45 cfs, -5, +10 Taiban	35 cfs Taiban	45 cfs, -5, +10 Taiban		
Acme Constant	35 cfs Acme	35 cfs Acme	35 cfs Acme	35 cfs Acme	35 cfs Acme	35 cfs Acme		
Acme Variable	35 cfs Acme	12 cfs Acme	35 cfs Acme	24 cfs Acme	35 cfs Acme	48 cfs Acme		
Critical Habitat	35 cfs Taiban minimum	Critical habitat kept wet; avoid intermittency Acme	35 cfs Taiban minimum	5 cfs Acme	35 cfs Taiban minimum	10 cfs Acme		
No Action (current operations, based on current BO)[1]	35 cfs Acme	Upper critical habitat kept wet; avoid intermittency Acme	35 cfs Acme	20 cfs Acme	35 cfs Acme	35 cfs Acme	**Same as other alternatives except:** **Time of year:** No stipulation to avoid releases during 6 weeks around August 1. **Duration:** Maximum of 65 days per year.	**Same as other alternatives except:** AMP is not specifically included. Water would continue to be acquired from current sources, and new sources would be developed.

[1] Target flows are based on the Final Biological Opinion for the Bureau of Reclamation’s Proposed Pecos River Dam Operations, March 1, 2003, through February 28, 2006, dated June 18, 2003 (BO) (U.S. Fish and Wildlife Service [Service], 2003).



Map 2.1 Pecos River stream gage locations

What is the Relationship Between Alternatives and Water Acquisition Options?

Alternatives are the six proposals for changes to Carlsbad Project water operations to conserve the shiner. They vary primarily in the target flows specified at the Near Acme or Taiban gages. Changes in Carlsbad Project operations would cause further depletions to the Carlsbad Project water supply, which is chronically short and must also be conserved. The amount of depletions anticipated varies by alternative.

Water acquisition options are a suite of prescreened potential sources of acquiring additional water for the Carlsbad Project (16 options) or for maintaining flows for the shiner (18 options). These options are not linked to specific alternatives and are analyzed independently. When an alternative is chosen, any option or combination of options could be developed further to address depletions or provide water for the shiner. Additional planning and permitting may need to be conducted. Some options may not be within the current authority of Reclamation and may need to be implemented in cooperation with other entities.

A fish conservation pool would be maintained in Santa Rosa Reservoir and Sumner Lake and managed for the benefit of the shiner. Each action alternative includes common guidance for block releases. The action alternatives include an Adaptive Management Plan (AMP) that is intended to monitor target flows and net depletions; to establish procedures, mitigative actions, and sources of water when compliance with target flows is threatened; and to respond to new information and changing conditions. Under the action alternatives, Reclamation would cooperate with other agencies in ongoing and future conservation measures, including developing wells and pumping infrastructure for supplementing short-term flows, removing non-native riparian vegetation, participating in channel restoration projects, and other direct and indirect actions to enhance shiner conservation. Reclamation participation would be limited by its authority, and most of these measures would require additional permitting and project-specific NEPA analysis.

In accordance with the Council on Environmental Quality (CEQ) regulations implementing NEPA, a No Action Alternative must always be evaluated in an environmental impact statement (EIS). The No Action Alternative represents a projection of current conditions to the most reasonable future conditions and impacts that could occur if none of the action alternatives were implemented. The No Action Alternative may not meet the purpose of and need for the proposed action, but it is the basis for comparison of the impacts with other alternatives. The No Action Alternative for this DEIS is based on current water operations; the Final Biological Opinion for the Bureau of Reclamation's Proposed Pecos River Dam Operations, March 1, 2003, through February 28, 2006, dated June 18, 2003 (BO) (U.S. Fish and Wildlife Service [Service], 2003); and other current and anticipated actions, trends, and agreements affecting flows and availability of water in the Pecos River basin.

How are Dry, Average, and Wet Hydrologic Conditions Determined?

The target flows for the No Action, Acme Variable, and Critical Habitat Alternatives vary based on dry, average, or wet hydrologic conditions. Hydrologic conditions are currently assessed using the methodology defined in the BO (Service, 2003). An annual assessment is made with the possibility for adjustment throughout the irrigation season. Dry, average, and wet hydrologic conditions are based on "effective Brantley storage" in conjunction with the Palmer Drought Severity Index (PDSI). Effective Brantley storage is an approximation of CID's storage as if all of the water were stored in Brantley Reservoir. Effective Brantley storage is determined as follows:

Avalon storage + Brantley storage + (0.75 x Sumner storage) + (0.65 x Santa Rosa storage)

The monthly PDSI records from 1895 to 2003 were averaged to derive previous 9-month and 2-month average values on each April 1 evaluation date. Results were then classified for each interval (9 months, 2 months, and 1 month) as dry, average, or wet. If all indices were average, then that year was average. However, if any one of the indices was wet or dry, then that year was classified as such. None of the years had both wet and dry indices. As a result of this analysis, the following definitions were developed:

- Dry hydrologic condition: Effective Brantley storage is less than 75,000 acre-feet.
- Average hydrologic condition: Effective Brantley storage is greater than 75,000 acre-feet and less than 110,000 acre-feet.
- Wet hydrologic condition: Effective Brantley storage is greater than 110,000 acre-feet.

Storage would be assessed initially on March 1. However, because the amount of water in the system can change dramatically in the Pecos River basin, Reclamation, the Service, the State, and other interested parties would meet regularly (May 1, June 1, July 15, and September 1) to assess whether the amount of water in storage has markedly increased or decreased. Target flows for alternatives that vary by hydrologic condition could be adjusted if there were a substantial increase or decrease in seasonal storage, consistent with prudent water management practices and fish conservation needs (Service, 2003).

3. Alternative Assumptions

3.1 Target Flows

Each of the alternatives prescribes target flows as measured at specific gage locations. These target flows would be monitored according to methods to be outlined in the final AMP. Target flows are a goal, and they do not preclude higher flows or the possibility that target flows would not be met 100 percent of the time. Declines in shiner population have been associated with recent periods of intermittency. Keeping the river whole and avoiding intermittency is an important priority for conserving the shiner and in reversing the reported decline in shiner populations (Kehmeier, et al., 2004). Intermittency affects fish in two ways. First, drying of the channel traps fish in isolated pools which exposes fish to internal and external predators. Extended drying will degrade water quality conditions, further stressing fish to the point of death, and eventual dewatering of the pool altogether. Secondly, movement and migration of the shiner helps redistribute and repopulate upstream habitats. Intermittency disrupts this process and affects upstream population numbers. If intermittency does occur, the next priority would be to provide a continuous flow in occupied habitat. Rewetting of the river should be carefully assessed to avoid further isolating shiner in disconnected pools. Reclamation will fully use its authorities and discretion to prevent intermittency to the greatest extent possible, but it could occur under all alternatives.

3.2 Sumner Dam Operations

Reclamation has limited opportunities and discretion to store and release water from Sumner Lake under its State water rights permit and the Sumner Dam authorization. Reclamation must bypass through Sumner Dam the current amount of natural flow water that FSID is entitled to, an amount that is determined by the New Mexico Office of the State Engineer (NMOSE) using a flow calculation based upon flows from the previous 2 weeks at the Above Santa Rosa, Below Santa Rosa, and Near Puerto de Luna gages. If there is inflow into Sumner Dam above the amount that must be bypassed for FSID, Reclamation would bypass all or a portion of that additional inflow as necessary to meet the downstream target flows. The additional inflows that are not bypassed would be diverted to storage for the Carlsbad Project. FSID may request that its water not be bypassed, which can occur when the soil is too wet to irrigate.

3.3 Block Releases

Water would be released from storage at the request of CID for the beneficial use of irrigation. The magnitude of individual releases would be set, based on the request of CID. With typical reservoir elevations, releases are limited to approximately 1,400 cubic feet per second (cfs) and, at full reservoir elevations, flows greater than 1,600 cfs are not possible. Historically, releases average approximately 1,060 cfs. Releases would be made in a manner to maximize efficiency and to avoid excessive losses through seepage and evaporation. No ramp up or ramp down of releases would be required. In the past, releases were sometimes initiated gradually (ramp up) and/or ended gradually (ramp down) with the intention of benefiting the shiner. There is a lack of consensus on the value of these releases to the shiner, and they are associated with large depletions. The duration of individual block releases from Sumner Lake would be restricted to a maximum of 15 days to avoid transporting shiner eggs and larvae into Brantley Reservoir. The frequency of block releases would be at the request of CID. There should be a minimum of 14 days between individual block releases. All alternatives, except the No Action Alternative, include a stipulation that block releases should be avoided, if possible, during the 6 weeks around August 1 to reduce the impacts of releases on shiner reproduction. Under certain conditions, a release during this period may be desirable if needed to avoid intermittency or if demand is higher than expected during this time.

> **What is the Purpose of an Adaptive Management Plan?**
>
> An Adaptive Management Plan provides a means to address **uncertainty**. Changing conditions in the future related to climate, hydrology, water use, and other factors will result in unexpected situations. The AMP serves as a guide for monitoring target flows, addressing actions to be taken for target flows that are in jeopardy, and addressing changing conditions in the future management of river operations by modifying operations within established parameters. The AMP provides a framework to ensure that the preferred alternative meets the purpose of and need for the proposed action.

3.4 Adaptive Management Plan

The use of an AMP is specified as part of all of the action alternatives. An interagency workgroup is developing the framework for an AMP concurrently with this DEIS. (See the Draft Adaptive Management Plan, Appendix 1.) Adaptive management is defined as follows:

> . . . *a cyclic learning-oriented approach to managing complex environmental systems with high levels of uncertainty about system processes and the potential ecological, social, and economic impacts of different management options. Adaptive management establishes a procedure for monitoring the results of management actions and integrating this new knowledge into future policy and management actions* (Jacobson, 2003).

Adaptive management is based on the recognition that knowledge about natural resource systems and the effects of management actions are often uncertain and may require changes in management to respond to dynamic conditions. The adaptive management process provides a defined procedure to address uncertainty and respond to change. Details of the final plan would be tailored to the alternative chosen in the Record of Decision (ROD).

3.4.1 Roles and Responsibilities

Reclamation would implement the AMP within the context of the existing Pecos River water management working group, consisting of Federal, State, and local agency managers and representatives, researchers, and water users. Interagency cooperation, long-term commitments, regular communications, and scheduled meetings are necessary for a successful adaptive management strategy. Pecos River stakeholders have different interests, legal rights, and responsibilities with regard to river management. Likewise, there is fundamental disagreement on flow and habitat needs of the shiner and the effects of management actions.

The AMP would provide a structure for making decisions in this uncertain environment and provide conflict resolution methods that respect the different roles of stakeholders.

3.4.2 Flow Monitoring

The fundamental means of conserving the shiner is maintaining the target flows that would be prescribed in the ROD. Methods to monitor and means to maintain these flows would be defined in the final AMP. Drought conditions and lower flow alternatives may require different approaches to meeting target flows and avoiding intermittency.

3.4.3 Depletion and Monitoring

Hydrologic modeling is limited in its ability to predict the effects of management actions and the ability of options to provide water. Estimates of net depletions to the Carlsbad Project water supply and the effectiveness of water acquisition options would be monitored to ensure that the Carlsbad Project water supply is conserved. An accounting method would be developed and used to determine depletions and the replacement water.

3.4.4 Management Action Triggers

The final plan would define thresholds that would trigger management responses if target flows were not met or if CPWA options were not sufficient to meet the purpose of and need for the proposed action. The plan would describe the range of management options and the priorities for addressing unmet flow and acquisition targets.

3.4.5 Other Management Actions

Additional measures that complement the purpose of and need for the proposed action, such as salt cedar removal, habitat improvement projects, well and pumping infrastructure, or development of additional water sources, are anticipated and are not precluded by the ROD. Opportunities may exist in which additional water is temporarily available to enhance base inflows beyond target flows. Likewise, Reclamation anticipates that monitoring, new knowledge, and new technologies could lead to revised goals and new proposals. The AMP provides a decision and reporting process for considering other management actions or modifying operations within established parameters analyzed in this DEIS in response to changing conditions. Actions not evaluated in this DEIS would require additional NEPA compliance.

4. Alternatives Analyzed In Detail

4.1 No Action Alternative

Under the No Action Alternative, Reclamation would continue to manage Carlsbad Project operations in accordance with the current BO, Reclamation authorizations, water rights, and contractual obligations (Service, 2003). These management actions include operating Sumner Dam in a manner that not only seeks to avoid jeopardizing the shiner, but also conserves and protects the species under section 7(a)(1) of ESA. Prior to expiration of the current BO, Reclamation would enter into section 7(a)(1) consultation with the Service to define future management actions beyond the term of the current BO. The No Action Alternative (current operations) includes the conservation of the Carlsbad Project water supply through lease of various water rights, an operational practice that would continue if this alternative were selected.

4.1.1 Target Flows

Under the No Action Alternative, target flows defined in the current BO would continue through February 2006. Current target flows vary by dry, average, and wet hydrologic conditions and by season, as defined in the current BO. (See sidebar entitled, “How are Dry, Average, and Wet Conditions Determined?”)

During dry hydrologic conditions from March 1 to October 31 (irrigation season), Reclamation would maintain flow through the upper critical habitat and avoid intermittency at the Near Acme gage, if at all possible. Block releases are suggested to be scheduled from May to September to alleviate the lowest of flows. In dry hydrologic conditions, the intent is to avoid intermittency, if at all possible. If not enough water is available to maintain a connected river, then, at a minimum, flowing water should be maintained through the upper critical habitat. Maintaining flows would provide at least a minimal amount of habitat for the shiner and reduce mortality of all life stages from entrapment in isolated pools. The No Action Alternative would seek to avoid rewetting or reconnecting the river if intermittency is likely to occur again, especially if dry conditions threaten to persist, because rewetting can cause further harm to fish if they become stranded later. From November 1 to February 28 (nonirrigation season), Reclamation would target flows of 35 cfs at the Near Acme gage.

During average hydrologic conditions, Reclamation would target flows of 20 cfs at the Near Acme gage during the irrigation season. Block releases would be scheduled from May to September to alleviate low flows during the irrigation season. During the nonirrigation season, Reclamation would target flows of 35 cfs at the Near Acme gage.

During wet hydrologic conditions, Reclamation would target flows of 35 cfs at the Near Acme gage throughout the year. Whenever possible, higher flows should be bypassed for the shiner and maintenance of channel morphology. Reclamation would fully use its authorities and discretion to prevent intermittency to the greatest extent possible, but it could occur under all alternatives.

4.1.2 Block Releases

Under the No Action Alternative, block release protocols would be the same as under the other alternatives, except that the current BO does not stipulate that block releases should be avoided during the 6 weeks around August 1. The frequency of block releases would be at the request of CID; there should be a minimum of 14 days between block releases. According to the BO, there may be times when the Pecos River is anticipated to have substantial intermittency. If there is only enough stored water available for one block release, Reclamation should attempt to schedule multiple smaller block releases with CID, to the extent that it is possible within beneficial use constraints.

4.1.3 Carlsbad Project Water Acquisition

Reclamation would continue to acquire additional water needed for the Carlsbad Project water supply resulting from ongoing actions to conserve the shiner. Sources of water could include those water acquisition options and priorities developed by the water offset options group.

4.1.4 Supplemental Water

Reclamation would continue to pursue agreements with FSID to lease a minimum of 20 percent of the irrigated acres in FSID. If 20 percent of FSID's historical diversion amount were leased, Reclamation anticipates that approximately 16 cfs of water could be bypassed through the FSID Diversion Dam for the shiner.

Reclamation would continue to lease and pursue additional leases of water rights from ground-water pumpers upstream of the upper critical habitat and pump the water to the Pecos River.

Reclamation would continue discussions with FSID about ceasing the pump-back operation when flows at the Taiban gage are less than 35 cfs. The pump-back operation is an action taken by FSID to pump flows directly out of return canals and reapply that water to nearby farmland within the district. When water is pumped out of return canals, return flows to the river are reduced or eliminated, which results in reduced riverflows and a greater probability of intermittency, especially in dry years. Although ceasing the pump-back operation would provide immediate water to the river, it is not known when or if an agreement can be reached on this source of water.

4.1.5 Shiner Management Measures

In cases of intermittency, Reclamation would follow procedures outlined in the BO for documenting and recording the extent of intermittency and its effect on the shiner. If the level of incidental take defined in the BO were exceeded, Reclamation would again consult with the Service and review the management measures. Reclamation would immediately provide the Service with an explanation of the cause of the taking and would review with the Service the possible need for modifying reasonable and prudent measures for managing the shiner within Reclamation's authority.

Reclamation would continue to conduct regular meetings of the existing Pecos River water management working group, consisting of managers, agency representatives, researchers, and water users, who would work to reach a common understanding of the issues, to build trust among the groups, and to develop innovative ways to manage the river to reduce the incidental take of the shiner.

4.1.6 Fish Conservation Pool

Reclamation would maintain the current 500-acre-foot fish conservation pool and continue working with NMISC, CID, and the Service to create a larger fish conservation pool in Santa Rosa Reservoir and/or Sumner Lake, consistent with State and Federal law. Storage currently is not subject to evaporative losses or losses due to reservoir spills. A larger pool would provide more flexibility and management options to respond to river conditions. The current 500-acre-foot pool cannot be exceeded unless authorized and funded by the Congress. Fish conservation water would be released to protect the shiner during low-flow periods by meeting target flows and limiting intermittency.

Reclamation would continue to exchange artesian ground water (250 to 375 acre-feet) for surface water. Reclamation has authority to continue to pump water from wells in the Seven Rivers area to replace depletions caused by modified operations at Sumner Dam. Pending State permit, an equivalent amount of water (approximately 500 acre-feet, accounting for delivery losses) could be stored in Sumner Lake and released downstream to maintain flows.

4.1.7 Shiner Conservation Measures

Reclamation would consider and cooperate with other entities in developing conservation programs for the benefit of the shiner, as detailed in the BO. Conservation recommendations are discretionary agency activities designed to minimize or avoid adverse effects of an action on listed species or critical habitat, to help implement recovery plans, or to develop information.

4.2 Taiban Constant (Preferred) Alternative

4.2.1 Target Flows

Reclamation has identified the Taiban Constant Alternative as the preferred alternative for this DEIS. (See section 6 for selection criteria.) Under this alternative, Reclamation would target year-round flows of 35 cfs at the Taiban gage. The goal of the Taiban Constant Alternative is to avoid intermittency in the reach between the Taiban and Near Acme gages. Using the modeled average loss relationships between the Taiban and Near Acme gages, the Taiban target flows would provide a range of 2 to 20 cfs at the Near Acme gage, depending on hydrologic condition. Even when the target flows are being met, intermittency could still occur.

4.2.2 Block Releases

Under the Taiban Constant Alternative, block release protocols would be the same as under all of the other action alternatives. No ramp up or ramp down of releases would be required. The duration of individual block releases from Sumner Lake would be restricted to a maximum of 15 days to avoid transporting shiner eggs and larvae into Brantley Reservoir. There should be a minimum of 14 days between individual block releases. The frequency of block releases would be at the request of CID, but block releases during the 6 weeks around August 1 should be avoided, if at all possible, to reduce the impacts of releases on shiner reproduction. If the shiner have spawned, fertilized eggs can be washed down into Brantley Reservoir and not develop into maturity. CID, Reclamation, and the Service may coordinate on conducting a release during this period if water is available. A release may be desirable if needed to avoid intermittency, stimulate a spawn, or meet demand.

4.2.3 Carlsbad Project Water Acquisition

The Carlsbad Project water supply would be conserved through actions and priorities developed by the water offset options group and implemented by Reclamation. Bypassing inflows through Sumner Lake would deplete the water supply because the transmission efficiency of low-flow bypasses through the reservoir would be reduced. The amount of anticipated net depletions varies by alternative. The water offset options group examined and ranked options on their effectiveness for providing additional water for the Carlsbad Project water supply. The projected water amounts available would be further reduced by losses incurred in the conveyance of water to Brantley Reservoir. Any combination of options or single option may be used. Depletion accounting methodology and monitoring would be determined as part of a separate process. These options and their rankings are described in detail later in this chapter.

4.2.4 Additional Water Acquisition

Reclamation has identified options for direct water acquisition to augment riverflows to conserve the shiner. Reclamation does not have authority to acquire water specifically for the purposes of augmenting instream flows. These options would provide water to upper reaches of the Pecos River system when changes in Carlsbad Project operations alone would not provide adequate flows to meet target flows or minimally avoid intermittency. The water offset options group examined and ranked these AWA options, which are described in detail later in this chapter.

4.2.5 Shiner Management Measures

Reclamation would continue to conduct regular meetings of the existing Pecos River water management working group, consisting of managers, agency representatives, researchers, and water users, who would work to reach a common understanding of the issues, to build trust among the groups, and to develop innovative ways to manage the river to reduce the incidental take of the shiner.

4.2.6 Fish Conservation Pool

Reclamation would maintain a permanent fish conservation pool in Santa Rosa Reservoir and Sumner Lake. The current 500-acre-foot pool would be used to maintain flows to prevent intermittency in the upper critical habitat, to the extent possible. Reclamation would continue working with NMISC, CID, and the Service to create a larger fish conservation pool in Santa Rosa Reservoir and/or Sumner Lake, consistent with State and Federal law. A larger pool would allow more flexibility and management options to respond to river conditions, but would require congressional authorization and funding.

4.2.7 Shiner Conservation Measures

Reclamation would consider and cooperate with other entities in developing conservation programs for the benefit of the shiner. Conservation recommendations are discretionary agency activities designed to minimize or avoid adverse effects of an action on listed species or critical habitat, to help implement recovery plans, or to develop information.

4.2.8 Adaptive Management Plan

An AMP, as described previously and detailed in appendix 1, would be developed and implemented under all action alternatives.

4.3 Taiban Variable Alternative

Under the Taiban Variable Alternative, target flows would vary by season and would be monitored at the Taiban gage. During the nonirrigation season, Reclamation would target flows of 35 cfs at the Taiban gage. During the irrigation season, target flows would be 40 cfs to 55cfs, depending on water availability and other operational constraints. Taiban target flows would provide minimum flows of 20 cfs at the Near Acme gage during the nonirrigation season and flows ranging from 5 to 12 cfs during the irrigation season, depending on hydrologic condition, but intermittency could occur under all alternatives.

Proposed block release protocols, Carlsbad Project and additional water acquisition, shiner management and conservation measures, fish conservation pool, and AMP are as described for the Taiban Constant Alternative and are the same for all action alternatives.

4.4 Acme Constant Alternative

Under the Acme Constant Alternative, Reclamation would continue to use the Near Acme gage as the primary flow monitoring location and would target year-round flows of 35 cfs there. Reclamation would fully use its authorities and discretion to prevent intermittency to the greatest extent possible, but intermittency could occur under all alternatives.

Proposed block release protocols, Carlsbad Project and additional water acquisition, shiner management and conservation measures, fish conservation pool, and AMP are as described for the Taiban Constant Alternative and are the same for all action alternatives.

4.5 Acme Variable Alternative

Under the Acme Variable Alternative, target flows at the Near Acme gage would vary by season and by hydrologic condition. During the irrigation season in dry hydrologic conditions, Reclamation would target flows of 12 cfs at the Near Acme gage and flows of 35 cfs during the nonirrigation season.

During the irrigation season in average hydrologic conditions, Reclamation would target flows of 24 cfs at the Near Acme gage and flows of 35 cfs during the nonirrigation season.

During the irrigation season in wet hydrologic conditions, Reclamation would target flows of 48 cfs at the Near Acme gage and flows of 35 cfs during the nonirrigation season.

Proposed block release protocols, Carlsbad Project and additional water acquisition, shiner management and conservation measures, fish conservation pool, and AMP are as described for the Taiban Constant Alternative and are the same for all action alternatives. Reclamation would fully use its authorities and discretion to prevent intermittency to the greatest extent possible, but intermittency could occur under all alternatives.

4.6 Critical Habitat Alternative

Under the Critical Habitat Alternative, target flows and minimum flows would be monitored at the Taiban and Near Acme gages and would vary by season and by hydrologic condition. During the irrigation season in dry hydrologic conditions, when no other discretionary options are available, Reclamation would minimize intermittency at the Near Acme gage and would keep the critical habitat wet. During the nonirrigation season, Reclamation would target minimum flows of 35 cfs at the Taiban gage.

During the irrigation season in average hydrologic conditions, Reclamation would target flows of 5 cfs at the Near Acme gage. During the nonirrigation season, Reclamation would maintain minimum flows of 35 cfs at the Taiban gage.

During the irrigation season in wet hydrologic conditions, Reclamation would target flows of 10 cfs at the Near Acme gage. During the nonirrigation season, Reclamation would maintain minimum flows of 35 cfs at the Taiban gage.

Proposed block release protocols, Carlsbad Project and additional water acquisition, shiner management and conservation measures, fish conservation pool, and AMP are as described for the Taiban Constant Alternative and are the same for all action alternatives. Reclamation would fully use its authorities and discretion to prevent intermittency to the greatest extent possible, but intermittency could occur under all alternatives.

5. Alternatives Considered But Not Analyzed in Detail

The final alternatives for analysis were shaped by the goals and objectives of the alternatives development workgroup and the study management team and were the result of a systematic screening process that evaluated more than 30 alternative proposals and refinements. This process is documented in the alternatives development report (Reclamation, 2005a), but a general discussion of the rationale for the exclusion of certain alternatives and alternative elements is appropriate.

5.1 Pre-1991 Baseline as a No Action Alternative

As mentioned previously, the CEQ regulations implementing NEPA require a No Action Alternative to be included in an EIS. One of the primary purposes of the No Action Alternative is to provide a benchmark for comparing the magnitude of environmental effects of the action alternatives. Reclamation considered defining the No Action Alternative on the basis of conditions and water operations as they existed before 1991. This pre-1991 baseline recognizes that operations after the 1991 BO on the shiner have been either experimental or reactionary actions developed on a year-to-year basis. Given that recent operations are reactionary, not formalized, and variable, "normal conditions" would be those before 1991. The pre-1991 baseline would clearly disclose the impacts of the ESA-related actions. Under this scenario, the current operations and conditions (target flows and releases) defined by the BO would be addressed as one of the "action" alternatives, or there would be two no action, or baseline, alternatives.

The management team decided to use a more conventional approach for addressing the No Action Alternative and, therefore, based it on current conditions and operations. In the absence of a long-term reoperation program, the current BO is the closest approximation of present and near-term conditions. Action alternatives are compared against this No Action Alternative, which represents no change from current management direction, thereby providing a realistic picture of any changes that would take place under any of the action alternatives. A pre-1991 alternative would be difficult to present to the public and difficult to define for many resources and would not be viable, given the current regulatory context. Even though the pre-1991 baseline is not considered as a formal action alternative, pre-1991 baseline information is incorporated in the impact analysis, as appropriate, to demonstrate the degree and impacts of operational changes on the Carlsbad Project water supply. Comparisons with the pre-1991 baseline are used in the analysis of the effects of the alternatives on water resources, water quality, agricultural soil and land resources, biological resources, and the regional economy, as shown in chapter 4.

5.2 Range of Target Flows

The final alternatives include a range of target flows, gaging locations, seasonal variability, and variability for dry, average, and wet hydrologic conditions. Reclamation had considered target flows of up to 72 cfs at the Near Acme gage for some of the early alternatives. Preliminary modeling indicated that water would not be available within the Pecos River system to sustain these higher target flows, leading to increased intermittency, which would be harmful to the shiner and would deplete the Carlsbad Project water supply beyond levels that Reclamation could reasonably be expected to acquire. (See appendices 2 and 3.) Such alternatives clearly would not meet the purpose of and need for the proposed action. An alternative proposing year-round flows of 35 cfs at the Near Acme gage and one that has target flows of 48 cfs during the irrigation season in wet hydrologic conditions represent the high range of flows in the alternatives proposed for detailed analysis.

5.3 Block Release Proposals

The early alternatives included many proposals for specifying the block release duration, frequency, magnitude, ramp up/ramp down, delivery efficiency, and restrictions on time of year. In formulating the final alternatives, Reclamation proposed common rules for making block releases that would simplify alternative comparison and allow managers to be responsive to changing river conditions. In the case of duration, frequency, and delivery efficiency, most proposals were similar and compatible with typical release patterns. Depending on the level of Sumner Lake, the magnitude of releases through the outlet works is generally limited to approximately 1,400 cfs. Historically, block releases average approximately 1,060 cfs. Flows greater than 1,600 cfs are not possible and, thus, larger "flushing flows" could not be made and were not considered further. Proscriptions specifying the size of releases were dropped in order to allow flexibility.

Defining specific ramp-up and ramp-down protocols for releases also was eliminated from the alternatives because of a lack of consensus on their value to the shiner and anticipated depletions associated with these releases. These protocols had been part of experimental operations but, in effect, had extended the length of block releases beyond 15 days. The Service considers continuous flows greater than 300 cfs exceeding 15 days to be detrimental to the shiner, because these flows increase predation by washing eggs downstream into Brantley Reservoir. Lower flows at the beginning of a release essentially disappear as they travel down the river, and ramp downs also were inefficient in delivering irrigation water (and contrary to beneficial use requirements of State and Federal law). Also, the natural pattern of the steeply rising and falling flows, combined with the streambank storage and return effect along the river, yield a more gradual transition in flows through the critical habitat for the shiner.

Proposed block release restrictions ranged from total seasonal bans during the nonirrigation season or irrigation season to no restrictions or guidance. The common proposal brought forward would allow releases on CID demand but specifies avoidance to the extent possible during the 6 weeks around August 1 to minimize the transport of shiner eggs and larvae into Brantley Reservoir.

5.4 Linking CPWA Options to Alternatives

The management team considered linking specific water acquisition options to specific alternatives. This idea was rejected, and implementation of any of the CPWA and AWA options is possible with any of the alternatives. In this way, impacts of these options are addressed, while allowing flexibility in determining how best to acquire additional water needed to conserve the Carlsbad Project water supply. Following a sound evaluation process, anticipated availability, amounts, and timing are still variable and subject to changing conditions. Choice is also desirable in order to provide other benefits, such as incorporating options that would provide direct water for the fish or reducing environmental impacts or costs by using a combination of options. Reclamation will define in the ROD those options that could be used to meet project purposes, whether current authority exists, and the process for implementation.

5.5 Habitat Restoration and Conservation Measures

Many of the early discussions of alternatives included proposals for specific habitat improvement projects, such as channel restoration and non-native vegetation removal, or conservation measures, such as creating a hatchery and rearing facility. Others have suggested that fish populations could be moved to reaches of the Pecos River where intermittency does not occur. These proposals may contribute to conserving the shiner, but likely would not be central to meeting the purpose of and need for the proposed action, not comply with the ESA, and may be outside the mission and authority of the lead agency. Therefore, specific proposals of this kind were not included in the final alternatives, but their consideration is recommended as discretionary actions by the responsible agencies and could be part of the adaptive management framework.

5.6 Dam Removal and Elimination of Irrigation

No alternatives calling for the removal of water storage facilities or the elimination of irrigated agriculture were raised during public scoping, meetings of the interdisciplinary team, or through the alternatives development process. One early alternative proposed changing operations to more closely mimic the "natural hydrograph," based on passing water through the dams rather than dam removal and elimination of irrigated agriculture.

The management team has considered these concepts and found them unreasonable and not meeting the purpose of and need for the proposed action, which require alternatives that both conserve the shiner and the Carlsbad Project water supply. It is not clear whether dam removal and/or elimination of irrigation agriculture would conserve the shiner. Alternatives that do not address the conservation of the Carlsbad Project water supply cannot be evaluated further. Reclamation also lacks authority to remove or substantially alter the existing dams or to consider the elimination of agriculture. Carlsbad Project facilities exist and are operated for the congressionally mandated purposes of flood control and irrigation. Reclamation is obligated under contract to continue the Carlsbad Project and deliver Carlsbad Project water. Further, in developing alternatives for conducting Carlsbad Project water operations, Reclamation was required to respect existing water rights and Compact obligations.

6. Selection of Reclamation's Preferred Alternative

Reclamation has selected the Taiban Constant Alternative as the preferred alternative for this DEIS and for initiation of section 7 consultation with the Service. Under this alternative, Reclamation proposes to operate the Carlsbad Project to (1) divert to storage when flows at the Taiban gage are greater than 35 cfs, and (2) deliver from storage Carlsbad Project water as contracted for irrigation and consistent with applicable Federal and State laws. This alternative best meets the purpose of and need for the proposed action. See the detailed description of the Taiban Constant Alternative in section 4.2.

The initiation of section 7 consultation requires the identification of a proposed Federal action. Selecting a preferred alternative does not define Reclamation's final decision. The intention is to let the public know what the agency considers the best alternative, based upon the information available. Public comments or other considerations may result in a change in the preferred alternative and may even result in the final decision (recorded in the ROD) not being the preferred alternative in either the DEIS or the final EIS.

6.1 Criteria Used for Selection of the Preferred Alternative

Reclamation developed criteria for selection of the preferred alternative (table 2.3). Reclamation assessed each alternative against these criteria. The following sections describe the criteria and the assessment of the Taiban Constant Alternative.

Table 2.3 Criteria used for selection of the preferred alternative, ordered by consideration

Ranked importance	Criteria
1	Ensuring that Reclamation's actions do not jeopardize the shiner
2	Amount of additional water needed to meet target flows and augment the supply for the Carlsbad Project
3	Ease of operation
4	Minimal restrictions on block releases
5	Occurrence of intermittency
6	Likelihood of the Service accepting the alternative
7	Stability of BO
8	Flexibility of the alternative

6.1.1 Ensuring that Reclamation's Actions Do Not Jeopardize the Shiner

ESA requires that Reclamation's discretionary actions on the Carlsbad Project cannot jeopardize the shiner or other listed species; therefore, conserving the shiner is part of the purpose of and need for the proposed action. Conserving the shiner means that Reclamation would ensure that any discretionary action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. Reclamation believes that the Taiban Constant Alternative provides target flows sufficient to avoid jeopardizing the shiner.

6.1.2 Amount of Additional Water Needed (AWN) to Meet Target Flows

AWN is a modeled estimate of the amount of additional water that would need to be acquired for the Carlsbad Project to meet target flows specified in an alternative. The amount of AWN is an important consideration because of the need to conserve the Carlsbad Project water supply and to respect existing water rights and Compact obligations. Reclamation is limited in its authority to implement options to acquire water. The demand for water is high, and financial and environmental costs are associated with the need to obtain greater amounts of additional water. Therefore, alternatives with a low amount of AWN are more desirable from a cost and environmental standpoint and more sustainable over the long term. The Taiban Constant Alternative and the Critical Habitat Alternative have the lowest estimated average annual AWN of all of the alternatives.

6.1.3 Ease of Operation

Ease of operation refers to the location of the target gages, the ease with which changes in flows can be made, and whether target flows are adjusted by hydrologic condition. The use of the Taiban gage is preferred because it is generally reliable, the travel time for flows from Sumner Dam is shorter, its proximity allows Reclamation to react to rain events, and its location upstream of the critical habitat allows better monitoring of drying conditions. Target flows under the Taiban Constant Alternative do not change by hydrologic condition; thus, the amounts of water acquired would be more predictable.

6.1.4 Minimal Restrictions on Block Releases

Block release restrictions can limit the timely delivery of Carlsbad Project water to irrigators. The Taiban Constant Alternative and all of the action alternatives would have the same block release restrictions and would include a 6-week avoidance period around August 1 that is not currently required.

6.1.5 Occurrence of Intermittency

Avoiding intermittency is an important priority for conserving the shiner. With bypass water only, all of the alternatives are essentially the same in the amount of modeled intermittency. Under the Taiban Constant Alternative, intermittency is likely to occur even if target flows are met. Under all alternatives modeled, intermittency occurred at the Near Acme gage 1 percent or less of the time.

6.1.6 Likelihood of the Service Accepting the Alternative

Reclamation will be seeking a BO in consultation with the Service for long-term operation of the Carlsbad Project. In assessing the alternatives, Reclamation considered whether each alternative would be seen as an acceptable basis for a long-term BO on Carlsbad Project operations.

6.1.7 Stability of Biological Opinion

This refers to an evaluation of whether the alternative and measures in the BO would be sustainable in the long term by Reclamation. Reclamation seeks to avoid future jeopardy determinations and new section 7 consultations. Reclamation has determined that the reasonable target flows, small amount of AWN, use of the Taiban gage, and the adaptive management process under the Taiban Constant Alternative would avoid the potential for jeopardy better than other alternatives.

6.1.8 Flexibility of the Alternative

Maintaining flexibility in operating the Carlsbad Project is also a consideration in defining a preferred alternative. All of the action alternatives include measures that are designed to provide maximum flexibility to Reclamation managers in meeting the needs of the shiner. These include the use of the adaptive management process to respond to changes in river conditions and the use of a suite of water acquisition options. Because the Taiban Constant Alternative requires the least amount of AWN, Reclamation would have more flexibility than would be available under the alternatives that require more AWN to choose among the CPWA options and obtain sufficient water.

7. Water Acquisition Options

To conserve the water supply of the Carlsbad Project, options for acquiring additional water were developed, analyzed, and ranked by the water offset options group. The additional water would be needed because changes in Carlsbad Project operations to benefit the shiner would deplete the Carlsbad Project water supply. Section 8 provides a discussion of the evaluation criteria, analysis, and ranking of CPWA options; section 9 provides a detailed description of the CPWA options.

The water offset options group was later directed to explore options, called AWA options, for acquiring additional water for the river reaches where the shiner is found. This water would be used when changes in Carlsbad Project operations would not provide adequate flows to meet target flows, avoid intermittency at gaged sites, or, at a minimum, maintain flows in the critical habitat stream reach. A distinction is made between the two sets of water acquisition options. CPWA options are designed specifically to provide replacement water for delivery and irrigation use in the CID, whereas the AWA options are designed to meet the need of the shiner upstream. Some AWA option supplies may reach Brantley Reservoir and become available for use as Carlsbad Project water supply. Section 10 provides a discussion of the AWA evaluation criteria, analysis, and ranking; section 11 provides a detailed description of the AWA options.

These water acquisition options were developed without seeking a definitive determination of the authority of Reclamation or other agencies for their implementation. Reclamation is limited to implementing actions that are within its authority. NEPA, however, requires consideration of all reasonable alternatives within or outside the jurisdiction of the Federal agency. New authorities could be sought or other entities may be able to acquire water using options analyzed here. ESA does not provide Reclamation additional authority to meet its obligations under the Act.

8. CPWA Options Development Process

8.1 Evaluation Criteria, Analysis, and Ranking of CPWA Options

The water offset options group identified 26 options (designated A-Z), which were assigned to various group members for evaluation of the probable amount of water supplied, location of the supply, general cost of the water supply, and other pertinent attributes of the option. Group members documented their understanding of the water supply attributes of each option in technical reports that were reviewed by group members. During the review process, many of the original options were expanded into subcategories that further defined or delineated the option. For example, the water right purchase and retirement option was redefined into several options, depending on the location of the water right within the basin and by estimates of historic or escalated costs to acquire the right. Subcategories were evaluated as separate water acquisition options and were identified by a letter corresponding to the original 26 options, followed by a number in sequence for each subcategory of that option. For example, the water right purchase and retirement option was designated as "option D." The subcategories of this option were designated D-1 for surface water rights, D-2 for shallow ground-water rights, and D-3 for artesian ground-water rights. D-1A indicated surface rights in FSID, D-1B indicated surface rights in the Roswell area, and D-1C indicated surface rights in CID. The "X" designation on some of these options indicated an option identical to the option without the "X," except for a 40-percent increase in the option's water right cost due to the Settlement Agreement and NMISC's ongoing purchases of water rights in the basin. With subcategories, there were a total of 80 options. However, 10 of the original options or their subcategories were eliminated without further analysis as options for obtaining water already implemented, options with little or no potential, or as options that duplicated other options.

Rating Criteria for Carlsbad Project Water Acquisition Options

Quantitative	Qualitative
• Location	• Sustainability
• Amount of water potential	• Political risk to implement
• Cost	• Risk that the option would actually realize the water supply
• Time needed to implement	• Flexibility in diverting the supply
• Time needed to realize water for the Carlsbad water supply	
• Effect on State-line deliveries	

Options were analyzed to determine their effectiveness in providing additional water for the Carlsbad Project water supply. Water offset options group members estimated quantitative properties of the options, including location, amount, cost of the option, time to implement the option, and time to realize water from the option. Group members, as a whole, reviewed and, in some cases, modified these quantitative properties. Four additional qualitative criteria were developed to evaluate the more subjective properties of the water acquisition options, including sustainability of the option, political risk to implement, the relative risk that the option would actually realize the water supply, and flexibility in diverting the supply. These quantitative and qualitative properties of water acquisition options were used as ranking criteria for further analysis. In addition, a final criterion was added that evaluated the effect of the options on State-line flows.

Each ranking criterion was assessed for performance levels, and each performance level was assigned a ranking value of 0 to 5, with 5 being the most desirable. Care was taken to develop costs for all water acquisition options on an equivalent basis. Equivalent uniform annual costs (EUAC) were developed for each option by computing the present value of the capital and operation and maintenance costs of the water acquisition options and then converting that amount into a series of annual costs using a Federal project development rate of 5.875 percent. Two ranking officers selected by the workgroup prepared complete rankings for each option, by criteria. These ranking officers worked independently of each other during the initial ranking of each water acquisition option and compared differences once the initial ranking was complete. The numeric ranking for each of the 10 criterion was summed by water acquisition option, with larger numeric values indicating preferred options. The best possible score assigned by each ranking officer was 5, multiplied by the number of criteria, 10, for a total of 50. Each officer's total rank was then added to represent the total average score, with preference to higher scores and a possible perfect score of 100.

What is Equivalent Uniform Annual Cost?

Equivalent Uniform Annual Cost is the unit annual cost in dollars per acre-foot for developing a water resource, considering capital, operation and maintenance costs, project life, and the time value of money as the Reclamation annual planning rate of 5.875 percent.

As part of the ranking process, the water offset options group also considered prioritization of certain criteria to replace net depletions on an average basis or to replace maximum depletions. Results of the ranking options to meet average and maximum depletions through the use of weighted criteria are included in the water offset options group documentation report (appendix 2).

8.2 CPWA "A" List Options

At the request of the management team, the water offset options group developed "A" and "B" lists to focus the impact analysis on those CPWA options that could be implemented in the near term. The "A" and "B" lists were developed to reduce the number of options to be analyzed in detail. The criteria for developing these lists were the time it would take to implement the option and time to access the water. For "A" list options, the combination of time to implement the option and time to realize water in the river was limited to a maximum of 3 years. The "B" lists included options that required extensive planning beyond the scope of this NEPA process. "B" list options may still be developed in the future, but as part of a longer-term strategy, and they are not analyzed in this DEIS. Details on development of these lists can be reviewed in the water offset options group documentation report (appendix 2).

Table 2.4 presents the "A" list of 16 CPWA options resulting from the use of unweighted criteria. The "A" list is further refined by recognition that the amount of water generated by the option would not be fully effective in replacing depletions to the Carlsbad Project water supply. For example, the purchase and retirement of FSID water rights make water available far upstream of the Carlsbad Project, and less than the full amount of water generated at FSID would be available farther downstream because of conveyance losses. Chapter 4 provides further information on the development of the offset efficiency factors.

Table 2.4 "A" list: equally weighted ranking of CPWA options

Rank	Designation[1]	Option name/ description	Reclamation authority	Amount available (consumptive acre ft/year)[2]	Average CPWA efficiency to CID[3]	Average effective CPWA (acre ft/year)	Combined total score (no units)	Adjusted EUAC[4] ($/acre-ft/year)
1	Q1-SR	Develop well field: Seven Rivers	No authority to construct facilities, but authority to acquire water for the Carlsbad Project.	10,000	67%	6,700	77.0	433
2	Q1-BV	Develop well field: Buffalo Valley	No authority to construct facilities, but authority to acquire water for the Carlsbad Project.	10,000	58%	5,800	76.0	455
3	D-1B	Surface water right purchase: Roswell area	Yes – for Carlsbad Project uses.	1,600	55%	1,300	74.0	180
4	E-1B	Surface water right lease: Roswell area	Yes – for Carlsbad Project uses.	1,600	55%	1,300	73.0	165
5	D-1A	Surface water right purchase: FSID	Yes – for Carlsbad Project uses.	1,000	23%	300	72.0	431
6	D-1BX	Surface water right purchase: Roswell area	Yes – for Carlsbad Project uses.	1,600	55%	1,300	72.0	252
7	L-3	Changes to cropping patterns: (CID)[5] (very low water use crop)	Yes – for Carlsbad Project uses.	10,500	100%	10,500	71.5	182
8	E-1A	Surface water right lease: FSID	Yes – for Carlsbad Project uses.	1,000	23%	300	71.0	396

Table 2.4 "A" list: equally weighted ranking of CPWA options

Rank	Designation[1]	Option name/ description	Reclamation authority	Amount available (consumptive acre ft/year)[2]	Average CPWA efficiency to CID[3]	Average effective CPWA (acre ft/year)	Combined total score (no units)	Adjusted EUAC[4] ($/acre-ft/year)
9	D-1C	Surface water right purchase: CID	Yes – for Carlsbad Project uses.	3,150	100%	3,150	71.0	99
10	E-1C	Surface water right lease: CID	Yes – for Carlsbad Project uses.	3,150	100%	3,150	70.0	91
11	D-1AX	Surface water right purchase: FSID	Yes – for Carlsbad Project uses.	1,000	23%	300	70.0	603
12	D-1CX	Surface water right purchase: CID	Yes – for Carlsbad Project uses.	3,150	100%	3,150	69.0	139
13	L-2	Changes to cropping patterns: (CID)[5] (low water use crop)	Yes – for Carlsbad Project uses.	8,800	100%	8,800	66.5	249
14	L-1	Changes to cropping patterns: (CID)[5] (average of all water use amounts)	Yes – for Carlsbad Project uses.	8,900	100%	8,900	65.5	206
15	L-4	Changes to cropping patterns (CID)[5] (medium water use crop)	Yes – for Carlsbad Project uses.	6,000	100%	6,000	64.5	209
16	U	FSID gravel pit pumping	Unknown – construction may be considered operations and maintenance, but do have the authority to acquire water for the Carlsbad Project.	300	74%	222	62.0	13

[1] Options designated with an "X" represent the option with the same designation but with an escalated cost of 40% to account for market pressures.

[2] Amount presented for all water rights acquisition options is the Consumptive Irrigation Requirement (CIR). The CIR is the amount of irrigation water, exclusive of precipitation, stored soil moisture or groundwater needed consumptively for crop production.

[3] Note that "amount available" column multiplied by efficiency in this column does not yield effective offset. Only diverted amounts (convert from CIR amount by multiplying by 3 acre-feet/acre and dividing by 2.1 acre-feet/acre) can be multiplied by efficiencies in this column to determine effective offset.

[4] EUAC was "adjusted" to account for CPWA option efficiencies.

[5] The changes to cropping patterns were based on conversion of 5,000 acres of alfalfa to the crops with the indicated level of water.

9. Detailed Description of CPWA Options

Each CPWA "A" list option is discussed in the following five general categories: water right purchase and land retirement, water right lease and land fallowing, change cropping patterns, well field development, and FSID gravel pit pumping. Additional NEPA analysis may be required for some options and may include the preparation of documents tiered from this DEIS, such as environmental assessments and categorical exclusions. For some options, resource specific field studies (cultural and biological resource studies) may be conducted.

9.1 Water Right Purchase and Land Retirement

Water right purchase and land retirement options include D1-A, D1-AX, D1-B, D1-BX, D-1C, and D-1CX. Water rights are real property rights for which ownership can be transferred, much like land. The water right holder can apply to NMOSE for a change in point of diversion, place, and purpose of use of the water right, as long as doing so would not impair other appropriators, the transfer is not contrary to conservation of water in the State, or the transfer is not detrimental to the public welfare of the State.

Because water rights are transferable, a market exists for their sale and purchase. For agricultural water use, the value may be the difference in the price of farmland with and without irrigation water rights attached to the land. For municipal, commercial, industrial, and institutional water use, the market is usually for water rights alone, separate from the land.

Under these CPWA options, Reclamation would purchase surface water rights from willing sellers at market rates. These rights would be permanently retired in place, and this water would remain in the Pecos River and would not be diverted. A reduction in the quantity of the right sometimes occurs when a water right is transferred. Because the objective is to replace new depletions to the river, the source should reduce existing depletions or the consumptive portion of a water right. These options would not require changes to infrastructure, but precise locations of the retired land cannot be predicted. Six CPWA "A" list options are in this category; three of these options differ only in that they anticipate higher costs of acquiring water rights. NMISC is purchasing substantial quantities of land with surface water and ground-water rights for implementing the Settlement Agreement. The market has changed as a result of this and other anticipated future activity. (See chapter 1, section 6.4.1.). However, NMISC has received offers in excess of its needs, and the price of purchasing or leasing water rights can only be estimated until offers are received.

Under CPWA options D-1A and D-1AX, Reclamation would seek to acquire surface water rights to approximately 1,000 acre-feet per year and permanently retire approximately 490 acres in the FSID. Under CPWA options D-1B and D-1BX, Reclamation would seek to acquire water rights to 1,600 acre-feet per year and permanently retire approximately 750 acres in the vicinity of Roswell. Under CPWA options D-1C and D-1CX, Reclamation would seek to acquire water rights to 3,150 acre-feet per year and permanently retire approximately 1,500 acres within CID. Reclamation would not purchase the land associated with the water right. Reclamation has the authority to acquire water for the Carlsbad Project.

9.2 Water Right Lease and Land Fallowing

Water right lease and land fallowing options include E1-A, E1-B, and E-1C. Under these CPWA options, Reclamation would lease surface water rights from willing parties and then would fallow the acreage. Annual water allotments would remain in the Pecos River or the aquifer for the term of the lease, typically 5 years. Under State law, the lease term is limited to 10 years. The landowner would retain the water rights and would be free to use or transfer them at the end of the lease (Water-Use Leasing Act, 72-6-1 through 72-6-7, New Mexico Statutes, Annotated, 1978).

These CPWA options would not require changes to infrastructure. Exact locations of land with water rights available for lease and fallowing cannot be predicted.

Three CPWA "A" list options involve leasing and fallowing. Acres leased for CPWA purposes are independent of acres purchased for CPWA purposes, even though they may be from the same source. Under option E-1A, Reclamation would seek to lease consumptive surface water rights to approximately 1,000 acre-feet per year and would temporarily fallow approximately 490 acres in FSID. Under CPWA option E-1B, Reclamation would seek to lease water rights to 1,600 acre-feet per year and would fallow approximately 750 acres in the vicinity of Roswell. Under CPWA option E-1C, Reclamation would seek to acquire water rights to 3,150 acre-feet per year and would temporarily fallow approximately 1,500 acres within CID. Reclamation has the authority to acquire water for the Carlsbad Project.

9.3. Changes to Cropping Patterns

Options to change cropping patterns include L-1, L-2, L-3, and L-4. Alfalfa is the predominant crop within CID. An acre of alfalfa requires approximately 4.5 acre-feet per year of water, including a leaching requirement of about 0.9 acre-foot per year because of soil salinity (Brummer, 2001). When less water is applied, yields are reduced. Under these options, Reclamation would encourage farmers to plant crops that require less irrigation water, such as cotton, small grains, and corn. Because these crops are less profitable than alfalfa, the farmers would need to be reimbursed for the loss in profit. CID and/or individual farmers also would have to agree to release the water saved due to the lower water consumption and from growing lower value crops. These options would not require changes to infrastructure, and exact locations of cropland conversion cannot be predicted.

In developing these options and estimating costs, Reclamation made the following assumptions:

- L-1: Reclamation assumed a program in which 5,000 acres would be converted from alfalfa to a mix of very low, low, and medium water use crops in equal amounts.
- L-2: Reclamation assumed a program in which 5,000 acres would be converted from alfalfa to a low water use crop.
- L-3: Reclamation assumed a program in which 5,000 acres would be converted from alfalfa to very low water use crops.
- L-4: Reclamation anticipates a program in which 5,000 acres would be converted from alfalfa to a medium water use crop.
- Saved water would remain in the Pecos River system.

Reclamation has the authority to implement these options if the water is saved for the Carlsbad Project water supply.

9.4 Well Field Development

Well field development options include Q1-SR and Q1BV. Under these CPWA options, Reclamation would purchase or lease water rights and transfer them to well fields to be developed at the Seven Rivers or Buffalo Valley areas. Ground water would be pumped from these wells and piped into the Pecos River for delivery to Brantley Reservoir when operations to benefit the shiner cause additional depletions. The number, exact locations, depths, and distance from the river of new wells have not been determined. Under CPWA option Q1-SR, Reclamation would develop a well field at Seven Rivers near river mile 479. Under option Q1-BV, Reclamation would develop a well field at Buffalo Valley near river mile 533. Each option could provide 10,000 acre-feet of water per year. Reclamation does not currently have the authority to construct new facilities but does have the authority to acquire water for the Carlsbad Project from this source.

9.5 FSID Gravel Pit Pumping

Under CPWA option U, water from an abandoned gravel pit on the south side of Fort Sumner would be pumped to the Pecos River through an irrigation drain. A total of 300 acre-feet per year is available, but the pit is connected to an aquifer upon which domestic wells depend. Minimal infrastructure would be required, resulting in low unit water costs. Water quality is unknown. The authority for Reclamation to implement this option is unknown. Reclamation has the authority to acquire water for the Carlsbad Project, but construction of a pipe may exceed its operations and maintenance authority.

10. AWA Options

10.1 Evaluation Criteria, Analysis, and Ranking of AWA Options

Additional water acquisition is defined as new water added to the Pecos River system for the purpose of providing flows for the shiner. The water offset options group formulated AWA options by revisiting the list of CPWA options and determining which of these could be applied upstream of the shiner critical habitat. Group members added other potential acquisition options, including some in areas upstream of Santa Rosa. Options north of Santa Rosa may be viable for acquiring water, but these options were not included in the initial scoping and affected environment for this DEIS and would require additional analysis and public involvement activities. Ten sources for AWA were identified and were divided into subcategories or variations that are associated with the option. These were developed into 47 proposals that were evaluated by the water offset options group (Reclamation, 2005b). AWA options were assigned their own designations, which differ from the CPWA options.

AWA options were evaluated using similar methods, including development of a list of possible supplies, defining the water supply attributes of those options, developing criteria for ranking the options, and summarizing the findings. Many of the AWA options were derived from similar CPWA options and used the same analytical information. However, some of the criteria for ranking the AWA options were altered to reflect the changed circumstances for use of the water. Criteria for ranking the "location" of the additional water supplies were changed to reflect the need to supply water to the upper critical habitat of the shiner rather than the Carlsbad Project location. Further, the "amount available" ranking criterion was reduced to reflect the smaller supplies available for additional water acquisition. Finally, the "flexibility of supply" ranking criterion was adjusted for seasonal timing needs of the water supply for the shiner. At the conclusion of the ranking of the AWA options, the options were again assigned to an "A" or "B" list, depending on the ability of the option to provide water within 3 years of selection and whether extensive additional NEPA analysis would be required. These results and the "B" list can be reviewed in appendix 2 (Reclamation, 2005b).

10.2 "A" List AWA Options

Table 2.5 presents the "A" list of AWA options. The table includes the final combined total score, the amount of potentially available water, and the projected cost. The table describes the AWA options that could be implemented to provide water within 3 years. Additional NEPA analysis may be required for some options and may include the preparation of documents tiered from this DEIS, such as environmental assessments and categorical exclusions. For some options, resource specific field studies (cultural and biological resource studies) may be conducted.

Table 2.5 "A" list AWA options

Designation[1]	Option name	Reclamation authority	Combined total score	Amount available (consumptive acre-feet/year)	EUAC ($/acre-feet/year)
A-1	Surface water right purchase: CID	Yes – for Carlsbad Project uses	75.5	3,150	99
A-2	Surface water right purchase: FSID	Yes – for Carlsbad Project uses	73.5	1,000	99
A-1X	Surface water right purchase: CID (additional 40-percent inflation)	Yes – for Carlsbad Project uses	73.5	3,150	139
B-1	Surface water right lease: CID	Yes – for Carlsbad Project uses	72.5	3,150	91
A-2X	Surface water right purchase: FSID (additional 40% inflation)	Yes – for Carlsbad Project uses	71.5	1,000	139
B-2	Surface water right lease: FSID	Yes – for Carlsbad Project uses	70.5	1,000	91
I	FSID gravel pit pumping	Unknown – construction may be considered operations and maintenance, but do have the authority to acquire water for the Carlsbad Project	63.5	300	10
J-2	Fort Sumner area large-capacity well field	No authority to construct facilities, but authority to acquire water for the Carlsbad Project	62.0	1,384	150
J-1	Fort Sumner area small-capacity well field	No authority to construct facilities, but authority to acquire water for the Carlsbad Project	61.0	500	164
D-1C	Changes to cropping patterns: CID (very low water use crop)	Yes – for Carlsbad Project uses	60.0	10,500	128
D-1A	Changes to cropping patterns: CID (average of all water use amounts crop)	Yes – for Carlsbad Project uses.	60.0	8,900	144
D-1D	Changes to cropping patterns: CID (medium water use crop)	Yes – for Carlsbad Project uses	60.0	6,000	147
D-1B	Changes to cropping patterns: CID (low water use crop)	Yes – for Carlsbad Project uses	60.0	8,800	175
D-2	Changes to cropping patterns: FSID (small grain)	Yes – for Carlsbad Project uses	59.0	3,375	158
A-4	Surface water right purchase: Puerto de Luna area	Yes – for Carlsbad Project uses	57.5	110	99
A-4X	Surface water right purchase: Puerto de Luna area (additional 40-percent inflation)	Yes – for Carlsbad Project uses	55.5	110	139
B-4	Surface water right lease: Puerto de Luna area	Yes – for Carlsbad Project uses	54.5	110	91
D-4	Changes to cropping patterns: Puerto de Luna area (very low water use crop)	Yes – for Carlsbad Project uses	47.5	360	168

[1] Options designated with an "X" represent the option with the same designation but with an escalated cost of 40% to account for market pressures.

11. Detailed Description of AWA Options

Each “A” list AWA option is discussed in the following five general categories: water right purchase and land retirement, water right lease and land fallowing, change cropping patterns, well field development, and FSID gravel pit pumping. Additional NEPA analysis may be required for some options and may include the preparation of documents tiered from this DEIS, such as environmental assessments and categorical exclusions. For some options, resource specific field studies (cultural and biological resource studies) may be conducted.

11.1 Water Right Purchase and Land Retirement

Water right purchase and land retirement options include A-1, A-1X, A-2, A-2X, A-4, and A-4X. Under these AWA options, Reclamation would purchase surface water rights from willing sellers at market rates. These rights would be permanently retired in place, and this water would remain in the Pecos River and would not be diverted. These AWA options would not require changes to infrastructure, and precise locations of the retired land cannot be predicted. Six “A” list AWA options are in this category; three of these options differ only in that they anticipate higher costs of acquiring water rights. NMISC is purchasing substantial quantities of land with surface water and ground-water rights for implementing the Settlement Agreement. The market has changed as a result of this and other anticipated future activity. (See chapter 1, section 6.4.1.). However, NMISC has received offers in excess of its needs, and the price of purchasing or leasing water rights can only be estimated until offers are received.

Under AWA options A-1 and A-1X, Reclamation would seek to acquire water rights to 3,150 acre-feet per year and would permanently retire approximately 1,500 acres within CID. Because these water rights would be retired downstream from where the additional water would be needed, they would be exchanged for the release of surface water stored in Sumner Lake or Santa Rosa Reservoir. The portion of the water reaching CID would need to be accounted for in the exchange.

Under AWA options A-2 and A-2X, Reclamation would seek to acquire surface water rights to approximately 1,000 acre-feet per year and would permanently retire approximately 490 acres within FSID. Under AWA options A-4 and A-4X, Reclamation would seek to acquire water rights to 110 acre-feet per year and would permanently retire approximately 52 acres in the vicinity of the village of Puerto de Luna, south of Santa Rosa. Reclamation has the authority to acquire water for Carlsbad Project uses.

11.2 Water Right Lease and Land Fallowing

Water right lease and land fallowing options include B-1, B-2, and B-4. Under these AWA options, Reclamation would lease surface water rights from willing parties and would fallow acreage. Annual water allotments would remain in the Pecos River for the term of the lease, typically 5 years. Under State law, the lease term is limited to 10 years (Water-Use Leasing Act). The landowner would retain the water rights and would be free to use or transfer them at the end of the lease. These AWA options would not require changes to infrastructure, but exact locations of land with water rights available for lease and fallowing cannot be predicted.

Three "A" list AWA options involve leasing and fallowing. Under AWA option B-1, Reclamation would seek to acquire water rights to 3,150 acre-feet per year and would temporarily fallow approximately 1,500 acres within CID. Under AWA option B-2, Reclamation would seek to lease surface water rights to approximately 1,000 acre-feet per year and would temporarily fallow approximately 476 acres within FSID. Under AWA option B-4, Reclamation would seek to lease water rights to 110 acre-feet per year and would fallow approximately 52 acres in the vicinity of the village of Puerto de Luna, south of Santa Rosa. Reclamation has the authority to acquire water for Carlsbad Project uses.

11.3 Changes to Cropping Patterns

Options to change cropping patterns include D-1A, D-1B, D-1C, D-1D, D-2, and D-4. Under these AWA options, Reclamation would encourage farmers to plant crops that require less irrigation water, such as cotton, small grains, and corn. Because these crops are less profitable than alfalfa, the farmers would have to be reimbursed for the loss in profit. The irrigation districts and/or individual farmers would also have to agree to release the water saved due to lower water consumption and from growing lower value crops. The point of diversion or place of storage for water saved by CID will have to be transferred or exchanged upstream of Sumner Dam. These AWA options would not require changes to infrastructure, and exact locations of cropland conversion cannot be predicted.

In developing these options and estimating costs, Reclamation made the following assumptions:

- D-1A: 5,000 acres within CID would be converted from alfalfa to a mix of very low, low, and medium water use crops in equal amounts.

- D-1B: 5,000 acres within CID would be converted from alfalfa to low water use crops.

- D-1C: 5,000 acres within CID would be converted from alfalfa to very low water use crops.

- D-1D: 5,000 acres within CID would be converted from alfalfa to medium water use crops.

- D-2: 1,125 acres within FSID would be converted from alfalfa to very low water use crops

- D-4: 120 acres near the village of Puerto de Luna would be converted from alfalfa to very low water use crops.

- Saved water would remain in the Pecos River system.

Reclamation has the authority to implement these options if the water is saved for the Carlsbad Project water supply.

11.4 Well Field Development

Under these AWA options, a well field would be developed in the vicinity of Fort Sumner. Ground water would be pumped from these wells and piped into the Pecos River to provide direct flows for shiner conservation in the upper critical habitat. Purchased or leased water rights would be transferred to the well field. The number, precise locations, depths, and distance from the river of new wells have not been determined. Under AWA option J-1, a small-capacity well field was assumed which could provide up to 500 acre-feet per year of supplemental water to the Pecos River. Under AWA option J-2, a large-capacity well field was assumed which could provide up to 1,384 acre-feet per year of supplemental water. Reclamation does not currently have the authority to construct new facilities, but it does have the authority to acquire water for the Carlsbad Project from this source.

11.5 FSID Gravel Pit Pumping

Under AWA option I, water from an abandoned gravel pit on the south side of Fort Sumner would be pumped to the Pecos River through an irrigation drain. A total of 300 acre-feet per year is potentially available, but the pit is connected to an aquifer upon which domestic wells depend. Minimal infrastructure would be required as long as the water quality is acceptable, and this water could be provided to augment flows at a low cost. The authority for Reclamation to implement this option is unknown. Reclamation has the authority to acquire water for the Carlsbad Project, but construction of pipe may exceed its operations and maintenance authority.

12. Summary of Impacts Table

Table 2.6 summarizes the impacts of the alternatives on the resource indicators analyzed in this DEIS.

Table 2.6 Summary of impacts of alternatives on resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Water Resources						
Difference in percent of time modeled flows of 10 cfs at the Near Acme gage are exceeded	10 percent more frequently than under pre-1991 baseline	3 percent less frequently than under No Action	3 percent less to 4 percent more frequently than under No Action	7 percent more frequently than under No Action	5 percent more frequently than under No Action	2 percent less frequently than under No Action
Difference in percent of time modeled flows of 20 cfs at the Near Acme gage are exceeded	19 percent more frequently than under pre-1991 baseline	10 percent less frequently than under No Action	8 to 9 percent less frequently than under No Action.	10 percent more frequently than under No Action	3 percent more frequently than under No Action	6 percent less frequently than under No Action
Difference in percent of time modeled flows of 30 cfs at the Near Acme gage are exceeded	24 percent more frequently than under pre-1991 baseline	23 percent less frequently than under No Action	23 percent less frequently than under No Action.	8 percent more frequently than under No Action	0.6 percent more frequently than under No Action	23 percent less frequently than under No Action
Difference in frequency of modeled intermittency at the Near Acme gage	0.3 percent less frequently than under pre-1991 baseline	0.04 percent less frequently than under No Action	0.08 to 0.3 percent less frequently than under No Action	0.3 percent less frequently than under No Action	0.3 percent less frequently than under No Action	0.1 percent more frequently than under No Action
Additional water needed (AWN) to meet target flows	Average of 2,900 acre-feet per year more than under pre-1991 baseline	Average of 720 acre-feet per year more than under pre-1991 baseline	Average of 1,400 to 4,200 acre-feet per year more than under pre-1991 baseline	Average of 9,500 acre-feet per year more than under pre-1991 baseline	Average of 5,300 acre-feet per year more than under pre-1991 baseline	Average of 620 acre-feet per year more than under pre-1991 baseline
Modeled average annual depletion (net depletions) to Carlsbad Project water supply	Average of 1,600 acre-feet per year greater than under pre-1991 baseline	Average of 1,200 acre-feet per year greater than under pre-1991 baseline	Average of 1,200 to 1,700 acre-feet per year greater than under pre-1991 baseline	Average of 3,900 acre-feet per year greater than under pre-1991 baseline	Average of 3,000 acre-feet per year greater than under pre-1991 baseline	Average of 1,200 acre-feet per year greater than under pre-1991 baseline
Modeled average annual flows at the New-Mexico State line	1,200 acre-feet per year lower than under pre-1991 baseline	440 acre-feet per year lower than under pre-1991 baseline	690 to 1,600 acre-feet per year lower than under pre-1991 baseline	2,100 acre-feet per year lower than under pre-1991 baseline	1,600 acre-feet per year lower than under pre-1991 baseline	530 acre-feet per year lower than under pre-1991 baseline

Table 2.6 Summary of impacts of alternatives on resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Water Quality						
EC	EC as much as 900 µS/cm higher in Brantley Reservoir and more than 300 µS/cm higher in CID; higher EC in all year types, but highest in dry year, lowest in wet year. Impacts would be moderate, localized, and long-term.	Slightly higher EC in wet year, but higher than under No Action in other year types. Impacts would be minor, localized, and long-term.	Higher EC in dry years and lower EC in normal and wet years at high and intermediate target flows; lower EC in wet years and higher EC in normal and dry years at lowest target flows. Impacts would vary with target flows, but overall would be minor, localized, and long-term.	Lower EC in normal and dry years, but higher in wet years when EC is generally lower. Impacts would be moderate, localized, and long-term.	No change in EC in wet year, but lower EC in normal and dry years, highest EC in dry years. Impacts would be moderate, localized, and long-term.	Higher EC in all year types, Impacts would be minor, localized, and long-term.
Agricultural Soil and Land Resources						
Overall resource	Minor localized adverse impacts to agricultural soil and land resources compared to pre-1991 baseline	Minor adverse impacts compared to No Action	Minor adverse impacts compared to No Action	Minor adverse impacts compared to No Action, mainly because of greater land retirement	Minor adverse impacts compared to No Action	Minor, mitigatable impacts compared to No Action
Biological Resources						
Terrestrial and flood plain ecosystem components	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Riverine aquatic ecosystem components: Santa Rosa Reservoir to Sumner Lake	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	No change The lack of AWA options and adaptive management guidelines would not provide the management flexibility necessary to offset these potential impacts.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different

Table 2.6 Summary of impacts of alternatives on resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
		from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under No Action. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under No Action. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under No Action. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under No Action. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	from No Action. Same as No Action. AWA/AWN options would not reduce or eliminate intermittency as under other action alternatives.
Riverine aquatic ecosystem components: Brantley Dam to New Mexico-Texas State line	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Reservoir aquatic ecosystem components	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Pecos bluntnose shiner	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as impacts presented for Riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir
Regional Economy						
Change in annual value of regional output ($)	- 350,000 to - 2,165,000	+ 88,000 to + 525,000	+ 88,000 to + 525,000 **to** - 22,000-131,000	- 504,000 to - 3,149,000	- 307,000 to - 1,902,000	+ 88,000 to +525,000
Change in annual regional income ($)	- 27,000 to - 871,000	+ 7,000 to + 211,000	+ 7,000 to + 211,000 **to** -2,000 to + 53,000	- 39,000 to - 1,267,000	- 24,000 to - 766,000	+ 7,000 to - 211,000
Change in regional employment (jobs)	-0.3 to -28.1	+0.1 to +6.8	+0.1 to +6.8 **to** 0.0 to -1.7	- 0.5 to -40.8	- 0.3 to -24.7	+0.1 to +6.8

Table 2.6 Summary of impacts of alternatives on resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Recreation						
Reservoir recreation and impacts	No change	Approximately the same as No Action	Approximately the same as No Action	Approximately the same as No Action	Approximately the same as No Action	Approximately the same as No Action
River recreation and impacts	No change	Less recreation use implies less recreation related spending and lower net benefits than No Action	Less recreation use implies less recreation related spending and lower net benefits than No Action	More recreation use implies more recreation related spending and higher net benefits than No Action	More recreation use implies more recreation related spending and higher net benefits than No Action	Approximately the same recreation use implies approximately the same recreation related spending and approximately the same net benefits as No Action
Cultural Resources						
Presence or potential for significant cultural resources	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Riverflow and reservoir storage levels and fluctuation where resources could be disturbed	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Ground-disturbing activities, modification, loss, or abandonment of historic structures	No change	Unknown. Least amount of AWN. Lower potential to exercise water acquisition options which could affect cultural resources.	Unknown. Low AWN. Lower potential to exercise water acquisition options which could affect cultural resources.	Unknown. Most AWN. Highest potential to exercise water acquisition options which could affect cultural resources.	Unknown. High AWN. Higher potential to exercise water acquisition options which could affect cultural resources.	Unknown. Low AWN. Lower potential to exercise water acquisition options which could affect cultural resources.
Indian Trust and Treaty Assets						
Potential to affect Indian real property, physical assets, or intangible property rights	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action

EC = specific electrical conductance, AWN = additional water needed, µS/cm = microSiemens per centimeter

Chapter 3

Affected Environment

Chapter 3
Affected Environment

This chapter describes the resources of the study area that could be affected by the proposed action, its alternatives, and other proposed management actions. Study area resources are numerous and complex. Therefore, the descriptions focus on various resource *indicators*. A resource indicator is a particular measure of a resource used to assess impacts on the overall resource. The effects of the alternatives on the selected resource indicators are evaluated in chapter 4. These analyses are considered adequate to address all potentially significant effects on each resource.

Potentially affected resources are water resources; water quality; agricultural soil and land resources; biological resources, including special status species; regional economy; recreation; cultural resources; Indian trust and treaty assets (ITA); and environmental justice.

1. Study Area Setting

This section briefly describes the study area's general setting. The study area extends from Santa Rosa Reservoir in Guadalupe County through De Baca, Chaves, and Eddy Counties to the New Mexico-Texas State line at the southern end of Eddy County. Larger communities in the study area include Santa Rosa, Fort Sumner, Roswell, and Carlsbad (map 1.1).

Pecos River Facts

Headwaters: North of Pecos, New Mexico, in the Sangre de Cristo Mountains

Terminus: Discharges to the Rio Grande between Comstock and Langtry, about 38 miles northwest of Del Rio, Texas

Length: Approximately 900 miles

Drainage area: Approximately 33,000 square miles

General flow direction: South/southeast

The Pecos River originates in the Sangre de Cristo Mountains of northern New Mexico. From its headwaters, it meanders across 500 river miles (about 330 straight-line miles) as it flows south across eastern New Mexico, until it crosses into Texas south of Carlsbad, New Mexico. It flows another 400 river miles to its confluence with the Rio Grande near Langtry, Texas. The total drainage area at its confluence with the Rio Grande is approximately 33,000 square miles, with 19,000 square miles within New Mexico. In addition to the mountains at the northern end of the Pecos River basin outside the study area, the basin is bordered by the Capitan and Sacramento Mountains to the southwest.

At the northern end of the study area, the climate is typical of the southern High Plains, transitioning to upper Chihuahuan Desert at the southern end. The elevation varies greatly throughout the basin, and the region is considered semi-arid, with average rainfall across the basin ranging from 11-15 inches annually. Relative humidity, which affects evaporation, ranges from an average of near 65 percent around sunrise to near 30 percent in midafternoon; however, afternoon humidity in warmer months is often less than 20 percent and occasionally may go as low as 4 percent (Western Regional Climate Center, 2005). In the northern portion of the study area, average temperatures vary from the low 50s to low 20s (degrees Fahrenheit [°F]) in the middle of winter and from the low 90s to the low 60s in the middle of summer. In the southern portions of the basin, average temperatures vary from the high 50s to high 20s in the middle of winter and from the low 100s to the high 60s in the middle of summer. In addition to humidity and temperature, winds can be moderate to extreme and can greatly affect potential evaporation and, ultimately, water resources in the Pecos River basin. Measured wind velocities in the study area have exceeded 70 miles per hour; springtime is the most consistently windy period.

USGS Gages on Mainstem of the Pecos River in New Mexico

- Near Pecos
- Near Anton Chico
- Above Santa Rosa Lake
- Below Santa Rosa Dam
- Near Puerto De Luna
- Below Sumner Dam
- Below Taiban Creek Near Fort Sumner
- Near Dunlap
- Near Acme
- Near Artesia
- Kaiser channel Near Lakewood
- Below Brantley Dam Near Carlsbad
- Below Avalon Dam
- Below Dark Canyon At Carlsbad
- Near Malaga
- At Red Bluff

The Pecos River system in New Mexico includes three major reservoirs: Santa Rosa Reservoir, Sumner Lake, and Brantley Reservoir; a fourth smaller reservoir (Avalon) just south of Brantley Reservoir is used by the Carlsbad Irrigation District (CID) for staging and diverting Brantley Reservoir releases (map 1.1). U.S. Geological Survey (USGS) gages (map 2.1) on the mainstem of the Pecos River in New Mexico are listed in the sidebar.

From Santa Rosa Dam to Sumner Lake, the Pecos River flood plain mostly is incised into bedrock canyons of varying width and up to 300 feet deep. In the subreach from Santa Rosa to Puerto de Luna, agricultural fields irrigated by river diversions and riparian vegetation, both native (e.g., cottonwoods and willows) and non-native (e.g., Russian olive and tamarisk, commonly known as salt cedar), occupy the flood plain. From Sumner Dam to Brantley Reservoir is a broad valley that was a relatively treeless, dry flood plain before the 1900s (Hufstetler and Johnson, 1993). Today, the lower valley, from the Near Acme gage to Brantley Reservoir, is filled with farm fields, and the entire flood plain is clogged with invasive trees. In recent years, however, the Bureau of Reclamation (Reclamation), CID, and the State of New Mexico have made great strides in eradicating the non-native invasive species. Major tributaries include the Arroyo del Macho, Rio Hondo, Rio Felix, Rio Penasco, South Seven Rivers, Black River, and Delaware River from the west, along with Long Draw, Alamagordo Creek, and Taiban Creek from the east. These tributaries are predominantly ephemeral.

Evidence shows that the river channel currently is narrower than it was historically. Channel narrowing is attributable to several factors, including the following:

- Decrease in the frequency and magnitude of the channel-forming discharge because of flow regulation (Tetra Tech, Inc., 2000b).
- Decrease in sediment load from sediment trapping and storage in dams (Tetra Tech, Inc., 2000b).
- Encroachment by non-native vegetation, such as salt cedar, which has armored the streambanks in many places. Armored streambanks contribute to channel narrowing and restrict the river's ability to migrate and meander across its flood plain (Tetra Tech, Inc., 2000b).
- Direct human manipulations of the channel and flood plain, such as bridges, levees, dikes, channelization, and meander cutoffs (Tetra Tech Inc., 2000b).
- Declining ground-water level because of human activities (e.g., lower water yields from high elevation watersheds, and ground-water diversion).

The water supply in the Pecos River basin is derived from three sources: snowmelt from the northern mountains, runoff from summer storms across the basin, and ground-water base inflows. The snowmelt and runoff sources are highly variable. Ground-water inflows along the reaches from the Below Santa Rosa Dam gage to the Near Puerto de Luna gage, from the Near Acme gage to the Near Artesia gage, and directly into Brantley Reservoir from Major Johnson Springs generally are more consistent and less affected by the varying climatic conditions.

2. Irrigation Districts

Farming along the river is very important to the regional economy and is mostly concentrated in three major irrigation districts. Fort Sumner Irrigation District (FSID) is located just downstream from Sumner Dam, on the east side of the river. FSID irrigates approximately 6,000 acres out of 10,000 authorized by its diversion right, which is a direct flow right of the natural riverflows up to 100 cubic feet per second (cfs). The Pecos Valley Artesian Conservancy District (PVACD) relies on ground water and irrigates approximately 100,000 acres of land west of the river from Roswell to south of Artesia. The Hagerman Canal (owned by Hagerman Irrigation Company [HIC]) supplies water to approximately 9,000 acres in the PVACD area using a combination of surface water diverted from the Rio Hondo and ground water pumped from the Roswell basin.

A key water project in the study area is the Carlsbad Project. Reclamation owns the Carlsbad Project dams, which CID operates under contract. CID owns the Carlsbad Project irrigation facilities. Carlsbad Project water is stored in Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir to provide irrigation water to about 25,000 acres within CID, located near Carlsbad. Because of fallowing, rotation, and permanent improvements, CID annually irrigates approximately 20,000 acres out of the 25,055 authorized by the Carlsbad Project.

Carlsbad Project Facts

***Reservoirs for Storage**:* Santa Rosa, Sumner, Brantley, Avalon

***Irrigated Acreage**:* 25,055 acres

***Project Owner**:* Bureau of Reclamation

***Project Operator**:* Carlsbad Irrigation District

***Conservation Storage**:* Storage of water in individual reservoirs for later release for stipulated project uses, in contrast with reservoir storage capacity used for flood control. (Conservation storage capacities for each of the reservoirs used by the project are provided in table 3.1.)

***Project Storage**:* Sum of storage in all reservoirs (Santa Rosa, Sumner, Brantley, and Avalon) cannot exceed project storage of 176,500 acre-feet.

3. Water Resources

This section describes the water resources indicators in detail. To provide additional context for these indicators, this section also describes several topics related to existing water resources in the study area: reservoir storage, evaporation, and seepage; operational priorities; water operations; streamflows; and ground water. (Appendix 3, Hydrologic and Water Resources, provides additional information.)

3.1 Resource Indicators

The following indicators were selected to evaluate water resources:

- Flow frequency at the Near Acme gage
- Additional water needed (AWN) to meet target flows
- Carlsbad Project water supply
- Pecos River flows at the New Mexico-Texas State line
- Base inflows in the Acme to Artesia reach of the Pecos River
- Carlsbad Project water acquisition option efficiencies

3.1.1 Flow Frequency at the Near Acme Gage

The primary goal of the proposed actions is to augment flows in critical habitat for the Pecos bluntnose shiner (shiner), while conserving the Carlsbad Project water supply. The alternatives are named based on the prescribed target flows in the vicinity of the upper critical habitat for the shiner; thus, resulting flows in the habitat for the shiner are clearly an important indicator for each alternative. Flow exceedance curves provided the information needed to analyze flow augmentation. The focus was on flows at the Near Acme gage, located just downstream from the upper critical habitat. The Near Acme gage is located in a stretch of the river that undergoes complete drying, so flow frequency at this location is also a good indicator of intermittency (or flow of 0 cfs). Several other gages along the Pecos River were examined; however, the Near Acme gage proved the most useful in demonstrating the impacts of the alternatives.

The results of the analysis of flow exceedance curves also were used to determine the frequency of intermittency and to compare the number of days of intermittency under the alternatives and the pre-1991 baseline.

3.1.2 Additional Water Needed to Meet Target Flows

Bypassing available flows above FSID's diversion right through Sumner Dam often would be insufficient to meet an alternative's identified target flows.

Because augmenting flows to meet specified targets in critical habitat for the shiner is the primary goal of each alternative, additional water needed to always meet these targets was computed and adopted as a resource indicator. The acquisition and management of this water would likely include, but is not limited to, a fish conservation pool (FCP) in Santa Rosa Reservoir and/or Sumner Lake.

3.1.3 Carlsbad Project Water Supply

One of the key goals of the proposed actions is to conserve the Carlsbad Project water supply. Operations of Sumner Dam (and, more recently, Santa Rosa Dam) on the Pecos River were historically set to deliver water to CID as efficiently as possible. Even for the most efficient operation, depletions occur. Water is stored and eventually conveyed to the main CID diversion at Avalon Dam. Some of that water is depleted because of evaporation at the reservoirs. Conveyance losses are also substantial because of evaporation from the water surface, along with seepage and losses to transpiration from riparian vegetation. The Pecos River RiverWare surface water model simulates the effects of all of these processes.

Depletions would differ among the alternatives, but all of the proposed alternatives would cause higher depletions than the pre-91 baseline, primarily because of the lower efficiency of bypassing flows compared to diverting that water to storage and releasing it later in more efficient block releases.

3.1.4 Pecos River Flows at the New Mexico-Texas State Line

Under the Pecos River Compact (Compact), the State of New Mexico is obligated to deliver flows to the New Mexico-Texas State line (measured at the Red Bluff gage). While New Mexico may obtain a credit for overdelivery, it is not allowed to incur a debt; therefore, the impact of the proposed actions on flows at the State line is another key water resources indicator. Changes in surface water delivery to CID affect return flows to the Carlsbad ground-water basin and also may cause changes in the supplemental well pumping regime in CID. Both of these hydrologic components affect base inflows to the Pecos River downstream from Avalon Dam. These changes in the Carlsbad basin, plus changes in spills at Avalon Dam, may substantially impact the State of New Mexico's ability to meet its delivery obligation under the Compact. Similar to the calculation of net depletions to the Carlsbad Project water supply, net depletions to State-line flows were computed as the difference between modeled State-line flows under each alternative and modeled flows under the pre-1991 baseline. Another aspect of the Compact that may be affected by actions contemplated in this draft environmental impact statement (DEIS) is New Mexico's delivery obligation, which depends, in part, on releases from Sumner Dam. Because State-line flows are anticipated to be more strongly affected than the obligation, depletion to flows at the State line was used as the sole indicator of New Mexico's status relative to the Compact.

3.1.5 Base Inflows in the Acme to Artesia Reach of the Pecos River

The Carlsbad Project water supply includes a substantial contribution from base inflows from the Roswell ground-water basin along the reach from the Near Acme gage to the Near Artesia gage. Historically, the contribution of base inflows to the Carlsbad Project water supply has been about 20,000 to 35,000 acre-feet per year. Any actions that would affect these base inflows would directly affect the Carlsbad Project water supply. The alternatives do not include prescribed changes in ground-water pumping operations in the Roswell basin; however, two Carlsbad Project water acquisition options do involve ground-water retirement and/or ground-water pumping in the Roswell basin. These options would impact base inflows to the river from the Roswell basin; thus, base inflows along the reach from the Near Acme gage to the Near Artesia gage were included as a water resource indicator.

3.1.6 Carlsbad Project Water Acquisition

Net depletions to the Carlsbad Project water supply were initially determined for each alternative with bypass flows only and no water acquisition options. As previously described, to mitigate for net depletions to the chronically short Carlsbad Project water supply, Reclamation would acquire water from one or more potential sources; these potential sources are referred to as Carlsbad Project water acquisition (CPWA) options. Recognizing that some options may more effectively mitigate depletions than others, a CPWA option efficiency resource indicator was defined. The efficiency is the percent of the water acquired at the source that effectively offsets net depletions to the Carlsbad Project water supply; this efficiency was computed from model results. These efficiencies also were used to determine the *amount* of water that would need to be acquired from the available sources to mitigate net depletions to the Carlsbad Project water supply.

3.2 Impact Area

The actions evaluated in this DEIS would affect both the hydrological systems in the Pecos River basin (specifically the Pecos River from Sumner Lake to the New Mexico-Texas State line and the two major ground-water basins, Roswell and Carlsbad) and associated water users.

As discussed in Section 1, “Setting,” the water supply in the Pecos River basin is derived from three sources: snowmelt from the northern mountains, runoff from summer rainstorms (monsoon season) across the basin, and base inflows from connected ground-water basins. Surface water flows in the Pecos River also are strongly affected by reservoir operations, as well as pumping in the Roswell basin. (See Section 3.9, “Ground Water,” for a discussion of ground-water basins in the study area; map 3.1 shows ground-water basins in the study area.)

The runoff from snowmelt and monsoon season rainfall is highly variable from year to year. Elevations in the headwaters are almost 13,000 feet in some areas, and these areas can receive heavy snowfall. An average snowfall of 156 inches has been reported for Harvey’s Upper Ranch, at an elevation of 9400 feet. Average annual runoff to Santa Rosa Reservoir, from snowmelt, rainfall, and base inflows in the headwaters, based on the Above Santa Rosa and Below Santa Rosa gages for the period 1929-2002, is 87,000 acre-feet, with a maximum of 547,000 acre-feet in 1940 and a minimum of less than 16,000 acre-feet in 2002 (USGS, 2002).

Runoff from precipitation downstream from Santa Rosa Reservoir also is highly variable. On the basis of historical streamflow data collected since 1940, the average annual volume of ungaged storm inflows to the river between Santa Rosa Reservoir and Avalon Dam has been estimated to be 77,000 acre-feet, with a gaged maximum and minimum of 798,000 and 14,800 acre-feet, respectively (USGS, 1999; Tetra Tech, Inc., 2000b; Tetra Tech, Inc., 2001).

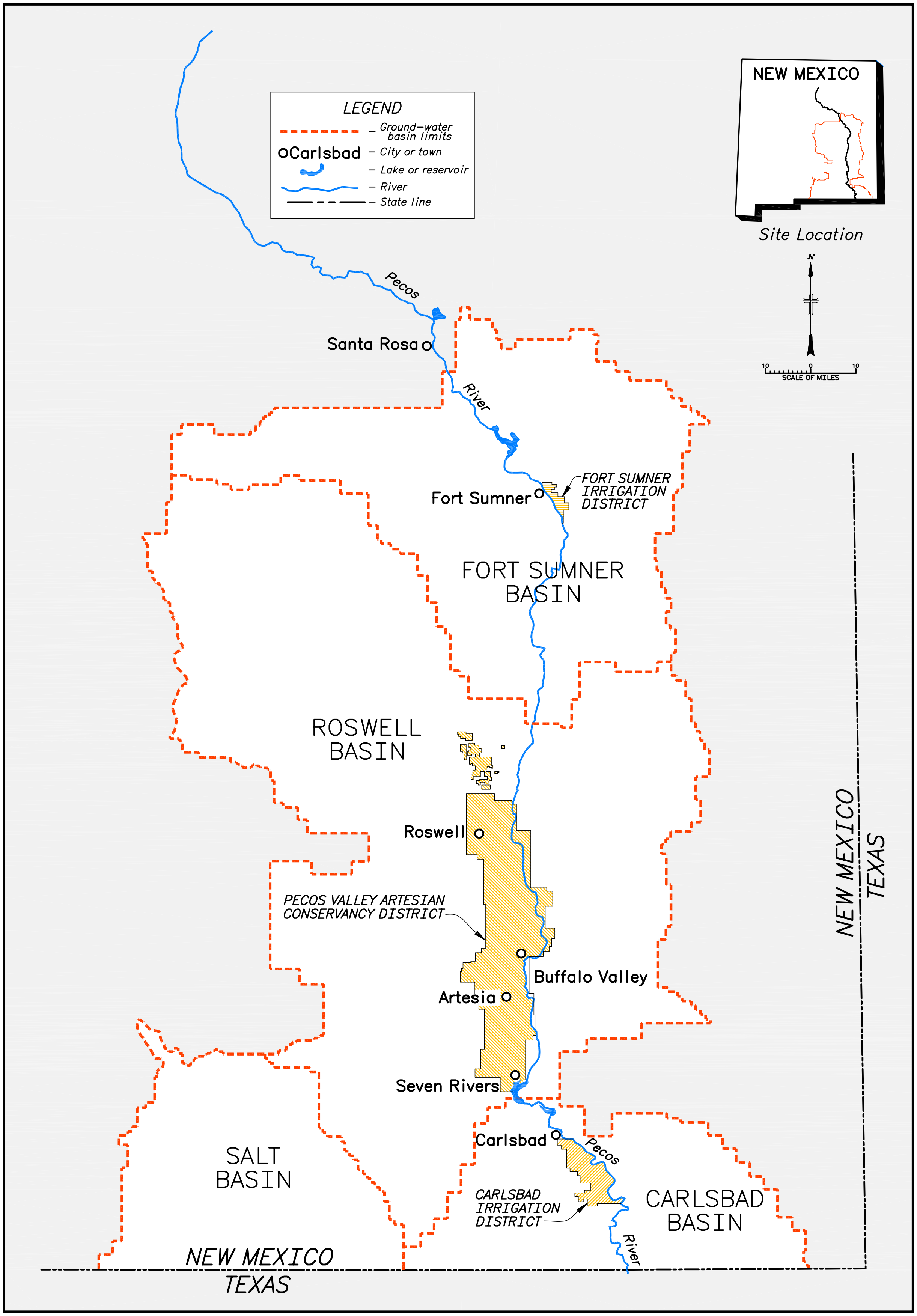
In addition to runoff from snowmelt and rainfall, ground-water inflows also affect flows in the river. While ground-water inflows vary in response to climatic conditions and ground-water pumping, they tend to exhibit much less variability than the surface water inflows. Ground-water inflows add a net of approximately 80,000 acre-feet to the river annually in the Fort Sumner and Roswell basins in the reach between Santa Rosa Reservoir and Brantley Dam. Ground-water inflows also occur south of Brantley Dam in the Carlsbad basin. Ground-water inflow trends are discussed in greater detail in Section 3.9.1, "Ground-Water Accretions to the River."

The primary users of surface water in the study area are FSID, CID, and HIC, but diversions also occur at the Puerto de Luna and Anton Chico acequias. River pumpers between the Near Acme and Near Artesia gages also divert directly from the Pecos River to support agricultural lands. Diversions by CID and FSID, along with the subsequent return flows, directly affect flows in the Pecos River.

Thus, flows in the lower Pecos River (downstream from Santa Rosa Reservoir) are primarily a function of monsoon season rainfall and seasonal ground-water inflow, as well as reservoir operations set by CID, FSID, U.S. Army Corps of Engineers (Corps), and New Mexico Office of the State Engineer (NMOSE). The primary factors governing scheduling of deliveries for the Carlsbad Project are the need to meet irrigation demands and the need to deliver water efficiently. (Delivery efficiency is discussed in Section 3.6, "Operational Priorities," and Section 3.7, "Water Operations.")

3.3 Reservoir Storage

The total annual allowable entitlement storage for the Carlsbad Project, as defined by the Pecos River Compact, in Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir combined is 176,500 acre-feet. The maximum allowable entitlement or "conservation storage" limit is the amount of water that the Carlsbad Project can store for irrigation. Each reservoir also is constrained by its own conservation storage limit. The portion of conservation storage allocated for the Carlsbad Project in Santa Rosa Reservoir, for example, is approximately 100,000 acre-feet, although the entire storage is approximately 500,000 acre-feet. Only that amount allocated for the Carlsbad Project is termed conservation storage or "project storage." The conservation storage limit in Santa Rosa Reservoir and Sumner Lake changes each year, based on estimated sediment deposition since the last survey. The conservation pool elevation in Avalon Reservoir cannot exceed 3177.4 feet (elevation measurement based on the National Geodetic Vertical Datum of 1929 [NGVD 29]), which corresponds to



Map 3.1 Ground–water basins in the study area

4,466 acre-feet of storage, based on the 1996 survey. The conservation pool elevation in Sumner Lake cannot exceed 4261 feet (NGVD 29) from May 1 to September 30, which corresponds to 42,898 acre-feet of storage, based on the 2001 survey. From October 1 to April 30, the Carlsbad Project is entitled to store an additional 20,000 acre-feet in the Sumner Lake flood pool, but this water must be evacuated by April 30 every year. Brantley Reservoir has a constant conservation storage limit of 40,000 acre-feet in addition to the 2,000-acre-foot minimum pool and sediment deposition; thus, the elevation of the conservation pool increases as sediment accumulates. The conservation pool in Santa Rosa Reservoir is equal to 176,500 acre-feet (the total allowable entitlement storage) less the sum of the individual conservation storage limits determined each year for Sumner Lake, Brantley Reservoir, and Avalon Reservoir. The conservation storage limit and corresponding elevation in Santa Rosa Reservoir change every year, based on sediment accumulation in Sumner Lake and Avalon Reservoir. Based on the most recent surveys of Sumner Lake (2001) and Avalon Reservoir (1996), the conservation storage limit at Santa Rosa Reservoir is 92,236 acre-feet.

Table 3.1 presents data about Pecos River reservoirs, including purpose, ownership, completion date, allowable conservation storage space, and total storage capacity. Sumner Lake and Brantley Reservoir were last surveyed in 2001. Avalon and Santa Rosa Reservoirs were last surveyed in 1996.

Table 3.1 Pecos River reservoirs

Reservoir	Purpose(s)	Ownership	Year completed	Allowable conservation storage space[1] (acre-feet)	Total storage capacity[2] (acre-feet)	Minimum pool (acre-feet)
Santa Rosa	Flood control and irrigation	Corps	1980	92,236	438,364	0
Sumner	Irrigation and flood control	Reclamation	1937	40,398	93,828	2,500
Brantley	Irrigation and flood control	Reclamation	1988	40,000	414,466	2,000
Avalon	Irrigation	Reclamation	1907	3,866	4,466	600

[1] Excludes minimum pool.
[2] Top of flood pool; accounts for sedimentation using latest surveys; does not include flood surcharge space.

3.4 Reservoir Evaporation

Evaporation from the reservoirs in the study area is quite high because of the semi-arid climate. Evaporation not only affects the water supply in the basin, it also directly affects how water is stored for later use. CID generally keeps water in Santa Rosa Reservoir and Sumner Lake as much as possible. Average annual reported evaporation losses from Brantley Reservoir and Sumner Lake are 89 inches and 84 inches, respectively (Corps, 1979, 1991a, 1991b, and 1995). The Corps' Los Esteros (Santa Rosa) Water Control Manual pre-project estimates of evaporation at Santa Rosa Reservoir were very similar to those for Sumner Lake (Corps, 1979). However, actual reservoir evaporation values at Santa Rosa Reservoir for the period 1991-97 were closer to 68 inches per year (Corps, 1999; Tetra Tech Inc., 2003e), which indicates a lower specific (per unit area) evaporation rate than Sumner Lake, primarily because the elevation of Santa Rosa Reservoir is higher and the mean annual temperature in that area is lower.

Another important concept regarding reservoir evaporation is the amount of surface area compared to the amount of stored water. Reservoirs that are shallow and more spread out, such as Sumner Lake, tend to have greater evaporation loss per volume stored than reservoirs that are deeper and less spread out, such as Santa Rosa or Brantley Reservoirs. While the specific (per unit area) evaporation rates are similar at Sumner Lake and Santa Rosa Reservoir because of their proximity, Santa Rosa Reservoir is deeper and generally experiences less evaporation because less surface area is exposed to the atmosphere. Conversely, Sumner Lake, with a per unit area potential evaporation of 84 inches and a surface area of approximately 4,500 acres at its conservation storage limit of 42,898 acre-feet actually is more adversely affected by evaporation than Brantley Reservoir, which experiences a potential evaporation of 89 inches per unit area but has a surface area of only 2,800 acres at its conservation storage limit of 42,000 acre-feet.

3.5 Reservoir Seepage

Seepage losses are evident at Avalon Reservoir. These losses can be large and are directly related to the reservoir pool elevation. The annual loss for typical Avalon reservoir pool elevations is about 10,000 acre-feet (Tetra Tech, Inc., 2000a, 2000b, 2003b; Natural Resources Planning Board, 1942; Engineering Advisory Committee of the Pecos River Compact Commission, 1949; Anderson et al., 1960; Pecos River Master's Manual, 2003). Brantley Reservoir also loses water to seepage but, in addition, picks up inflows from Major Johnson Springs. The net rate of gain over time from the combination of inflows from Major Johnson Springs and seepage losses in Brantley Reservoir is about 3 cfs (approximately 2,172 acre-feet per year). The connection with the Major Johnson aquifer also results in a bank storage effect at Brantley Reservoir. As the pool elevation changes, water moves in or out of bank storage, and the rate of inflow from Major Johnson Springs varies (Tetra Tech, Inc., 2000b, 2002, 2003b; Hydrosphere Resource Consultants [HRC], 2003e). Seepage losses from Santa Rosa Reservoir and Sumner Lake are thought to be negligible.

3.6 Operational Priorities

The Carlsbad Project is one of the most senior storage water right holders on the Pecos River. Typically, CID stores most of the water in Santa Rosa Reservoir and Sumner Lake to maintain available capacity in Brantley Reservoir to capture runoff from monsoon season rainfall in the lower portions of the basin. When CID needs water for irrigation, water is moved to Brantley Reservoir. For efficiency, water is moved as block releases, which are large-volume releases made over a number of days to transmit water downstream for irrigators. Large-volume block releases to Brantley Reservoir have greater delivery efficiency (also referred to as transmission efficiency) than lower flow releases. On the basis of historic data, the average magnitude of block releases is about 1,060 cfs, and the historic average volume per release is 33,500 acre-feet. The average duration of these releases is 16 days but may vary considerably depending on other factors affecting the storage in Brantley Reservoir. The travel time for block releases from Sumner Dam to Brantley Reservoir is about 5 days. The main CID diversion, at Avalon Dam, is located approximately 10 river miles downstream from Brantley Dam.

FSID holds one of the most senior direct diversion rights on the Pecos River. Although CID's priority date is prior to FSID's priority date—1896 versus 1903, respectively—the Hope Decree declares that FSID's diversion right is superior to CID's diversion right, but in priority claims with irrigation districts or diverters other than CID, FSID's original priority date takes precedence (U.S. District Court, 1925). FSID is essentially entitled to divert the natural inflows to Santa Rosa Reservoir plus the inflows between Santa Rosa Dam and Sumner Lake up to a maximum of 100 cfs. In addition to its right to divert during the irrigation season, FSID also has the right to divert for two 8-day periods during the nonirrigation season.

Another issue related to the Pecos River surface water resources is flows at the New Mexico-Texas State line, an important resource indicator. On the basis of the Compact and the 1988 U.S. Supreme Court Amended Decree (Amended Decree), the State of New Mexico is obligated to deliver a portion of the surface water resources to the State line, based on the calculations as described in the Pecos River Master's Manual (Pecos River Master's Manual, 2003). The primary sources of water at the State line are spills from Carlsbad Project storage, CID return flows, Carlsbad basin inflows, and side inflows entering the Pecos River downstream from Avalon Dam. As stated in the Amended Decree, New Mexico cannot accrue a debit of water to Texas and may be required to implement a priority call (a shutoff of junior water users) to mitigate any such debit that might occur as soon as it happens. However, because the junior water users are primarily ground-water pumpers in the Roswell basin, a curtailment of these rights will not immediately impact Pecos River flows; thus, surface water users, including CID, likely would be cut off.

3.7 Water Operations

The highest priority factor affecting water operations of the Pecos River system is flood control. However, because conditions rarely require flood operations, reservoir releases are generally not affected by flood operations. If a reservoir's designated flood pool elevation is exceeded, flood operations are initiated. Flood operations are set up to release water as quickly as possible without exceeding channel flow limits which are delineated in the Water Control Manuals for each dam (Corps, 1979, 1991, 1991a, 1991b, 1995). The designated river channel flow restrictions are 13,000 cfs at the Near Puerto de Luna gage, 8,500 cfs at the Near Artesia gage, and 20,000 cfs at the Below Dark Canyon gage.

When conservation storage limits are exceeded, inflows are essentially bypassed to keep the pool elevation at that limit, while ensuring that downstream flow restrictions are not exceeded. This situation is often referred to as a conservation spill.

Most of the time, agricultural demand drives water operations. The irrigation season for areas along the Pecos River typically extends from March 1 through October 31. At the beginning of each irrigation season, CID sets an allotment for irrigators in the district based on the water in storage, which is updated monthly, with consideration for delivery efficiencies to the farm gates.

In the spring, CID determines if enough water is available in Brantley Reservoir for irrigators and if the quality is acceptable. If additional water is needed or if water quality is poor and water is available upstream in Santa Rosa Reservoir and Sumner Lake, a block release is initiated from Sumner Dam to fill Brantley Reservoir. Runoff from monsoon season rainfall events can greatly affect flows downstream from Sumner Dam and the need for a block release. CID makes block releases during the irrigation season, as needed, but it attempts to end the irrigation season with the contents in Brantley Reservoir relatively low to provide storage for side inflows that may occur over the winter. Brantley Reservoir picks up inflows during the winter that are primarily from ground-water inflows along the reach of the Pecos River from the Near Acme gage to the Near Artesia gage and from delayed FSID return flows.

During periods in the irrigation season when block releases are not made and no releases are made from Santa Rosa Dam, then bypasses from Sumner Dam are set to the FSID diversion right. Releases from Brantley Dam are set to the CID diversion demand at Avalon Dam. Little storage capacity exists behind Avalon Dam, and it primarily serves as a diversion structure. In addition to irrigation releases, a minimum release of 20 cfs is maintained at Brantley Dam to mitigate for the inundation of Major Johnson Springs by Brantley Reservoir. Downstream releases are made from Avalon Dam only if conservation storage limits are exceeded. Historically, during the nonirrigation season, only the 20 cfs has been released from Brantley Dam and all other reservoir outflows are shut off. Current operations include bypasses of water during the nonirrigation season to benefit the shiner.

Since the listing of the shiner as a federally threatened fish species in 1987 and the beginning of Brantley Reservoir operations in 1989, water operations on the Pecos River can be separated into four distinct periods. From 1989 to 1991, operations continued much as they had before the species was listed. From 1991 to November 1997, test operations were conducted to facilitate data collection for development of the water operations RiverWare model and studies regarding the needs of the shiner. From November 1997 to May 2003, Reclamation’s changed operations at Sumner Dam included bypasses of inflows above FSID’s diversion right through Sumner Dam to augment flows for the shiner, with target flows of

35 cfs at the Near Acme gage. CPWA options were also introduced at this time to acquire additional water supplies to improve the Carlsbad Project's chronically short water supply. Block release operations were also modified during this time period to protect the shiner. The U.S. Fish and Wildlife Service (Service) issued the Final Biological Opinion for the Bureau of Reclamation's Proposed Pecos River Dam Operations, March 1, 2003, through February 28, 2006, dated June 18, 2003 (BO) (Service, 2003). The BO essentially recommends target flows, based on irrigation season and hydrologic condition, as reasonable and prudent alternatives (RPAs). The No Action Alternative is based on the operational rules prescribed in the BO.

As previously discussed, block releases are made to transmit water to Brantley Reservoir more efficiently. Historically, CID has used a 25-percent reduction in volume to account for transit losses between Sumner Lake and Brantley Reservoir in a block release. Analysis of flow data shows a similar result, with an average efficiency of 70 percent in the reach from Sumner Dam to Kaiser channel for typical block releases not affected by tributary flood inflows. Bypasses to meet target flows in critical habitat for the shiner are less efficient than block releases because of their smaller overall volume. Although the efficiency of a bypass from Sumner Dam to Kaiser channel is heavily dependent on its duration and magnitude, bypasses result in additional depletions to Carlsbad Project water supply because the water is moved less efficiently.

3.8 Streamflows

As discussed previously, runoff from monsoon season rainfall is an important component of streamflow in the entire study area. The magnitude of these storm inflows varies greatly. Inflows from individual storms may be a few hundred to thousands of cubic feet per second. The average annual volume of inflows between Santa Rosa Dam and Avalon Reservoir, which are predominantly from runoff from these storms, has been estimated to be 77,000 acre feet per year.

In addition to rainfall runoff, the two primary sources for inflows upstream of Sumner Dam are snowmelt runoff and ground-water inflows along the reach of the river from the Near Acme gage to the Near Artesia gage. Snowmelt runoff from the northern mountains is captured in Santa Rosa Reservoir, and ground-water inflows are captured in Sumner Lake. Flows in the Pecos River downstream from Sumner Dam are predominantly a function of reservoir operations, FSID bypasses for irrigation and subsequent return flows, and bypasses for the shiner. During the summer, if no specific measures are taken to augment flows in critical habitats for the shiner, resulting flows at the Near Acme gage may be intermittent if return flows from FSID are completely lost to seepage and evapotranspiration. The other primary factor affecting flows downstream from Sumner Dam is ground-water inflows along the reach from the Near Acme gage to the Near Artesia gage. These inflows are a function of climatic factors and pumping in the Roswell basin, and they typically range from 40 to 80 cfs, based on recent pumping rates.

Flows downstream from Brantley Dam are primarily a function of Brantley Dam block releases of water for CID. Flows downstream from Avalon Dam are primarily a function of CID irrigation return flows, groundwater inflows from Carlsbad Springs, storm inflows, seepage, and spills. Figure 3.1 shows flow duration, or the percentage of time, flow was historically at or above a certain rate, as measured at the Near Puerto de Luna, Near Acme, Near Artesia, and Red Bluff gages.

Flow at the Near Acme gage is an important resource indicator for the shiner because it is the first gage downstream from its upper critical habitat. The gage continuously measures flow, and USGS posts both 15-minute and daily averages of this value. The Near Acme gage has gone dry, or "intermittent," 11 percent of the time since 1938.

Reading Flow Exceedance Curves

Flow exceedance curves depict the percent of time that flows are exceeded at a particular location. Curves can be developed using flows before and after a specific action or change in operations to determine how that change may affect the occurrence of different flows.

The curves can be interpreted in two different ways: (1) percentage of flow exceeded given a flow in the river or (2) a flow in the river given a percentage of flow exceeded. To determine percentage of flow exceeded given a riverflow, look up the riverflow on the y-axis and trace a horizontal line to the flow exceedance curve. From that intersection, trace a vertical line to the x-axis. This is the percentage of time over the period of record (60-years for this study) that all riverflows equal or exceed the lookup riverflow. If the goal is to determine the amount of flow in the river corresponding to a certain percentage, look up the given percentage on the x-axis and trace a vertical line to the flow exceedance curve. From that intersection, trace a horizontal line to the flow on the y-axis. This is the flow that is exceeded by the lookup percentage of time.

3.8.1 Floods: Magnitude and Frequency

Flood magnitudes and frequencies in the study area have changed in the past century because of flow regulation. The construction of both Sumner Dam (completed in 1937) and Santa Rosa Dam (completed in 1980) reduced the peak flow events in the study area. Records do not extend back far enough to evaluate the effects of Sumner Dam, but at the Near Acme gage, the post-Santa Rosa Dam flood magnitude decreased considerably. Considering the effects of Sumner Dam, the 100-year and 2-year storm discharges at the Near Artesia gage are computed to be 28,300 and 2,860 cfs, respectively, while the corresponding floods without consideration for Sumner Dam are 73,700 and 10,200 cfs, respectively. The destruction to Avalon Dam in 1893 and 1904 provides evidence of floods on the order of 73,700 cfs at the Near Artesia gage before upstream regulation. Flood frequency at the Red Bluff gage also decreased greatly following the construction of Santa Rosa Dam. Again, the gage at Red Bluff was not established early enough to consider the effects of Sumner Dam. Further analyses of flood frequencies are not presented here because these conditions are not expected to change under the alternatives.

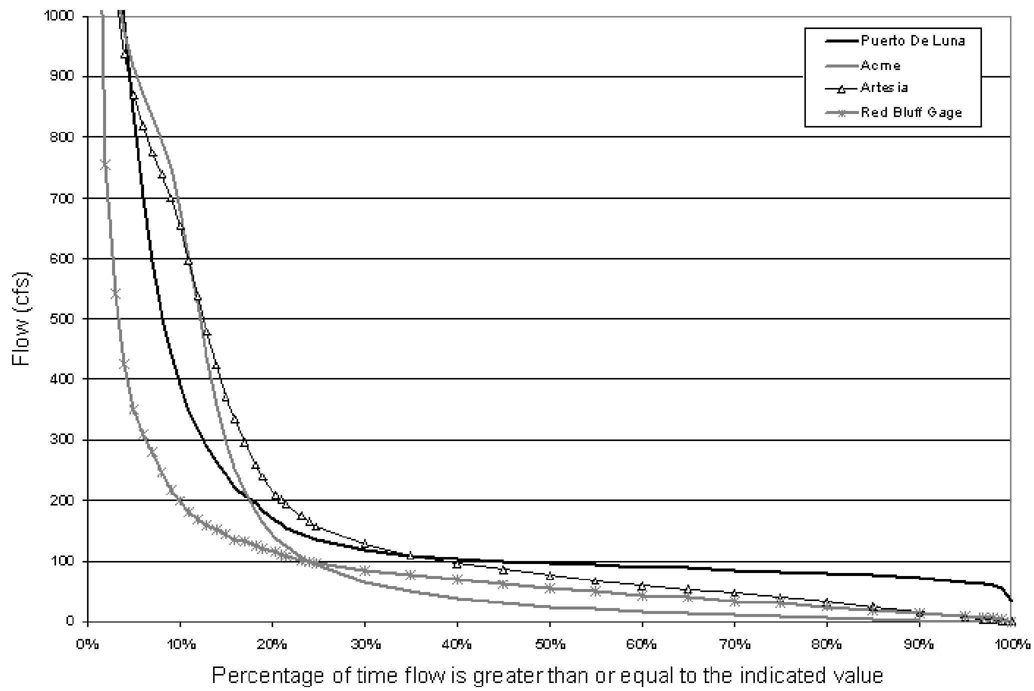


Figure 3.1 Flow duration at Near Puerto de Luna, Near Acme, Near Artesia, and Red Bluff gages (1938-2002).

3.8.2 Surface Water Diversions from the Pecos River

FSID and CID rely on surface water, while HIC relies on both surface and ground water. FSID and CID have average annual diversions of 37,500 and 77,100 acre-feet, respectively. The potential irrigated areas for FSID and CID are 10,000 and 25,055 acres, respectively. HIC currently irrigates approximately 8,300 acres with a combination of surface water from the Rio Hondo and tributary springs to the Pecos River and ground water, which is pumped into the HIC canal. The HIC water supply for the accounting years 1997-2001 was approximately 32,000 acre-feet, of which about 22 percent came from surface water and 78 percent came from ground water. Major crops grown by all of the irrigation districts are alfalfa, cotton, and sorghum.

The FSID diversion dam is located approximately 14 river miles downstream from Sumner Dam. FSID diversions typically range from 80 to 100 cfs. The FSID diversion rate is based on a 2-week formula developed and implemented by NMOSE (NMOSE, 1980). The computed diversion rate applies to the upcoming 2 weeks and is a function of the natural inflows into Santa Rosa Reservoir and Sumner Lake over the previous 2 weeks. The calculation does not adjust for evaporation while the water is detained for 2 weeks in the reservoirs. In other words, the diversions for the coming 2 weeks are set to the average of the natural inflows for the previous 2 weeks or 100 cfs, whichever is less.

Irrigation return flows from FSID are conveyed back to the river by two main drainage canals and seepage through the alluvial ground-water system. These drainage canal returns give FSID a means to control the flow in the system if there is a rainfall event or if irrigation demand decreases. These return flow paths are often used at night when irrigation demand is lower. Return flows are primarily a function of the diversion rate, but they also are influenced by temperature, rainfall, antecedent moisture conditions, humidity, ground-water levels, and other factors that affect evapotranspiration, infiltration, and soil moisture.

FSID irrigation return flow is occasionally reused within the system via a pump-back operation that diverts around 10 cfs back to the fields from a drainage canal.

CID’s diversion schedule exhibits some trends from year to year. Diversions are typically continuous throughout the irrigation season, but peak diversion times correlate with typical crop demands considering the climate and the growing season in the Carlsbad area. The first diversions typically begin in mid-March for the first irrigation of alfalfa and for preplanting cotton. The bulk of the next diversions usually occur in mid-May for the second irrigation of alfalfa. In June, diversions peak again for the first irrigation of cotton and third irrigation of alfalfa. During July and August, diversions are at peak levels for the irrigation of all crops. During early September, watering of new alfalfa and winter cover crops begins. The diversion gradually decreases through October and stops when the irrigation season ends on October 31.

Water is diverted to CID via the main canal on the southeast side of Avalon Dam. Currently, most of CID’s water delivery system is lined with concrete and is gaged in numerous locations. CID diversion rates vary, depending on allotments, and range from 100 to 375 cfs. Carlsbad Project supply in any given year is estimated by the sum of storage in all of the reservoirs. Because transmission losses are incurred as water is delivered from upstream reservoirs, the total storage is measured using reduction factors for the water stored in upstream reservoirs. CID typically sets the initial annual irrigation allotment in March based on the amount of water in storage, with a current maximum allotment of 3.7 acre-feet per acre (from 1994-2004, 3.5 acre-feet per acre was considered a maximum allotment; before 1994, 3.0 acre-feet per acre was considered a maximum allotment; Davis, 2005). The allotment is incrementally adjusted at the monthly board meetings as water becomes available. Historical annual allotments set by CID are presented in table 3.2 (Davis, 1998, 1999, 2003). The allotments were less during the 1960s and 1970s because of several below-average water years. No allotment data are available for 1959 and 1961: in 1959, the reservoirs were spilling on February 10; in 1961, canal work was being completed. CID is limited to a total diversion of 125,200 acre-feet and a storage allotment of 176,500 acre-feet in the reservoir system. The historical average annual diversion over the period from 1940 to 2002 was 77,100 acre-feet.

Table 3.2 Historical total annual CID allotments, based on CID allowable acreage of 25,055 acres

Year	Annual allotment (acre-feet/acre)	Year	Annual allotment (acre-feet/acre)	Year	Annual allotment (acre-feet/acre)
1952	0.9	**1969**	2.4	**1986**	3.0
1953	0.4	**1970**	2.5	**1987**	3.0
1954	0.8	**1971**	1.5	**1988**	3.0
1955	3.0	**1972**	3.0	**1989**	2.9
1956	2.8	**1973**	3.0	**1990**	2.8
1957	2.0	**1974**	2.0	**1991**	3.0
1958	3.0	**1975**	1.7	**1992**	3.0
1959	-	**1976**	0.9	**1993**	3.0
1960	3.0	**1977**	0.6	**1994**	3.0
1961	-	**1978**	1.6	**1995**	3.5
1962	3.0	**1979**	2.0	**1996**	3.5
1963	1.9	**1980**	2.6	**1997**	3.5
1964	1.1	**1981**	1.5	**1998**	3.5
1965	1.3	**1982**	2.7	**1999**	3.5
1966	1.6	**1983**	3.0	**2000**	3.1
1967	2.1	**1984**	3.0	**2001**	2.3
1968	1.9	**1985**	3.0	**2002**	1.3

Additional users of surface water are river pumpers, who divert directly from the river for agricultural purposes. River pumpers generally prefer to divert when riverflows are higher or during a block release when water quality is better, but irrigation demand is the primary factor affecting when diversions are made. Annual river pumper diversions from 1956-91 in the reach of the Pecos River from the Above Acme gage to the Near Artesia gage averaged 11,300 acre-feet per year. In the early 1990s, the New Mexico Interstate Stream Commission (NMISC) began purchasing river pumper rights to help meet Compact deliveries.

Following NMISC's buy-up, 10 river pumpers remained with an aggregate diversion right of 5,014 acre-feet per year. Of those 10 remaining pumpers, one right for 229 acre-feet per year is essentially inactive, leaving 4,785 acre-feet per year for the remaining 9 active pumpers. Of those nine, six—with diversion rights totaling 4,425 acre-feet per year—are currently leased by Reclamation to supplement Carlsbad Project supply due to depletions associated with recent bypasses to augment flows in the critical habitat for the shiner. The average diversions for the period 1992-98 for the nine remaining active pumpers were 4,215 acre-feet per year, and the average diversions for the same period for those three that are not currently leased by Reclamation were 499 acre-feet per year (with a consumptive use of 360 acre-feet). Most river pumper diversions are located in the reach between the Hagerman and Lake Arthur stream gages.

3.8.3 Depletions to Riverflows

Depletions from the river are most evident in the reach from Sumner Dam to the Near Acme gage. Most depletions in this reach are believed to be the result of direct evaporation, transpiration, and percolation into the shallow aquifer (which can easily be transpired back out) and do not serve to recharge the local ground-water aquifer. For low-flow periods, losses along this reach can equal 100 percent of the flows observed at the Taiban gage.

The reach of the Pecos River between the gages at Near Artesia and the Kaiser channel can vary between losing and gaining, depending on flow conditions, while the reach from Kaiser channel downstream to Brantley Reservoir is generally a losing reach. Losses from the subreach contained within the upstream and downstream limits of the Kaiser channel are substantial. The Kaiser channel was built from October 1948 to April 1949; it was originally a 4-mile channel that served to bypass flows through the immense delta that had formed on Lake McMillan (map 1.1). The channel was built to reduce transpiration losses from salt cedar that grew on the delta and presently still proliferate. Because of the construction of Brantley Reservoir and the breach of the old McMillan Dam, the Kaiser channel is now closer to 13 miles long and extends from the start of the old Lake McMillan delta to Brantley Reservoir.

3.9 Ground Water

Ground water and surface water in the Pecos River basin are linked. Important resource indicators for ground-water interactions with surface water in the Pecos River basin include ground-water inflows accruing to the Pecos River in the reach between the Near Acme and Near Artesia gages and aquifer storage levels in the Roswell basin. Inflows from the Roswell basin aquifer are important because they are a major contribution to Carlsbad Project water supply. Aquifer storage levels serve as an indicator for the long-term status of water supplies in the basin.

The study area includes two geologically distinct ground-water basins: the Roswell basin and the Carlsbad basin. Both of these basins contain two major water-bearing features: a shallow alluvial aquifer and a deep artesian carbonate aquifer. The Fort Sumner ground-water basin is also included in the study area, but this declared basin contains only a shallow alluvial aquifer that is highly connected with the Pecos River.

Throughout most of the Roswell basin, the shallow and carbonate aquifers are separated by a semi-confining layer (figure 3.2). Both aquifers, however, are connected in the northwestern part of the ground-water basin where the carbonate aquifer rises structurally to meet the shallow aquifer. The deep artesian aquifer is associated with the San Andres Formation and is confined on the east side and unconfined on the west. The shallow alluvial aquifer is unconfined throughout the basin, and in the southern part of the basin it contains the Major Johnson Springs aquifer. Both of the aquifers were developed for irrigation water supplies beginning in the late 19th century.

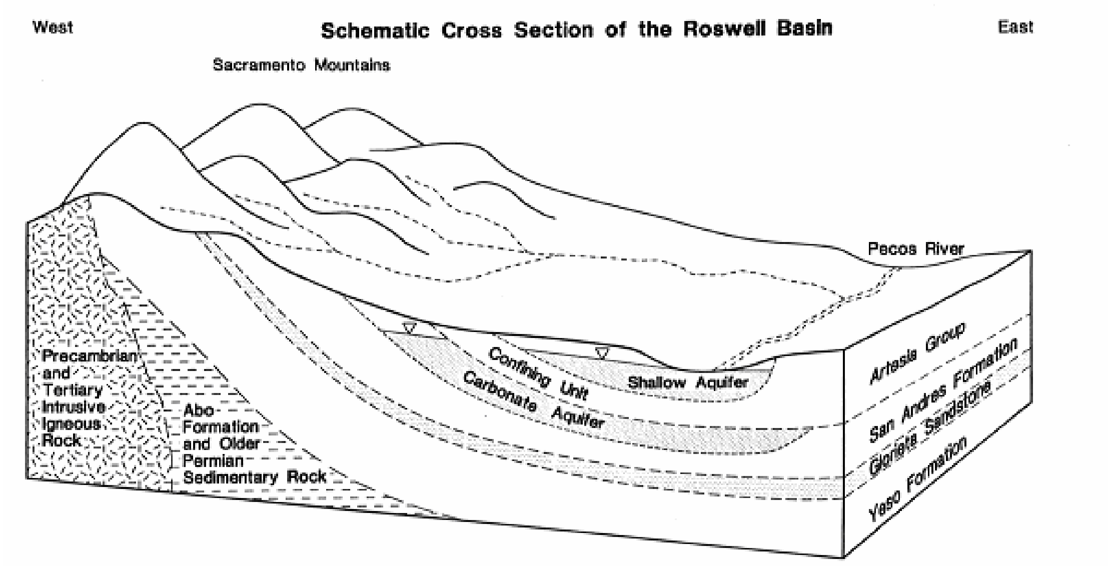


Figure 3.2 Conceptual block diagram showing the interactions between the aquifers and river.

The Carlsbad basin also contains a shallow alluvial aquifer and a deeper aquifer known as the Capitan Reef Complex. The Capitan Reef Complex is a large, arc-shaped aquifer that bends through the southeastern corner of New Mexico, with ends stretching into west Texas. The Pecos River, the alluvial aquifer, and the Capitan Reef aquifer are all interconnected. Just north of Carlsbad, the reef aquifer is believed to have the strongest connection to flows in the Pecos River. Wells associated with the city of Carlsbad, agricultural operations in southeastern New Mexico, and agricultural operations in west Texas withdraw water from the Capitan Reef Complex. The USGS Ground Water Atlas (Robson and Banta, 1995) indicates that in 1985, more than 0.61 acre-foot of water per day was extracted from the Capitan Reef Complex; 81 percent of it was used for agriculture.

The connectivity and relationships between ground-water levels in the aquifers and base inflows in the reach of the Pecos River from the Near Acme gage to the Near Artesia gage (which includes part of shiner critical habitat) are well known. These interactions are considered in detail in the following sections.

3.9.1 Ground-Water Accretions to the River

Large ground-water accretions (water gains to the river from aquifer leakage) are known to occur in the reaches between the Below Santa Rosa Dam and Near Puerto de Luna gages from natural springs. Ground-water inflows in the reach between the Below Sumner Dam and the Taiban gages are primarily return flows from FSID. Base inflows along the reach between the Near Acme to Near Artesia gages are from the Roswell basin aquifers; in the reach from Avalon Dam to the New Mexico State line, base inflows are from the Carlsbad basin aquifers.

The intensive development of the ground-water resources for irrigation supplies in the Roswell basin has significantly reduced base inflows compared to predevelopment levels.

From the late 1980s into the 1990s, base inflows in the Roswell basin varied between 20,000 and 40,000 acre-feet per year. By the late 1990s, base inflows stabilized somewhat to around 30,000 acre-feet per year (S.S. Papadoulas & Associates, 2004). The magnitude of the base inflows has been linked to precipitation and pumping rates in the Roswell basin. Based on recent pumping rates, the base inflows have generally varied seasonally from 40 to 80 cfs. However, because of drought, flows dropped below 5 cfs at the Near Artesia gage during the 2003 irrigation season. The Roswell Artesian Basin Ground Water (RABGW) model was calibrated to historical observed base inflows, and for this DEIS, model results provide estimates of changes in ground-water base inflows to the river associated with the changes in Carlsbad Project operations (chapter 4).

3.9.1.1 Below Santa Rosa Dam to Near Puerto de Luna

In the reach between the Below Santa Rosa Dam and the Near Puerto de Luna gages, there are very consistent base inflows from springs. Base inflows that appear in this reach come from springs around the town of Santa Rosa, such as "The Blue Hole." The magnitude of these spring inflows varies seasonally and typically ranges from 66 to 85 cfs (131 to 169 acre-feet per day). Data indicate that these spring inflows have been very consistent over time. In addition, there is no evidence that construction of Santa Rosa Dam affected the base inflows in this region. The average annual volume of base inflow contributions to the Pecos River is approximately 54,000 acre-feet in this reach.

3.9.1.2 Below Sumner Dam to Taiban

In the reach between the Below Sumner Dam and Taiban gages (just downstream from FSID), data indicate that the magnitude of ground-water inflows as a result of FSID return flows exceeds 15 cfs. This accretion is strongly dependent on FSID diversions and crop irrigation efficiency. These inflows are very consistent, but it usually takes months for the water applied to the field to reach the river. As a result, flows at Taiban exceed 15 cfs for much of the winter. These lagged returns greatly affect base inflows in the river downstream from Sumner Dam.

3.9.1.3 Near Acme Gage to Near Artesia Gage

In the reach between the Near Acme and Near Artesia gages, the Roswell basin provides unique conditions yielding large base inflows to the Pecos River. These base inflows are dependent on hydrologic factors and ground-water pumping from both the shallow alluvial and San Andres artesian aquifers in the Roswell basin. Ground water in the Roswell basin flows from the western recharge areas, through the deep artesian aquifer, up into the shallow alluvial aquifer, and, ultimately, into the Pecos River. Base inflow gains to the Pecos River from the late 1800s to the early 1930s have been estimated to range from 40,000 to 120,000 acre-feet per year (Daniel B. Stephens & Associates, 1995). From the early 1930s to the early 1960s, annual base inflow gains in the reach of the Pecos

River between the Above Acme and Near Artesia gages decreased to an average of about 20,000 acre-feet. Most of this decline is attributed to the ground-water development for irrigation water supplies, during which time artesian wells were allowed to flow year round; in addition, reduced watershed yield may also be a contributing factor. By 1967, all wells were metered and artesian wells no longer flowed all year. Base inflows from the early 1960s to the mid-1980s stayed constant at about 20,000 acre-feet per year. The conservation imposed by metering also caused a noticeable decrease in base inflows in the reach of the Pecos River between the Near Acme and Near Artesia gages because of a decrease in return flows to the shallow aquifer from croplands irrigated by deep artesian wells.

3.9.1.4 Major Johnson Springs

At the southern end of the Roswell basin, flow from Major Johnson Springs results in a large ground-water accretion. Discharges from the Major Johnson aquifer can range from 8 to 45 cfs (Haskett, 1984). The construction of Brantley Dam inundated the springs, but gains from Major Johnson Springs are still evident. Data indicate that Brantley Reservoir accrues a net gain of approximately 3 cfs (2,172 acre-feet per year) from the combined effects of Major Johnson Springs, ungaged losses between Kaiser channel and the McMillan Breach, and seepage from the reservoir.

3.9.1.5 Carlsbad Basin

Base inflows in the Carlsbad basin area are derived from two sources: return flows from CID and flows from Carlsbad Springs. Return flows from CID are directly dependent on surface water diversion amounts, supplemental pumping primarily from the shallow alluvial aquifer, crop irrigation efficiency, and precipitation in the Carlsbad area. Flows from Carlsbad Springs are believed to be the result of seepage from Avalon Reservoir into the geological formation known as the Tansill Formation, which is a fossil-rich limestone formed in a back reef environment (USGS, 1996a). Water from Avalon Reservoir moves through this formation and interacts with the Capitan Reef Complex and later resurfaces as Carlsbad Springs flows (USGS, 1996a).

3.9.2 Depth to Ground Water

The USGS Ground Water Atlas (Robson and Banta, 1995) indicates that in 1975, the artesian aquifer in the Roswell basin had a potentiometric surface that sloped gently to the southeast and ranged from 3550 to 3250 feet above sea level. The atlas also indicates that in 1926, when the first ground-water studies of the Roswell basin were conducted, the potentiometric surface of the carbonate rock aquifer near the river was as much as 100 feet above the land surface (Robson and Banta, 1995). By 1950, water levels had declined 10 to 30 feet below the ground surface in the eastern part of the aquifer.

The shallow aquifer in some locations in the Roswell basin also experienced declines in water levels from 1950-75. Water levels declined almost 40 feet in some locations during that period, while in the center of the basin, a cone of depression as great as 80 feet below the ground surface was noted (Robson and Banta, 1995). Areas with large declines in the carbonate aquifer do not coincide with areas of decline in the alluvial aquifer (Robson and Banta, 1995). By 1975, the carbonate aquifer's decline was so great that the gradient, which typically exhibited upward flow from the carbonate to the shallow aquifer, was reversed in some areas (Robson and Banta, 1995).

Base inflows in the reach of the Pecos River between the Near Acme and Near Artesia gages and more recent well data indicate that the water levels have been rising since 1967. These recoveries are attributed to the metering of wells by NMOSE in 1967 (which led to a decrease in pumping), NMISC's retirement of many of the wells in the Roswell basin, and PVACD's water conservation program that included the plugging of artesian wells that were previously allowed to flow year round. Because of the current drought, however, the water table has declined again to levels similar to those in the 1970s (HRC, 2005a).

4. Water Quality

4.1 Introduction

The following indicators were selected to evaluate water quality:

- Total dissolved solids (TDS)
- Specific electrical conductance (EC)

TDS and EC are important indicators of water quality for several reasons. In general, the factors that are responsible for water quality impairment are fishery related and generally would not be affected by changes in Carlsbad Project operations. The most extensive data available are for EC. While there is no water quality standard for EC, EC can be used to estimate TDS, which is a major concern for irrigators in CID. The TDS standard is well above a concentration that would cause either a reduction in yield or complete loss of even tolerant crops. (Appendix 4, Water Quality, provides additional information.)

4.2 Clean Water Act

Section 305(b) of the Clean Water Act requires each State to assess the quality of its waters in a report to the U.S. Environmental Protection Agency every 2 years. River reaches and reservoirs are considered impaired under the act if they are not fully supportive of their designated uses. The 2004 review showed five river reaches as impaired. The Carlsbad Project reservoirs (Sumner Lake and Santa Rosa, Brantley, and Avalon Reservoirs) are also shown as impaired. Table 3.3 summarizes the 2004 listing of impaired waters (section 303(d) list) in the mainstem of the Pecos River within the study area.

All of the river reaches, except for the reach downstream from Avalon Dam (dry), are listed as not fully supportive of a warmwater fishery, primarily because of siltation of the riverbed, which inhibits food production. The probable sources of the siltation, as shown in table 3.3, are primarily runoff from roads, parking lots, and grazing lands in the upper part of the Pecos River, with stream alterations increasing in importance farther downstream (New Mexico Water Quality Control Commission [NMWQCC], 2004a). Each of the reservoirs is also listed for mercury in fish tissue, but the source of the mercury is atmospheric deposition. The causes of siltation in Santa Rosa Reservoir and Sumner Lake are also shown as the causes of excessive nutrient loadings and eutrophication (NMWQCC, 2004b). None of these factors should be affected by the proposed action.

4.3 Pecos River

The data for most water quality measures are somewhat limited in the Pecos River basin. As mentioned previously, the best data are for EC, but there is no water quality standard for EC. There are water quality standards for TDS in the Pecos River basin, although none are exceeded. TDS is usually about two-thirds of EC.

Table 3.3 Summary of the 2004 303(d) listings of impaired waters, mainstem of the Pecos River within the study area

Pecos River reach or reservoir	Use(s) not supported	Probable cause(s)	Probable source(s)
1. Santa Rosa Reservoir to Tecolote Creek	Limited warmwater fishery	Sedimentation/siltation	Flow alterations from diversions Natural sources Grazing (unmanaged pasture)
2. Santa Rosa Reservoir	Limited warmwater fishery	Mercury in fish tissue, nutrient/eutrophication, sedimentation/siltation	Highway/road/bridge runoff (nonconstruction) Impervious surface/parking lot runoff Grazing (unmanaged pasture)
3. Santa Rosa Reservoir to Sumner Lake	Limited warmwater fishery	Sedimentation/siltation	Flow alterations from diversions Rangeland (unmanaged pasture)
4. Sumner Lake	Limited warmwater fishery	Mercury in fish tissue, nutrient/eutrophication, sedimentation/siltation	Atmospheric deposition: toxics Loss of riparian habitat Other recreational pollution sources
5. Brantley Reservoir	Limited warmwater fishery	Mercury in fish tissue	Atmospheric deposition: toxics
6. Black River to Tansil Lake	Warmwater fishery	Sedimentation/siltation	Irrigated crop production Loss of riparian habitat Grazing (unmanaged pasture) Source unknown Streambank modifications
7. Tansil Lake to Avalon Reservoir	Warmwater fishery	Usually dry	Low flow Alterations/diversions
8. Avalon Reservoir		Mercury in fish tissue	Atmospheric deposition: toxics
9. Texas border to Black River	Warmwater fishery	Sedimentation/siltation	Flow alterations from diversions Habitat modification Loss of riparian habitat Natural sources Grazing (unmanaged pasture)

Source: NMWQCC, 2004a.

Figure 3.3 shows the median EC at the major gages on the Pecos River. EC shows a general increase from upstream to downstream. The exception occurs between the Near Artesia and Below Brantley Dam gages, where EC declines rather dramatically. EC declines further in the reach between the Below Brantley Dam and the Below Dark Canyon gages. However, there is also a large spike in EC from a median of 2,680 microSiemens per centimeter (µS/cm) to

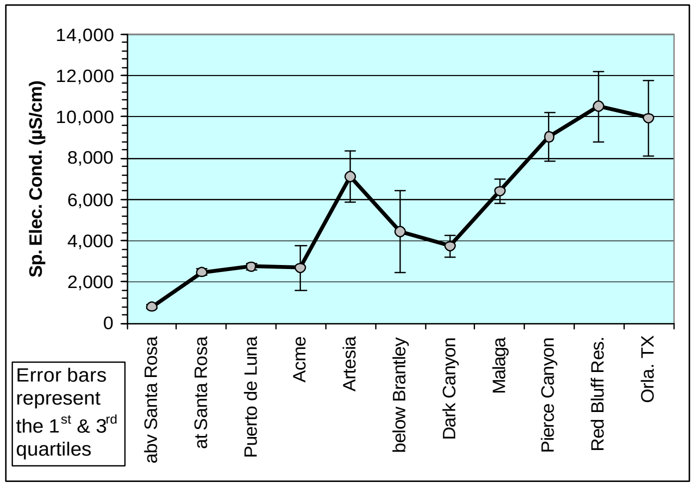


Figure 3.3 Median EC of the mainstem of the Pecos River from Above Santa Rosa Reservoir to Orla, Texas.

7,100 µS/cm between the Near Acme and Near Artesia gages. Subsequent dilution by mixing of less dilute high flows with more concentrated low flows in Brantley Reservoir and inflows from Dark Canyon reduce the EC at the Below Dark Canyon gage to a value somewhat closer to the EC at the Near Acme gage. The median EC then increases between the Below Dark Canyon and Near Malaga gages and between the Near Malaga and At Red Bluff gages. Each of those increases amounts to about 3,000 µS/cm, and the total change is from a median of about 3,700 µS/cm to more than 9,000 µS/cm. The median EC subsequently decreases from about 10,500 µS/cm At Red Bluff to about 9,900 µS/cm at Orla, Texas (figure 3.3).

Although there are no water quality standards for EC anywhere in the Pecos River basin, beginning with the Near Puerto de Luna gage and continuing to Orla (with the lone exception of the Brantley Reservoir release), there are standards for TDS, chloride, and sulfate (NMWQCC, 2002b), each of which relates to EC. None of the standards for TDS, chloride, or sulfate is exceeded. Although the concentrations of each constituent are high in the mainstem of the Pecos River and generally increase in a downstream direction, the standards also are high and increase downstream. Standards increase because high concentrations are considered natural and part of the background. The Clean Water Act recognizes that such natural conditions exist and makes an exception in the water quality standards to accommodate such conditions.

4.4 Pecos Basin Reservoirs

Table 3.4 presents a summary of selected water quality data for Pecos River basin reservoirs. As shown in table 3.3, Santa Rosa Reservoir is listed as being impaired for eutrophication (defined as the overenrichment of a lake or other water body with nutrients, resulting in excessive growth of organisms and depletion of oxygen). This eutrophication is illustrated by data in table 3.4 that show that dissolved oxygen (DO) in the bottom waters of the reservoir is depressed nearly all of the time (compared with the surface DO). However, data indicate that surface DO also can be depressed at times. This phenomenon is illustrated by the minimum surface DO shown for Santa Rosa Reservoir; at 4.76 milligrams per liter (mg/L), the DO concentration is about 70 percent of saturation.

Table 3.4 Summary of selected water quality data for Pecos River basin reservoirs (EC in µS/cm; DO in mg/L)

Reservoir	Water quality measure-ment	Minimum	Median	Maximum	Number of observa-tions
Santa Rosa	Inflow EC	120	790.5	4,350	96
	Outflow EC	340	2,125	3,710	100
	Surface EC	?	?	?	0
	Bottom EC	?	?	?	0
	Surface DO	4.76	7.38	10.38	10
	Bottom DO	0.06	2.13	4.67	10
Sumner	Inflow EC	297	2,630	4,100	319
	Outflow EC	231	1,845	3,730	1,896
	Surface EC	880	1,873	2,760	257
	Bottom EC	?	?	?	0
	Surface DO	1.9	8.5	12.4	257
	Bottom DO	?	?	?	0
Brantley	Inflow EC	921	5,390	11,496	298
	Outflow EC	1,516	4,675	7,465	298
	Surface EC	1,548	3,768	6,679	198
	Bottom EC	1,772	5,179	7,696	198
	Surface DO	5.95	8.74	12.70	197
	Bottom DO	0.11	4.44	11.94	197

On the basis of median EC, there is an apparent increase through the reservoir. The median EC of the outflow is about three times that of the inflow. Such an increase is unusual. In most Western reservoirs, the outflow has a lower EC than the inflow. The majority of the inflow is from either storm water runoff or snowmelt, each of which has a relatively low EC. The lower EC inflows tend to dilute the higher EC low flows during the remainder of the year. Unfortunately, there are no EC data for the reservoir itself to evaluate this finding further.

Sumner Lake is also listed as being impaired for eutrophication. No bottom DO data are available for Sumner Lake, but the surface measurements shown in table 3.4 were made by the New Mexico Department of Game and Fish (NMDGF) from May 2001 and May 2002 (Denny, 2003). The minimum DO in table 3.4 for Sumner Lake is very low for a surface measurement and is less than 40 percent of saturation, which indicates that respiration exceeded photosynthesis at the time. The surface DO was low at the time in several areas of the lake. Such a condition would be indicative of eutrophication.

The median outflow EC at Sumner Lake is lower than that of the inflow and similar to the surface EC (table 3.4). This result indicates that the previously described mixing effect predominates in the reservoir. However, there were many more outflow EC measurements than surface or inflow measurements. Furthermore, the periods of record for the measurements do not coincide. Both the inflow and outflow EC records began in September 1959. Measurements downstream from the dam ceased in 1988, while those for inflow continue. As noted previously, NMDGF only made lake surface measurements for one year. Because of all of the preceding differences, the data sets may not represent the same hydrologic conditions.

Brantley Reservoir also shows DO depression in both the surface and bottom waters, but much more so in the deeper water, as would be expected. The New Mexico DO standard for all categories of warmwater fisheries is 5 mg/L (NMWQCC, 2002b). The median DO in Brantley Reservoir is less than the standard; the standard is met less than half of the time. However, when the low DO is due to natural causes or the reasonable operation of irrigation or flood control facilities, the DO standard does not apply (NMWQCC, 2002b). In the case of Santa Rosa Reservoir, the bottom DO was below the standard in the 10 profiles measured during the period 1999-2001. Furthermore, the minimum surface DO concentrations in both Santa Rosa Reservoir and Sumner Lake (table 3.4) were below the standard. These results indicate that low DO is a significant environmental problem in all three of the mainstem reservoirs in the study area. Low DO restricts the access of fish to the deeper waters of a reservoir and favors a bottom fauna predominated by tolerant organisms such as *Tubifex* worms at the expense of less tolerant organisms such as insect larvae.

The median EC of the outflow from Brantley Reservoir is more than 700 µS/cm lower than that of the median inflow. The periods of record for the two data sets are the same. These data indicate dilution within the reservoir by the higher flow-lower EC water. However, the median EC of the surface water is more than 1,400 µS/cm lower than that of the bottom water, indicating that mixing is not occurring all of the time, and some form of salinity gradient is present in the reservoir most of the time. Because the EC of the bottom water is somewhat greater than the EC of the outflow, this indicates that some of the mixing is due to the withdrawal. In other words, the outflow does not consist solely of water siphoned off the bottom of the reservoir but, rather, a mix of that water and withdrawals from overlying, more dilute layer of water.

4.5 Ground Water

Figure 3.4 shows the EC of the ground water in the predominant aquifers of FSID, PVACD, the intervening area between FSID and PVACD, and CID. The data included on figure 3.4 consist of EC measurements made by the Roswell District of NMOSE between 1927 and 1999. Just as the EC in the Pecos River increases from the Near Acme gage to the Near Artesia gage (figure 3.3), the EC of the alluvial ground water increases downstream from FSID to PVACD, and it decreases downstream from Brantley Reservoir to CID (figure 3.4). The EC of the ground water in the Artesia Group shows a similar pattern. The EC of the ground water in the alluvial aquifer and the Artesia Group is similar in the area upstream of Brantley Reservoir. In the Roswell basin, the alluvial sediments and Artesia Group are generally grouped together as the shallow aquifer.

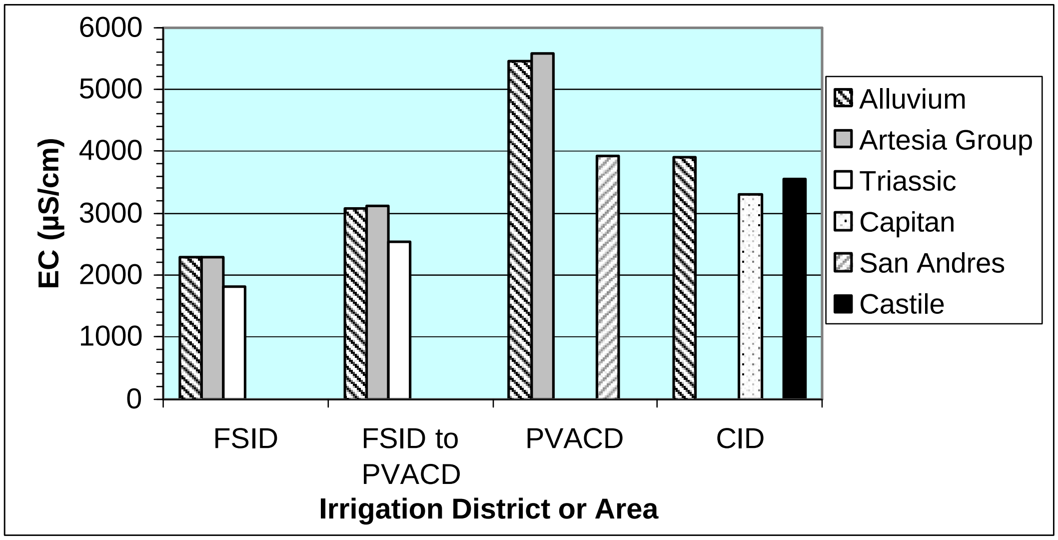


Figure 3.4 Median EC of ground water in various aquifers along the Pecos River.

Aquifers other than the alluvium and the Artesia Group differ in the four areas shown on figure 3.4. In the more northerly areas of FSID and the area to the immediate south, the next most commonly sampled wells were in the Triassic Chinle and Santa Rosa Formations. The EC of the Triassic aquifers is slightly lower than the EC of the alluvium and the Artesia Group wells. The most commonly sampled wells in PVACD were in the San Andres Formation, which was not sampled in any of the other three areas shown on figure 3.4. The San Andres Formation constitutes the artesian aquifer; the Artesia Group of strata forms the cap on the artesian aquifer (Barroll and Shomaker, 2003). The EC of the San Andres ground water is much lower than that of the overlying aquifers.

The geology changes just north of CID. Where to the north there are shelf deposits, the Delaware Basin lies to the south. The Delaware Basin is rimmed by the Capitan Reef (or Capitan Limestone) Complex, the most commonly sampled aquifer after the alluvium in CID (Barroll and Shomaker, 2003). The EC of the Capitan Reef is low to the west, near its recharge area in the Guadalupe Mountains, but it increases to the east because of mixing of poorer quality water from the bedrock aquifers in the Pecos Valley and seepage from Avalon Reservoir (Barroll and Shomaker, 2003). Where the Capitan Reef is absent, the alluvial aquifer is directly underlain by the Permian Castile and Salado Formations, which together comprise up to 2,500 feet of evaporite beds (Barroll, 2002).

5. Agricultural Soil and Land Resources

5.1 Introduction

The following indicators were selected to evaluate agricultural soil and land resources:

Soil resources

- Erosion potential (mainly wind erosion)
- Quality (mainly soil salinity)

Land resources

- Quality, as measured by the acres of lands meeting criteria for national prime farmland (PF) and the acres of lands meeting criteria for farmlands of Statewide importance (FSI)
- Acres of land infested with noxious weeds and plants (mainly salt cedar)

> **What is Prime Farmland?**
>
> ***Prime farmland*** is land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion, as determined by the Secretary of Agriculture (NRCS, 2005).

These indicators of agricultural soil and land resources are important because they affect soil and land productivity and the long-term food security of our Nation.

In addition to the two indicators of agricultural soil resources, this section describes soil sodicity (the presence of excess sodium) and drainage (soil wetness). Also, in addition to the two indicators of agricultural land resources, this section describes irrigated acreage, cropping patterns and trends, crop yields, water use efficiency, fallowing, land retirement, land development, and flooding damage. Conditions for the period 2002-04 are described.

5.2 Evaluation Area

The Pecos River has long provided irrigation water for valuable food and fiber crops, as well as cattle feed for the local livestock industry (Cummins, 1892). The State of New Mexico and Reclamation consider the irrigated land along the Pecos River to be a valuable resource, and the Federal Farmland Protection Policy Act requires an impact evaluation of prime and unique farmlands. According to this act, “the Department of Agriculture and other Federal agencies should take steps to assure that the actions of the Federal Government do not cause United States farmland to be irreversibly converted to nonagricultural uses in cases in which other national interests do not override the importance of the protection of farmland nor otherwise outweigh the benefits of maintaining farmland resources."

According to the Natural Resources Conservation Service (NRCS), many soil series comprising about 83,000 acres in the study area are considered to be PF when irrigated (Brummer, 2001). This analysis considers all irrigated lands to be valuable farmlands worthy of evaluation.

The waters of the Pecos River downstream from Santa Rosa Dam are marginal for irrigation because of their high salt content; thus, any changes in water quality or quantity or in the timing of deliveries could significantly affect irrigated agriculture (Brummer, 2001). The evaluation area includes the Pecos River basin from Guadalupe County to the Texas border; however, this evaluation focuses on CID because the historic release schedule is designed to maximize water quality and quantity for this district. Because some CPWA options could affect other irrigation districts, these other districts also are described. Other irrigated areas along the Pecos River include artesian basin area irrigators (mostly ground water), private river pumpers, wildlife areas, FSID, and Puerto de Luna and a number of other small irrigated areas upstream of Sumner Lake.

Soils in the evaluation area include flood plain, recent alluvial terrace, older terrace, and upland soils. The alluvial soils are best suited for irrigation, although large areas of old terraces (underlain by caliche) and upland soils (underlain by limestone or gypsum beds) are irrigated.

5.3 Soil Quality

Soil quality refers to organic matter content, nutrient and water-holding capacity, soil tilth (the physical condition of the soil with respect to its fitness for the growth of a specific crop), structure, and internal drainage. The soils in the study area tend to be high in calcium carbonate and gypsum. The high amounts of residual calcium carbonate tend to maintain an acceptable surface soil structure (Brummer, 2001). Soil organic matter is rather low. Irrigation tends to maintain or increase organic matter in the surface soil because irrigation usually results in the increased incorporation of crop residues into the soil. Soil salinity and sodicity are considered very important components of soil quality and are discussed separately.

5.4 Soil Salinity

The lands along the Pecos River tend to be somewhat saline. Soil salinity has increased as a result of irrigation. Comparisons of current data with 1948 data indicate that salinity has stabilized in most fields and that the lands are in equilibrium with the irrigation water. Table 3.5 lists the average percent salinity of more than 30 CID sites in 1948, 1993, and 1997 (Brummer, 2001).

Table 3.5 Average salinity of lands along the Pecos River

Year	Average percent salt (root zone)
1948	0.28
1993	0.27
1997	0.26

In areas of restricted drainage, soil salinity tends to increase until the lands can no longer be farmed profitably. Sensitive crops can be affected by 0.1 percent salts. (U.S. Department of Agriculture [USDA], 1954). Many areas of farmland along the lower Pecos River, as well as unharvested fields left for wildlife use, have been abandoned because of excess soil salinity in combination with chronic water shortage. Control of soil salinity is especially critical during the spring because excess salt on the planting beds greatly inhibits germination and emergence of seedlings. Areas invaded by salt cedar tend to be very high in salts. Salt cedar tends to concentrate salts in surface soils because the leaf fall contains a considerable amount of salt. For land to meet PF criteria, soil salinity, as measured by specific electrical conductance of the saturation extract (ECe) should be less than 4 deciSiemens in the top meter of soil. Soil salinity levels on many irrigated prime farmlands in the Pecos Valley currently are approaching the 4 deciSeimens per meter (dS/m) ECe threshold level. Any increase in irrigation water salinity would decrease the acreages of land qualifying for PF in the Pecos Valley.

5.5 Wind Erosion Potential

The lands in the Pecos Valley are subject to moderate-to-high wind erosion potential. Keeping lands in crop rotations tends to reduce wind erosion, while exposed, fallowed lands tend to have greater damage from wind erosion. Lands retired from irrigation should be reseeded with native grasses to reduce wind erosion damage. State-controlled land retirement programs call for reseeding and erosion control measures. Many lands that are otherwise eligible for PF designation are excluded from this category because of the elevated wind erosion hazard (Smith, 2004). The general soils map from the Eddy Area, New Mexico, soil survey indicates that more than 50 percent of the irrigable lands are subject to moderate to severe wind or water erosion; wind erosion is the major hazard.

5.6 Water Erosion Potential

Rainfall in the study area tends to come in intense thunderstorms during the summer. These storms have the potential to erode exposed soils. Water erosion potential generally increases with increasing slope length and steepness. Most of the irrigated lands along the Pecos River are nearly level to gently undulating or sloping; however, some water erosion has occurred. Irrigation-induced erosion occurs when excess flow and velocity of irrigation water move soil from the upper end of a field to the lower end. Reducing the flow in the furrows with methods such as surge valve irrigation can reduce erosion incidental to irrigation.

Many of the irrigated lands along the Pecos River have been bench-leveled (nearly level terraces) to facilitate efficient irrigation (Marshall, 2003). The only water erosion noted on these lands was erosion of the berms between the benched fields. Water erosion is a minor problem in the study area because current land management has helped to reduce this hazard.

The Pecos River has sandy and unstable banks. Erosion of unstable banks once allowed the river to move back and forth across the flood plain. Controlled releases from dams have probably reduced streambank erosion. Any alternative that leads to increased overbank flooding would increase the natural process of streambank erosion.

The soils of the Pecos Valley are somewhat susceptible to water erosion. Generally, only lands with slopes of 0 to 3 percent slope are included in PF inventories. Slopes of FSI in the Pecos Valley can range up to 10 percent but are commonly less than 6 percent (NRCS, 1986).

5.7 Soil Sodicity

Excess sodium causes dispersion of soil particles, resulting in reduced infiltration of irrigation water and precipitation. As a result, it may be difficult to replace soil water for crop use and crop yields may be reduced. To qualify for PF designation, the exchangeable sodium percentage level should not exceed 15 percent in the top meter of soil (National Archives and Records Administration [NARA], 2005).

5.8 Drainage

Some farmers along the lower Pecos River have poorly drained soils. Most of these poorly drained soils are the result of canal seepage or irrigation deep percolation perching on underlying gypsum beds or impermeable calcium carbonate layers. This situation creates perched, saline water tables that impede land productivity. As productivity declines, the farmer has less and less income to remedy the situation by installing drains. CID reports that impaired drainage is a major problem in the district. About 5,000 acres in CID are adversely affected by shallow ground water and soil wetness. CID’s existing drainage system consists of 30 miles of open drains and 2 miles of closed drains. Further drain construction and canal lining are needed to improve productivity in portions of CID.

Poor drainage is also a problem in the ground-water basin. As ground-water pumping has decreased in recent years, drainage problems have increased. These drainage problems have led to reactivation of some regional drainage districts, and some new drains have been constructed by growers to relieve soil wetness. Some FSID lands also are adversely affected by shallow ground water.

5.9 Important Farmlands

As discussed previously, important farmland in the study area consists of PF and FSI. PF has the soil quality, growing season, and moisture supply needed for the soil to economically produce sustained high yields of food, fiber, forage, and oilseed crops when properly managed. Of the several types of important farmland, only PF is based on national criteria. (The Farmland Protection Policy Act requires evaluation of PF.) Some of the criteria (NARA, 2005) that relate most directly to this evaluation include the following:

- Lands are irrigated
- Soil reaction pH is between 4.5 and 8.4
- Lands are not adversely affected by shallow ground water
- Soil salinity in the top meter is less than ECe 4 dS/m
- Exchangeable sodium percentage is less than 15 in the top meter of soil
- Lands are not subject to frequent flooding
- Surface soil erodibility does not present a serious erosion hazard when local climatic factors are considered

In some areas, land that does not meet the criteria for prime or unique farmland has been determined to be FSI by State or local officials in cooperation with the State Office of NRCS because it is the best land available in the region (NRCS, 2005). Generally, these areas produce excellent yields but require more intensive conservation treatments to ensure sustained yields relative to PF. Irrigated farmlands must be classed as at least irrigated capability class IV to qualify for the FSI designation based on New Mexico NRCS criteria. The NRCS capability class IV lands have very severe limitations that reduce the choice of plants, require very careful management, or both. Land and water right purchases during recent years have reduced the acreages of important farmlands along the Pecos River.

NRCS websites provide lists of soil series, mapping units, and associations that qualify as important farmland (NRCS, 2005). Lands must be irrigated in order to qualify as PF or FSI. Table 3.6 presents the number of soil types in the study area, their acreage by county, and the dates of the listings.

Table 3.6 Number of soil types in study area

County	PF[1]	FSI[2]	Date of listing
Eddy	5 (74,000 acres)	15	3/25/2002
Chaves south	0	20	1/17/2002
Chaves north	1 (1,200 acres)	11	1/27/2002
De Baca	4 (7,400 acres)	21	3/25/2002
Guadalupe	1 (no data on acres)	Not available	2/01/2002

Table 3.6 Number of soil types in study area

County	PF[1]	FSI[2]	Date of listing
Eddy	5 (74,000 acres)	15	3/25/2002
Chaves south	0	20	1/17/2002
Chaves north	1 (1,200 acres)	11	1/27/2002
De Baca	4 (7,400 acres)	21	3/25/2002
Guadalupe	1 (no data on acres)	Not available	2/01/2002

[1] Only irrigated lands qualify for PF in the Pecos River area because of the dry climate and the need for irrigation. Many soil series that would otherwise qualify for PF if irrigated were removed from the PF category a few years ago, based on the severe wind erosion hazards in the area (Smith, 2004).
[2] No FSI listings are available. Series and associations with an irrigated capability class of IV or higher were placed in this category based on soil survey information.
Source: NRCS, 2005.

As table 3.6 shows, the Pecos River basin contains extensive areas of important farmlands. (Supporting data include the listings of important farmland soil mapping units by county.) On the basis of a preliminary examination of soil surveys, it appears that more than 50 percent of the irrigated lands in CID are designated as PF. The percentage of PF irrigated in upstream areas is much lower; however, nearly all irrigated lands in the Pecos River Valley currently meet the criteria for FSI.

5.10 Noxious Weeds

Salt cedar invasion is considered a major problem on the Pecos River. Salt cedar consumes large amounts of water along the river corridor; reduces the usability of lands for range; and has invaded many irrigated farmlands, rangeland, and valuable wildlife habitat lands along the river. Estimated costs (Brummer, 2003) to control this plant with herbicides range from $89 to $141 per acre, while mechanical control costs are higher (about $600 per acre). Salt cedar is spread by seeds in floodwaters, and flooding in late summer and autumn tends to facilitate its spread. Nearly all water lost to seepage along the Pecos River is eventually transpired by the salt cedar and is permanently lost from the local water supply. The extent of the salt cedar invasion prior to control operations was estimated at more than 60,000 acres.

Lands invaded by salt cedar tend to be highly saline because of salts extruded by the salt cedar leaves, which eventually fall to the soil. Salt cedar can contribute to flood damage because dense stands will back up floodwaters; however, salt cedar can reduce streambank erosion.

Salt cedar control operations usually result in a mixed stand of perennial grasses, broom snakeweed, mesquite, and four-wing salt bush. Coyote willow and seep willow will colonize some of the wetter areas. Replacing salt cedar with vegetation dominated by perennial grasses is estimated to conserve about 1 acre-foot per acre per year of water because of transpiration differences (Reclamation, 1997).

Reclamation, soil and water conservation districts, and other State and local government agencies have dedicated abundant resources to the salt cedar eradication (water salvage) program begun in 1965. Over the past several years, large acreages of salt cedar have been sprayed with the herbicide imazapyr. These programs have reduced the acreage of salt cedar infestation to an estimated 25,000 acres, with less than 10,000 acres of dense stands (Brummer, 2003).

Federal Executive Order 13112 (Invasive Species) and the State Noxious Weed Control Act (sections 76-7-1 to 76-7-22 New Mexico Statutes Annotated [NMSA] 1978) may be applicable to weed control.

5.11 Irrigated Acreage

The total irrigated acreage in the study area averaged about 160,000 acres from 1980-85 (including tributary and ground-water irrigation). This acreage has decreased in recent years because of land retirement for water rights, as well as some land abandonment because of excess salt and seepage. The general trend in the Pecos River Valley is a gradual decline in irrigated acreage.

Reclamation records indicate that CID irrigated 16,500 acres in 1917; an average of 24,592 acres from 1921-33; and an average of 20,000 acres from 1934-40. By 1993, CID irrigated a total of 18,813 acres. Private pumpers along the Pecos River irrigated nearly 20,000 acres at one time, but this acreage has been reduced to about 3,000 acres currently. FSID currently irrigates about 6,000 acres, and PVACD irrigates more than 100,000 acres.

5.12 Cropping Patterns and Trends

CID is best suited for salt-tolerant crops. The soils are too saline for maximum yields of some climatically adapted crops, such as chili peppers and pecans, although these crops are grown successfully in upstream areas north of CID. In the early 1900s, some deciduous fruit was grown in the valley (Means and Gardner, 1900). However, none has been reported in CID crop reports since about 1970. There has been a long-term trend toward increased alfalfa production and decreased cotton production in CID. Alfalfa acreage increased from about 4,300 acres in 1925 to about 12,000 acres in 1992 (Reclamation, 1992). Apples formerly were an important crop in the Roswell and Fort Sumner areas; however, no commercial apple orchards were observed in current field inspections. Recent trends in the Roswell area include large increases in corn and small grain acreage for nearby dairies. Upstream areas, such as FSID, grow about 75 percent alfalfa. The other lands are mostly used for rotation crops between alfalfa plantings, such as small grains and forage mixes. Cropping patterns are based on Reclamation's 1992 crop report for CID and are presented in table 3.7 (Reclamation, 1992).

5.13 Crop Yields

New irrigation technology and crop improvements have led to general increases in crop yields over the past 30 years. These improvements have not been fully realized in the Pecos River Valley, especially in areas affected by excess salt.

Yields presented in table 3.7 are much lower than potential yields based on the climate of the area, despite irrigation water deliveries of 3.9 acre-feet per acre in 1992.

Table 3.7 CID cropping patterns (1992)

Crops	Acres	Percent of irrigated	Yield per acre
Alfalfa	11,755	65	6 tons acre
Cotton	4,243	24	0.85 bales
Irrigated pasture	633	3	8.3 animal unit months
Peppers	785	4	1,800 pounds
Pecans	229	1	1,400 pounds
Other crops	508	3	
Total irrigated cropland	18,153		

5.14 Water Use Efficiency

An important measure of water use efficiency is the comparison between crop yield and the volume of water used to produce the crops. Water use efficiency appears to be increasing slightly in CID because crop yield per acre has gradually increased over the years, while crop water deliveries per acre have been stable.

5.15 Fallowing

Fallowed acreage has fluctuated over the past 25 years. CID crop reports indicate nearly 6,000 acres were fallowed in 1992 and 1993. While fallowing for crop rotation, soil building, or moisture storage is considered beneficial, long-term fallowing can be detrimental to land productivity. Buildup of noxious weeds and, in some cases, salt, can occur on lands that are idle for long periods. Currently, some CID landowners can fallow their land for a crop year and receive a payment for the water supply.

5.16 Land Retirement

Irrigated lands are currently being purchased and retired on the basis of a settlement among NMISC, CID, and PVACD to ensure long-term compliance with the Pecos River Compact and the U.S. Supreme Court Amended Decree. Other lands have been retired from irrigation because of a water table buildup or a soil salinity increase. Still other lands have been retired because of high costs to pump ground water or other economic factors. Lands in the area of the artesian ground-water basin are being retired, and the ground water is being transferred to urban use.

5.17 Land Development

Little new land development is occurring in the Pecos River Valley because available water supplies are inadequate to fully irrigate existing lands. NRCS has been improving the infrastructure of existing irrigated lands under the

Environmental Quality Incentives Program, which may cost share up to 75 percent of the costs of certain conservation practices.

5.18 Flooding Damage to Lands

The lands along the Pecos River and its tributaries are subject to infrequent flooding from heavy spring and summer storms. This flooding has damaged irrigation structures, fences, and other properties of agricultural landowners on the flood plain. Flooding has also physically eroded valuable soils in farm and range lands. Upstream reservoirs have helped control flood damage; however, flooding is still a problem because of intense localized summer storms downstream from the dams. Prime farmland cannot be subject to frequent flooding.

6. Biological Resources

6.1 Introduction

This section identifies biological resources that may be affected by one or more of the alternatives. The affected environment for consideration of biological resources includes approximately 350 river miles of the Pecos River and the four reservoirs. Biological resources were evaluated within the following defined area:

- The Pecos River and adjacent flood plain between the Below Santa Rosa Dam and At Red Bluff gages, upstream of the New Mexico/Texas State line.
- Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir.

The following indicators were selected to evaluate the effects of the alternatives on biological resources:

Terrestrial and flood plain ecosystem components (including wetlands, riparian vegetation, and wildlife)

- Increased potential for overbank flows and erosion of riverbanks containing riparian, wetland, and terrestrial habitats.
- Increased potential for inundation of habitats used by nesting shorebirds, including interior least tern, terrestrial wildlife species, and wetland aquatic species.

Riverine aquatic ecosystem components

- Changes in frequency, extent, and duration of intermittency at the Near Acme gage that would cause direct mortality of aquatic organisms and loss of aquatic habitat.
- Changes in frequency of extreme low flows (less than 3 to 5 cfs) at the Near Acme gage that could result in rapid development of channel intermittency and loss of aquatic habitat.
- Change in frequency, magnitude, or duration of managed or natural peak flows at the Near Acme gage that could impact aquatic habitat or spawning activities.

Reservoir aquatic ecosystem components

- Changes in availability of sport fish spawning habitat and adult habitat in response to reservoir elevation changes.

Special status species that occur within the study area

- For each species, see the indicators listed previously for the ecosystem that contains its habitat (e.g., riverine aquatic for Pecos bluntnose shiner and terrestrial for interior least tern)

Critical habitat within the study area

- For each designated critical habitat, refer to the indicators listed previously for appropriate ecosystem type (e.g., riverine aquatic for Pecos bluntnose shiner critical habitat).

The importance of each of these indicators is described in the following sections.

6.2 Terrestrial and Flood Plain Ecosystem Components

Hildebrandt and Ohmart (1982) characterized riparian vegetation communities along the Pecos River from approximately Santa Rosa, New Mexico, to near Garvin, Texas. They identified seven major riparian vegetation community types and found woody riparian vegetation to be most abundant. Communities dominated by salt cedar (*Tamarix parviflora*) accounted for about 93 percent of the woody riparian vegetation, while communities dominated by cottonwood (*Populus* spp.) accounted for about 7 percent. Vegetation in the vicinity of the abandoned McMillan Reservoir delta accounted for almost half of the salt cedar-dominated vegetation community, and an extensive community of salt cedar also was found at Bitter Lake National Wildlife Refuge (BLNWR); outside of these areas, salt cedar typically occurred within narrow fringes along the riverbanks. Many of these areas have recently been sprayed to remove salt cedar. (See Section 5.10, “Noxious Weeds” in “Agricultural Soil and Land Resources.”)

Plains forested wetlands occur through much of the Pecos River basin and account for most of the vegetation in the study area. These wetlands occur on bars and terraces of wide flood plains at elevations ranging from 3500 to 4800 feet above mean sea level. Common plant species associated with these wetlands are Fremont cottonwood (*Populus fremontii*), salt cedar, willow (*Salix* spp.), and seepwillow (*Baccharis salicifolia*). Additional wetland types occur in patches throughout the study area. These wetland communities include southwest forested wetlands; southwest scrub-shrub wetlands; plains persistent-emergent wetlands; and warm temperate, southwest persistent-emergent wetlands. Within these wetland areas, populations of special status aquatic invertebrates (table 3.8) and other wetland dependent species occur in spring/seep habitats. In addition, upland vegetation includes plains dry steppe and shrub habitat and Chihuahuan desertscrub habitat. Typical vegetation includes short bunch grasses (e.g., buffalograss and blue grama), juniper, mesquite, and creosote bush.

Hildebrandt and Ohmart (1982) censused wildlife along vegetation community transects within the Pecos River basin. The bird community was the most diverse and abundant of all wildlife types, with 310 species recorded. At least 285 of those species (USGS, 2003) have been observed or may occur at BLNWR, an important resting and wintering area for migratory and resident bird species. The herptile (amphibian and reptile) community in the study area consisted of 40 species and was dominated by terrestrial reptiles. Predators and large mammals identified along these transects included beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), porcupine (*Erethizon dorsatum*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus ocythous*), ringtail (*Bassariscus astutus fulvescens*), raccoon (*Procyon lotor hirtus*), long-tailed weasel (*Mustela frenata*), badger (*Taxidea taxus*), striped skunk (*Mephitis mephitis hudsonica*), hog-nosed skunk (*Spilogale* sp.), bobcat (*Felis rufus pallescens*), mule deer (*Odocoileus hemionus hemionus*), and pronghorn (*Antilocapra americana americana*). Small mammal communities consisted of various species of ground squirrels (*Spermaphilus* spp.), mice, and rats (*Cricetidae* and *Muridae*).

The first indicator selected to evaluate the effects of the alternatives on terrestrial ecosystem components is the increased potential for overbank flows and erosion of riverbanks containing riparian and terrestrial habitats. Increased frequency of these overbank flow events could change the character of the stream channel and surrounding riparian vegetation. These changes to the vegetation would affect the diversity and abundance of local terrestrial wildlife.

The second indicator is the increased potential for inundation of habitats used by nesting shorebirds, including interior least tern, wildlife species, and wetland dependent species, including the special status invertebrate and fish species in the Roswell area. Inundation of these areas could change the character of the habitats and could displace individuals to unsuitable habitats.

6.3 Riverine Aquatic Ecosystem Components

More than 50 warmwater and coldwater species of fish have been documented in the study area between Santa Rosa Reservoir and the New Mexico-Texas State line (Sublette et al., 1990). Many of these species are specially adapted to live in the shifting sand and silt substrates that dominate the river between Fort Sumner and Brantley Reservoir. Generally, small-bodied fishes dominate the riverine fish community and have received much of the research attention in the system, because of the presence of the small-bodied Pecos bluntnose shiner (*Notropis simus pecosensis),* a federally threatened fish species. Aquatic species, including reptiles and amphibians dependent upon Pecos River flows, have been well documented in the basin. Numerous studies related to the shiner have provided much of the known information regarding the aquatic ecosystem.

The first indicator selected to evaluate the effects of the alternatives on riverine aquatic ecosystem components is a change in the frequency, extent, or duration of intermittency (defined as flows of 0 cfs) at the Near Acme gage. A period of intermittency would result in mortality for aquatic organisms, including fish, reptiles and amphibians, invertebrates, macrophytes, and algae. The Near Acme gage is located in a noncritical habitat stretch of the river for Pecos bluntnose shiner, but serves as important habitat and supports high numbers of shiners and other fish species.

The second indicator is a change in the frequency of extreme low flows (less than 3 to 5 cfs) at the Near Acme gage. This indicator is important because these low flows could result in the rapid development of channel intermittency and endanger local aquatic organisms and their habitat.

The third indicator is a change in the frequency, magnitude, or duration of managed peak flows at the Near Acme gage. This indicator is important because changes may affect the frequency and timing of fish spawning, the survival of eggs and juvenile fish, and the availability of habitat for juvenile and adult fish.

6.3.1 Santa Rosa Reservoir to Sumner Lake

In this reach, the river meanders through a fairly narrow valley. Small pockets of wetlands form in backwater areas and along slow-moving sections of the river. Generally, small-bodied fishes dominate the riverine fish community. Numerous populations of aquatic invertebrates occur throughout the study area in riverine and spring/seep habitats.

6.3.2 Sumner Lake to Brantley Reservoir

Approximately 30 river miles downstream from Sumner Dam, the Pecos River enters a broad alluvial plain. Between Fort Sumner and Roswell, the river is more typical of a Plains stream, with a relatively wide channel and a shifting sand substrate. Shallow runs and braided channels are prevalent, and there are small wetlands along the river and in oxbows. This reach provides the necessary habitat components for the shiner and other aquatic species.

Intermittency sometimes occurs for as much as 20-25 miles upstream of the Near Acme gage when base inflows are diverted. The river downstream from the Near Acme gage is generally wetter than it is upstream because of irrigation returns and spring inflows. However, the channel narrows and the geomorphic and hydrologic conditions necessary to provide adequate habitat for the shiner and other fish species are often lacking. Between Artesia and Brantley Reservoir, through the Kaiser channel, the river is very narrow and incised.

6.3.3 Brantley Dam to New Mexico-Texas State Line

Downstream from Brantley Dam, the channel is incised in limestone, which creates riffles and pools in the river. The salinity of the Pecos River increases as the river approaches the Texas border (Service, 1998). As in the other reaches, small-bodied fishes generally dominate the riverine fish community with a few large bodied species, including the blue sucker (table 3.8). This reach has been affected by numerous fish kills caused by golden algae (*Prymnesium parvum*). Little is known about why golden algae blooms occur.

6.4 Reservoir Aquatic Ecosystem Components

Sport fish stocked for recreation purposes dominate reservoir fisheries. Stocking records, creel censuses, and sport fish management activities have provided information on reservoir fisheries (Denney, 2004).

Santa Rosa Reservoir is a popular sport-fishery for catfish, largemouth and smallmouth bass, crappie, and walleye. Sumner Lake provides warmwater fishing, with several varieties of bass, crappie, pike, bluegill, carp, and catfish. Detritivores, including shad, carp, and warmwater suckers, may be important to trophic (food chain level) dynamics in Sumner Lake, because they have been found to accumulate large biomasses and influence food availability there (Cole et al., 1991). The Sumner Lake stilling basin contains catfish and trout. NMDGF stocks the stilling basin with rainbow trout from November through March.

Brantley Reservoir provides year-round fishing for white bass, catfish, largemouth bass, walleye, and crappie. In the last several years, Brantley Reservoir has been stocked with crappie, Florida strain largemouth bass, and catfish. Golden algae blooms are possible in Brantley Reservoir.

The indicator selected to evaluate the effects of the alternatives on the reservoir aquatic ecosystem is a change in reservoir elevations that might lead to changes in spawning, adult, or rearing habitat for sport fish.

6.5 Special Status Species

Special status species are those listed as threatened or endangered under provisions of the Federal Endangered Species Act of 1973, as amended (ESA); those proposed or considered as candidates for such listing; and those considered as rare or species of concern by the Service, NMDGF, and New Mexico Energy, Minerals and Natural Resources Department, Forestry Division.[1]

Not all special status species fall under Federal or State statutes concerning threatened and endangered species. Generally, species designated as threatened or endangered receive protection under the designating agency's applicable statutes, and species considered to be rare or species of concern do not receive protection under these statutes. Species considered by the Service as candidates for threatened or endangered status are not provided protection under ESA. However, Federal agencies are required to confer with the Service on actions likely to jeopardize the continued existence of a candidate species or to result in the destruction or adverse modification of proposed critical habitat. Species not receiving protection under statutes specifically related to threatened and endangered species may receive some protection under other State and/or Federal statutes.

[1] Although the New Mexico Energy, Minerals and Natural Resources Department, Forestry Division, has statutory authority for establishing a list of New Mexico endangered plant species, the list is maintained by the nongovernmental New Mexico Rare Plant Technical Council (NMRPTC, 1999).

> **What are Special Status Species?**
>
> ***Special status species*** are rare animal and plant species that have been identified by Federal or State agencies as needing protective measures. Special status species as defined and used in this document include the following:
>
> - Plant and animal species **listed** as **Federal threatened or endangered** under provisions of the Endangered Species Act of 1973, as amended (ESA).
> - Plant and animal species **proposed** for listing as Federal threatened or endangered under ESA with the proposed listing published in the *Federal Register.*
> - Animal species listed as **State endangered or threatened** under provisions of New Mexico Statutory Chapter 17, Article 2:17-17-2-37 through 17-2-46.
> - Plant species listed as **State endangered** under provisions of New Mexico Statutory Chapter 75, Article 6: 17-6-1.
> - Species designated as **sensitive** or **species of concern** by State and/or Federal management agencies.

Information on the occurrence and potential for occurrence of special status species within the study area was obtained from lists maintained by the Service, NMDGF, and New Mexico Rare Plant Technical Council (NMRPTC). A total of 45 special status species were identified as occurring in Guadalupe, DeBaca, Chaves, and Eddy Counties (New Mexico counties in the study area; table 3.8).

Many of the 45 species typically occupy habitats not occurring in the study area, are unlikely to be affected by the proposed action and, thus, were eliminated from detailed analysis. These species are not discussed in detail in this chapter or in Chapter 4, "Environmental Consequences." Species not eliminated require a more detailed analysis to determine if effects are possible. The two species requiring a more detailed analysis, Pecos bluntnose shiner and interior least tern, are discussed in the following sections.

Indicators from the appropriate ecosystem component are used to evaluate the effects of the alternatives on special concern species (i.e., riverine aquatic for Pecos bluntnose shiner and terrestrial for interior least tern). These indicators reflect changes in the availability of breeding and adult habitat. Both habitats are necessary for survival and reproduction, elements vital to maintaining a viable population.

6.5.1 Pecos Bluntnose Shiner (Notropis simus pecosensis)

The Pecos bluntnose shiner (family *Cyprinidae)* is a federally threatened species and a New Mexico threatened species. It is a small fish that is native to the Pecos River in New Mexico. The shiner (*Notropis simus)* was first collected in 1874 in the Rio Grande of New Mexico (Service, 1987).

Two subspecies were recognized: the Rio Grande bluntnose shiner (*N. s. simus*) and the Pecos bluntnose shiner (*N. s. pecosensis*) (Chernoff et al., 1982)

The Service designated the Pecos bluntnose shiner as a federally threatened species, with critical habitat, in 1987 (*Federal Register*, Volume 52, No. 34, February 20, 1987) under ESA. The upper critical habitat extends approximately from the Taiban Creek confluence to Crockett Draw (map 3.2). The lower critical habitat extends from approximately Hagerman to Artesia. At the time of listing, the Service identified the “most important factors in the species’ decline as reduced flow in the main channel of the river because of water storage, irrigation, and water diversion” (Service, 1987).

The State of New Mexico listed the shiner as endangered, group II, in 1976 (first listed under the name silverband shiner [*N.* cf. *shumardi*]; Sublette et al., 1990). Group II species were defined by the State as those whose prospects for survival or recruitment in New Mexico are likely to be in jeopardy within the foreseeable future (Service, 1987). In the September 2000 NMDGF Biennial Review and Recommendations, the species was listed as threatened with no change in status recommended (NMDGF, 2000, 2002b).

The shiner has been characterized as carnivorous-omnivorous, based on the shape of the digestive tract (Sublette et al., 1990). Bestgen and Platania (1987) found that organic matter, filamentous algae, and terrestrial plant matter (including seeds, seed coatings, and small woody debris) comprised 52 percent of all identified food items from the gut of 14 Rio Grande shiners. Terrestrial and aquatic invertebrates comprised the other 48 percent of the identified food items. Terrestrial plant organic matter and terrestrial invertebrates made up 75 percent or more of the contents in 43 percent of the guts examined. Platania (1993) examined 655 Pecos bluntnose shiner stomachs and found terrestrial invertebrates (ants and wasps), aquatic invertebrates, larval fish, and plant seeds.

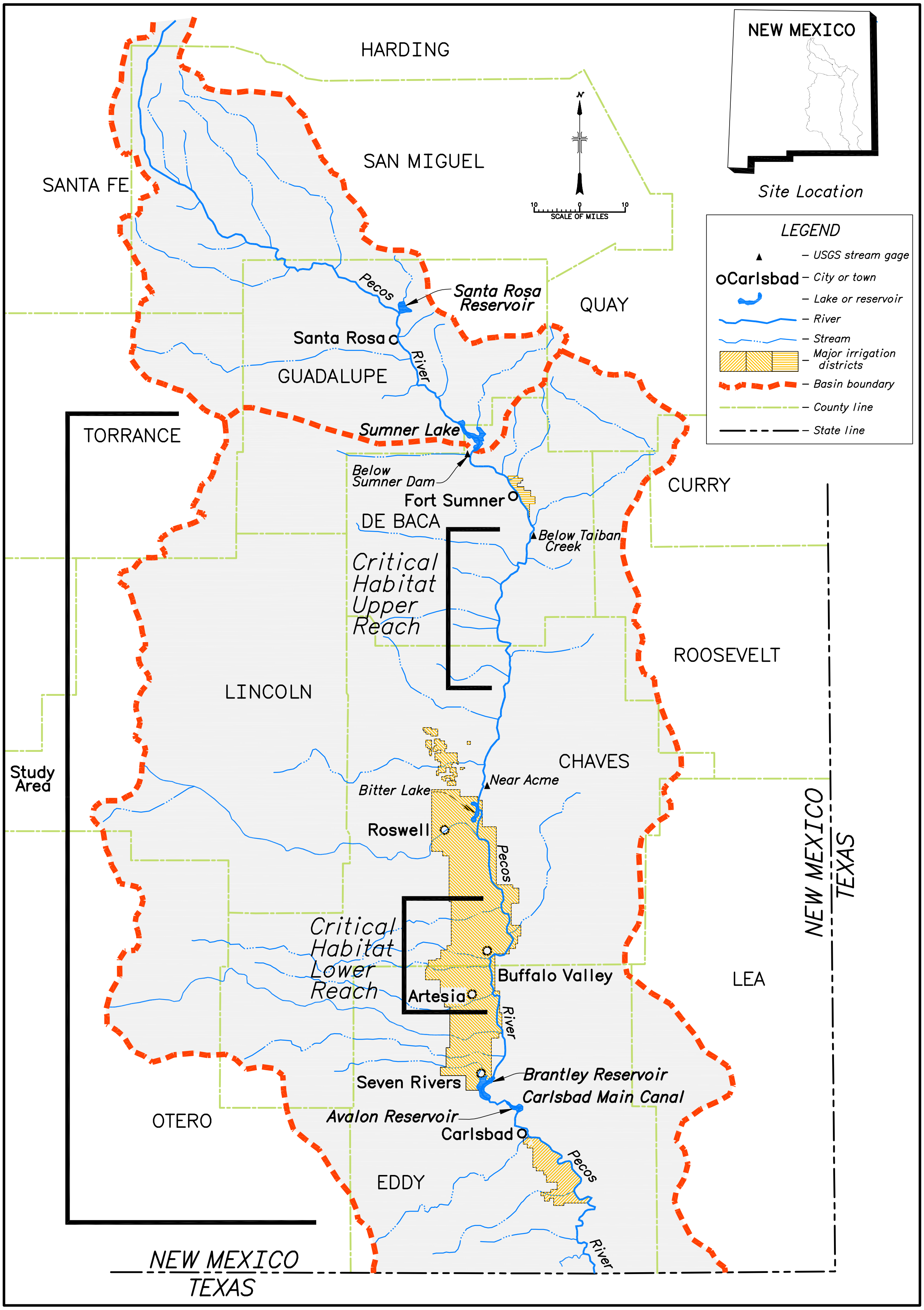
Individual shiners may live up to 3 years, but most individuals live about 2 years. The fish mature after their first year of life (age 1). Age 1 females produce up to 500 eggs per spawn; age 2 females produce up to 1,000 eggs, but few survive to spawn at age 3. Platania (1993) and Platania and Altenbach (1998) described the shiner as pelagic (open water), broadcast spawners that produce nonadhesive, semibuoyant eggs that are approximately 1 millimeter in diameter at expulsion and harden in water to about 3 millimeters. Platania (1995a) reported a positive correlation between reproduction of Pecos River broadcast-spawning species (including the shiner) and increases in river discharge between early June and late September. Hatch et al. (1985) reported that the shiner has a prolonged spawning season lasting into September. Platania (1993) reported the 1992 spawning season occurred between June and August. Elevated flows (irrigation releases, spring runoff, and rainstorm events) appear to be an environmental cue to initiate spawning (Platania and Altenbach, 1998). Females release eggs in the mid-water column, where males immediately fertilize them. After fertilization, the eggs incubate as they drift with the river current, and the larvae hatch in about 24 hours. The tiny protolarvae (about 5 millimeters long) continue to drift with the current for 3 to 4 days and then actively forage and select low-velocity habitats.

Platania (1995b) summarized historic collections of the shiner. Based on collections made from 1902 to 1949, the confirmed pre-1950 range of the shiner was from near the city of Santa Rosa, downstream to the vicinity of Major Johnson Springs, near Carlsbad. However, there is no reason to believe that the shiner did not historically occupy the Pecos River as far downstream as the Texas border. On the basis of collections made since 1982, the current range of the shiner is believed to be approximately 186 miles from near the Taiban Creek confluence, DeBaca County, downstream to Brantley Reservoir (Hoagstrom, 2003). Recently, eight juvenile shiners were collected downstream from Brantley Reservoir (NMDGF, 2004), presumably after being flushed through the reservoir during an irrigation release. All age classes of the shiner occupy the upper critical habitat section; primarily larval and juvenile forms occupy the lower critical habitat section with few adults collected (Hoagstrom, 2003).

The shiner has been collected only from the mainstem Pecos River or at the mouths of its major tributaries (Service, 1992; Platania, 1995b). There is a 1986 collection record for the species in the Rio Felix of Chaves County, approximately 1 mile upstream of the Rio Felix/Pecos River confluence, but Platania (1995b) considers this record aberrant. Hatch et al. (1985) found the species in every major habitat within its range, except stagnant pools, and found it most often in water 17 to 41 centimeters (6.7 to 16 inches) deep with smooth, nonturbulent flow and sandy substrate.

In research conducted in flows that ranged from 15 to 300 cfs, Hoagstrom (2003) found the shiner in all habitats sampled, although 94.4 percent of the total catch was from water less than 1.3 meters (4.3 feet) deep and flowing at a velocity of 0.84 meter per second (2.7 feet per second). Hoagstrom further concluded that of a total catch of 684, about 69 percent came from areas 0.12 to 0.25 meters (4.7 to 9.8 inches) deep with a flow of 0.04 to 0.42 meters per second (0.13 to 1.4 feet per second), and about 18 percent were collected from areas of 0.29 to 0.39 meter (11.4 to 15.3 inches) deep and with a flow of 0.04 to 0.42 meter per second (0.13 to 1.4 feet per second); there were no important differences in depth of water occupied by different size classes, but there was a difference in velocity, with age 0 fish occupying lower velocities. The shiner showed a preference for depths greater than 0.5 meter and velocities ranging from 0 to 0.7 meter per second (Hoagstrom, 2003).

Kehmeier et al. (2004) documented that between flows of 2 cfs and 81 cfs, water depth and velocities overlapped considerably for habitats used by small-bodied minnows in the Pecos River, including the Pecos bluntnose shiner, and were unsuitable when analyzed independently for development of habitat-to-flow relationships. Rather, Pecos River fishes use discrete mesohabitat types, which



Map 3.2 Pecos bluntnose shiner critical habitat

are generally described as habitat types that provided suitable combinations of features such as depth, velocity, substrate, turbulence, cover, and food. The shiner and other small-bodied cyprinids strongly selected perpendicular and parallel plunge habitats with average depths of 24 centimeters (0.78 feet) and average velocities of 0.18 meter per second (0.60 feet per second). These habitats were characterized by sudden increases in depth and reduced velocity, often with vertical recirculation or an eddy effect that have the potential to provide areas for resting, food entrainment, and adjacent cover for escape from predators. More than 60 percent of shiners were collected in these plunge habitats, which comprised a very small percentage of all available habitats at all flows.

6.5.2 Interior Least Tern (Sterna antillarum athalassos)

The interior least tern is a federally endangered species and a New Mexico endangered species. In New Mexico, this species is at the extreme southern and western periphery of its range. The first recorded sightings of interior least tern in New Mexico occurred in 1949 at BLNWR (Jungemann, 1988). A small population of least terns has used this area for the past 51 years; the number of terns sighted at BLNWR during peak abundance fluctuates annually.

Interior least terns may use areas within the Pecos River basin for both nesting and feeding. Throughout the interior least tern's range, the nesting period begins in mid-May and may last through August. Interior least terns typically nest in colonies on broad, unvegetated sandbars and flats. The nest is scraped in sand and/or gravel and is normally unlined. An important factor for successful interior least tern nesting is the adequacy of the food base. Interior least terns feed exclusively on small fish (Kingery, 1998), indicating that an adequate food base for both adult and young-of-the-year is common in the Pecos River.

Tern use of reservoir storage space has been documented outside of the study area (Kingery, 1998). However, it has been documented that nesting success within reservoir pools is less successful than nesting on islands and sandbars (Kingery, 1998). In 2004, several nesting pairs of interior least terns were sighted within the conservation storage space of Brantley Reservoir (between the 3240- and 3245-foot elevation contours). There is currently no knowledge of whether suitable habitat for the tern occurs at other elevations within the reservoir. Therefore, the known elevation was used as a benchmark to evaluate potential impacts to the species.

6.5.3 Other Special Status Species

Table 3.8 presents the other special status species listed within the study area, describes their requisite habitat components, and portrays whether the species is further analyzed in chapter 4. For those species not requiring further analysis, impacts to the species are included in analysis of impacts to their habitats encompassed by each resource area (e.g., Pecos assiminea snail habitat covered by the terrestrial and flood plain ecosystem components).

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Plants						
Gypsum wild buckwheat	*Eriogonum gypsophylum*	The species has been recorded in one location within the study area of the Pecos River basin (Hildebrandt & Ohmart, 1982; Martin & Hutchins, 1980, 1981), on some rocky hillsides near Seven Rivers, but not within riparian areas. It does not grow in sandy or loamy conditions.	T	E	Terrestrial ecosystem	No
Kuenzler hedgehog cactus	*Echinocereus fendleri var. Kuenzleri*	The species is xerophytic and occurs primarily on gentle, well-drained, gravelly-to-rocky slopes and benches on limestone or limey sandstone in upland habitat types. Resource inventory reports do not show this cactus growing within the study area.	E	E	Terrestrial ecosystem	No
Lee pincushion cactus	*Coryphantha sneedii* var. *leei*	This species grows primarily in cracks in limestone in areas of broken terrain and steep slopes of Chihuahuan desert scrub. In New Mexico, the species grows on rocky slopes or limestone ledges above 4000-foot elevation. No findings of this cactus have been reported within the riparian areas of the Pecos River basin.	T	E	Terrestrial ecosystem	No
Puzzel (Pecos) sunflower	*Helianthus paradoxus*	This species is common to desert wetlands, such as springs and seeps, as well as along margins of streams and impoundments. It is found in permanently saturated soils. It is found within study area on BLNWR and at the Dexter National Fish Hatchery near Dexter, New Mexico.	T	E	Terrestrial and flood plain ecosystem	No
Invertebrates						
Pecos assiminea snail	*Assiminea pecos*	This species is a terrestrial snail, inhabiting moist substrates adjacent to flowing water. It needs a humid microclimate (NMDGF, 1988). It has been observed underwater (NMDGF, 1996), but it is not known if this is typical behavior or an accidental occurrence. CH has been proposed for this species.	PE	E	Terrestrial and flood plain ecosystem	No
Noel's amphipod	*Gammarus desperatus*	This species inhabits brackish to freshwater springs associated with Permian marine sediments (Cole, 1985). Two populations have been extirpated since the 1950s. Loss of habitat and decreases in existing populations indicate that the species' persistence is precarious (NMDGF, 2002b). It is endemic to southeastern New Mexico; it is known only from springs at the Roswell Country Club, Lander Springbrook, and BLNWR (Cole et al., 1991). CH has been proposed for this species.	PE	E	Terrestrial and flood plain ecosystem	No

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Texas hornshell	*Popenaias popeii*	This species, also referred to as "Pope's mussel," occurs on soft or rocky substrates in larger streams. Texas hornshell populations in New Mexico are marginal at best. Current distribution in New Mexico is confined to approximately a 14-kilometer reach of the Middle Black River in Eddy County (NMDGF, 2002b).	--	E	Terrestrial and flood plain ecosystem	No
Roswell pyrg [springsnail]	*Pyrgulopsis roswellensis*	The Roswell pyrg is endemic to southwestern New Mexico, with populations occurring only at the Roswell Country Club and BLNWR (Taylor, 1987). These populations are thought to be stable under current conditions (NMDGF, 2002b). Preferred habitat appears to be limestone rubble in swift spring outflows (Noel, 1954). The species can survive in small seepage areas as long as flow persists, but population densities decrease with decreasing current velocity (NMDGF, 1988). CH has been proposed for this species.	PE	E	Terrestrial and flood plain ecosystem	No
Koster's springsnail	*Tryonia kosteri*	This species is strictly aquatic and occurs in slow-velocity water or off-spring habitats and streams. It occurs mainly on soft substrates, such as mud and organic debris, but it may attach to pebbles and vegetation. It occurs at Roswell Country Club and BLNWR; these populations are considered stable. Proposed CH is on BLNWR.	PE	E	Terrestrial and flood plain ecosystem	No
Fishes						
Blue sucker	*Cycleptus elongates*	This species inhabits deep pools and channels in moderate to large rivers. Adults prefer swift water. The blue sucker spawns in riffles over bedrock and cobbles and feeds in riffle habitats over firm substrates and areas with dense algal growth. It occurs between Brantley Dam and Avalon Reservoir and occasionally downstream from Avalon Dam to the New Mexico-Texas State line.	--	E	Riverine ecosystem	No
Pecos bluntnose shiner	*Notropis simus pecosensis*	See narrative.	T/CH	T	Riverine, special status species resources	Yes
Arkansas River shiner	*Notropis girardi*	This species was introduced into the Pecos River by bait bucket. It is a pelagic, broadcast spawner that spawns from May though July. The Arkansas River shiner feeds on invertebrates and detritus.	E	--	Riverine ecosystem	No
Pecos gambusia	*Gambusia nobilis*	This species is endemic to the Pecos River. It inhabits backwaters, pools in small tributaries, and springs of off-channel sites along the Pecos River between Sumner Dam and the New Mexico State line. No populations currently exist in the mainstem Pecos River in New Mexico.	E	E	Terrestrial/ flood plain ecosystem	No

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Pecos pupfish	*Cyprinodon pecosensis*	Little is known about the historic distribution and abundance of Pecos pupfish before 1950. It inhabits shallow ground water or springs associated with sinks and marsh habitat. The pupfish is present on BLNWR and Bottomless Lakes State Park areas, and it may enter the Pecos River from connected waterways.	--	T	Terrestrial/ flood plain ecosystem	No
Gray redhorse (sucker)	*Scartomyzon congestum*	The gray redhorse dwells in clear-to-moderately turbid, warm, sluggish, low-gradient streams. It occupies medium-to-large pools, with cobble, gravel, silt, or sand bottoms. At present, it is only found downstream from Brantley Dam in the Pecos River and in the lower reaches of the Black River.	--	T	Riverine ecosystems	No
Mexican tetra	*Astyanax mexicanus*	This species is associated with pool and backwater habitats in clear flowing water over gravel bottoms. It is known to occur in the Pecos River between Sumner Dam and Brantley Reservoir and on BLNWR. It also occurs at some stream and spring habitats off the Pecos River channel.	--	T	Riverine ecosystem	No
Greenthroat darter	*Etheostoma lepidum*	This species is associated with streams and small rivers having clear water, aquatic vegetation, and gravel-to-cobble substrates. It inhabits swift-flowing streams and springs, especially vegetated riffle areas with gravel and rubble substrates. The species is native to the Pecos River and occurs in the study area at BLNWR, Pecos River between Brantley Dam and Avalon Reservoir, including the Black River.	SC	T	Riverine ecosystem	No
Bigscale logperch	*Percina macrolepida*	This species is located in streams and rivers with deep, non-turbulent, fast flows over cobble substrate. It is also found within impoundments. It is documented in the Pecos River between Santa Rosa Dam and Sumner Lake and in the area of Carlsbad and the Black River.	--	T	Riverine ecosystem	No
		Herpetiles				
Western river cooter	*Pseudemys gorzugi*	This species prefers streams with slow-to-moderate current, firm bottoms, and abundant aquatic vegetation. It also inhabits stock tanks, ponds, large ditches, and even brackish tidal marshes. It is confined to the Pecos River drainage, including the Pecos, Black, and Delaware Rivers down stream from Brantley Dam.	--	T	Terrestrial/ flood plain ecosystems	No
Plainbelly water snake	*Nerodia erthrogaster*	This species inhabits backwaters, pools in wet woodlands, rivers, ponds, sloughs, lakes, dams, and any waterways. It is active from April to October and begins breeding soon after emergence. Its presence is known only from the lower Pecos Valley area, including along the Black and Delaware Rivers.	--	E	Terrestrial/ flood plain ecosystems	No

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Western ribbon snake	*Thamnophis proximus*	This species is found along the margins of water bodies, including rivers, streams, springs, stock tanks, and irrigation canals. It prefers areas that are open and sandy, associated more with brush than forest. It is known to occur in abundance at BLNWR.	--	T	Terrestrial/ flood plain ecosystems	No
Blotched water snake	*Nerodia erythrogaster transversa*	This is a highly aquatic species; it swims and dives with ease and seeks its prey in water. It is confined to areas of permanent water in New Mexico. It is known to occur only from the lower Pecos Valley area, including along the Black and Delaware Rivers.	--	E	Terrestrial/ flood plain ecosystems	No
		Birds				
Northern aplomado falcon	*Falco femoralis septentrionalis*	This falcon is associated with open desert grasslands in scattered yuccas, mesquite, and other shrub or forested borders. The species typically nests in April and May in shrubs and trees. The last nesting pair was reported near Deming, New Mexico, in 2002.	E	--	Terrestrial ecosystem	No
Bald eagle	*Haliaeetus leucocephalus*	Bald eagles usually overwinter in the study area from October to April. The density of this species depends on prey, suitable perch and roost sites, weather conditions, and, sometimes, lack of human disturbance. Individuals are generally found from the headwaters of the Pecos River to just downstream from Fort Sumner.	T	--	Terrestrial ecosystem	No
Interior least tern	*Sterna antillarum athalassos*	See narrative.	E	E	Terrestrial, special status species resources	Yes
Mexican spotted owl	*Strix occidentalis lucida*	This species inhabits mountains and canyons in dense, multistoried forests with close canopies. It nests in mixed-conifer forests, typically in April. The Mexican spotted owl broods less than three young. There are no reported sightings within study area.	T	--	Terrestrial ecosystem	No
Piping plover	*Charadrius melodus circumcinctus*	This species is found on beaches with wide, sandy, cobbly material near open water. The species is sensitive to human disturbance. It is rare in New Mexico; it was last reported in 1995.	T	E	Terrestrial ecosystem	No
Common ground dove	*Columbina passerina pallescens*	This species inhabits lowland riparian and marshy areas including cultivated and abandoned fields, gardens, citrus groves, and pine and scrub oak woods. It is rare in New Mexico; the last nest sighted in New Mexico was prior to 1990.	--	E	Terrestrial ecosystem	No

Table 3.8 Special status species list, including Federal endangered species - status of wildlife and plants listed within the study area: T = threatened, E = endangered, P = proposed, CH = critical habitat, SC = species of concern

Common name	Scientific name	Life requisite	FWS Status	NM Status	Resource area coverage	Further analysis
Brown pelican	*Pelecanus occidentalis*	This species is transient and strictly coastal. Vagrants or misdirected juveniles have been spotted in New Mexico. It inhabits shallow water estuarine areas or offshore sandbars. It nests on the ground or on slightly elevated platforms.	--	E	Terrestrial ecosystem	No
Mammals						
Black-footed ferret	*Mustela nigripes*	This species was once common in New Mexico, but it is now extirpated. Reported sightings throughout New Mexico may have been a long-tailed weasel subspecies. The black-footed ferret is closely associated with prairie dog communities, which are also rare in New Mexico. There are no recent records of the black-footed ferret in the Pecos River basin.	E	--	Terrestrial ecosystem	No
Least shrew	*Cryptotis parva*	This species is less than 3 inches long and lives in forested areas and weedy fields. The species burrows, making nests out of leaves and grasses. It may have up to three litters per year with up to nine young per litter. It is known to occur at BLNWR.	--	T	Terrestrial ecosystem	No

6.6 Critical Habitat Occurring Within the Study Area

Two sections of the Pecos River within the study area are designated critical habitat for the Pecos bluntnose shiner: (1) an approximately 64-mile section south of Fort Sumner in DeBaca and Chaves Counties and (2) an approximately 37-mile section near the cities of Hagerman and Artesia (Service, 1987).

Critical Habitat and ESA

Critical habitat under ESA:

- Within the **geographic area** occupied by a species as well as specific areas outside the occupied geographic area that are essential
- Contains **physical or biological features** essential to conservation of the species;
- May require **special management considerations and protection.**

Under ESA, Federal agency actions may not result in the destruction of habitat or adverse modification of designated critical habitat or habitat proposed for such designation.

Constituent elements identified for this critical habitat include permanent water, a main river channel habitat with sand substrate, and a low-velocity flow.

Critical habitat has been proposed for designation for four invertebrate species (*Pecos assiminea* snail, Noel's amphipod, Roswell springsnail, and Koster's springsnail) known to occur in some nonriverine aquatic habitats within the general study area (Service, 2002a). Proposed critical habitat for these species includes 1,127 acres of BLNWR. Primary constituent elements of critical habitat for these four species have been identified as permanent, flowing, unpolluted, fresh to moderately saline water; slow to moderate velocities of water over substrates ranging from deep organic silts to limestone cobble and gypsum substrates; presence of algae, submerged vegetation, and detritus in the substrata; water temperatures in the approximate range of 10 to 20 degrees Celsius (50 to 68 °F), with natural diurnal and seasonal variation slightly above and below that range. In addition to these primary constituent elements, *Pecos assiminea* proposed critical habitat has one additional element: moist soil at stream or spring-run margins with vegetation growing in or adapted to an aquatic or very wet environment (e.g., salt grass or sedges).

The indicators used to evaluate the riverine aquatic ecosystem also were used to evaluate the effects of the alternatives on the Pecos bluntnose shiner critical habitat. These indicators are appropriate because the critical habitat is located in a river section of the Pecos River system and numerous researchers (Hatch et al., 1995; Hoagstrom, 2003; and Kehmeier et al., 2004) identified frequency, extent and duration of peak and intermittency to be important indicators for Pecos bluntnose shiner survival.

7. Regional Economy

7.1 Introduction

The following indicators were selected to evaluate impacts on the regional economy:

- Change in value of regional output produced in the study area
- Change in regional income
- Change in regional employment
- Change in farm acreage

These indicators and the reasons for their selection are discussed in detail in chapter 4. To provide the context for these indicators, this section describes the following aspects of the regional economy:

- Population
- Education
- Total personal and per capita income
- Earnings by industry
- Employment/unemployment
- Poverty
- Value of agricultural production
- Agricultural acreage

Appendix 5, Estimating Regional Economic Impacts, provides additional information.

7.2 Impact Area

The study area (proceeding downstream) includes the New Mexico counties of Guadalupe, De Baca, Chaves, and Eddy (map 3.3). The larger economic impact area includes Curry and Roosevelt Counties. These two counties include regionally important cities that have strong economic ties to the four counties in the study area.

The Pecos River study area begins in northwest Guadalupe County and bisects the four counties as it flows south to the Texas border (map 3.3). Eddy County borders the west Texas panhandle and includes the towns of Artesia and Carlsbad, the county seat. Carlsbad Caverns National Park is about 16 miles southwest of Carlsbad. Roswell is the county seat of Chaves County and is also a tourism center. Fort Sumner is the county seat of De Baca County, and Santa Rosa is the county seat of Guadalupe County. The largest city in Curry County is Clovis, and the largest city in Roosevelt County is Portales. Government, services, and retail trade are the largest industry sectors of the regional economy, with agriculture important in some parts of this area. The majority of irrigated land in the study area is located in Eddy County.

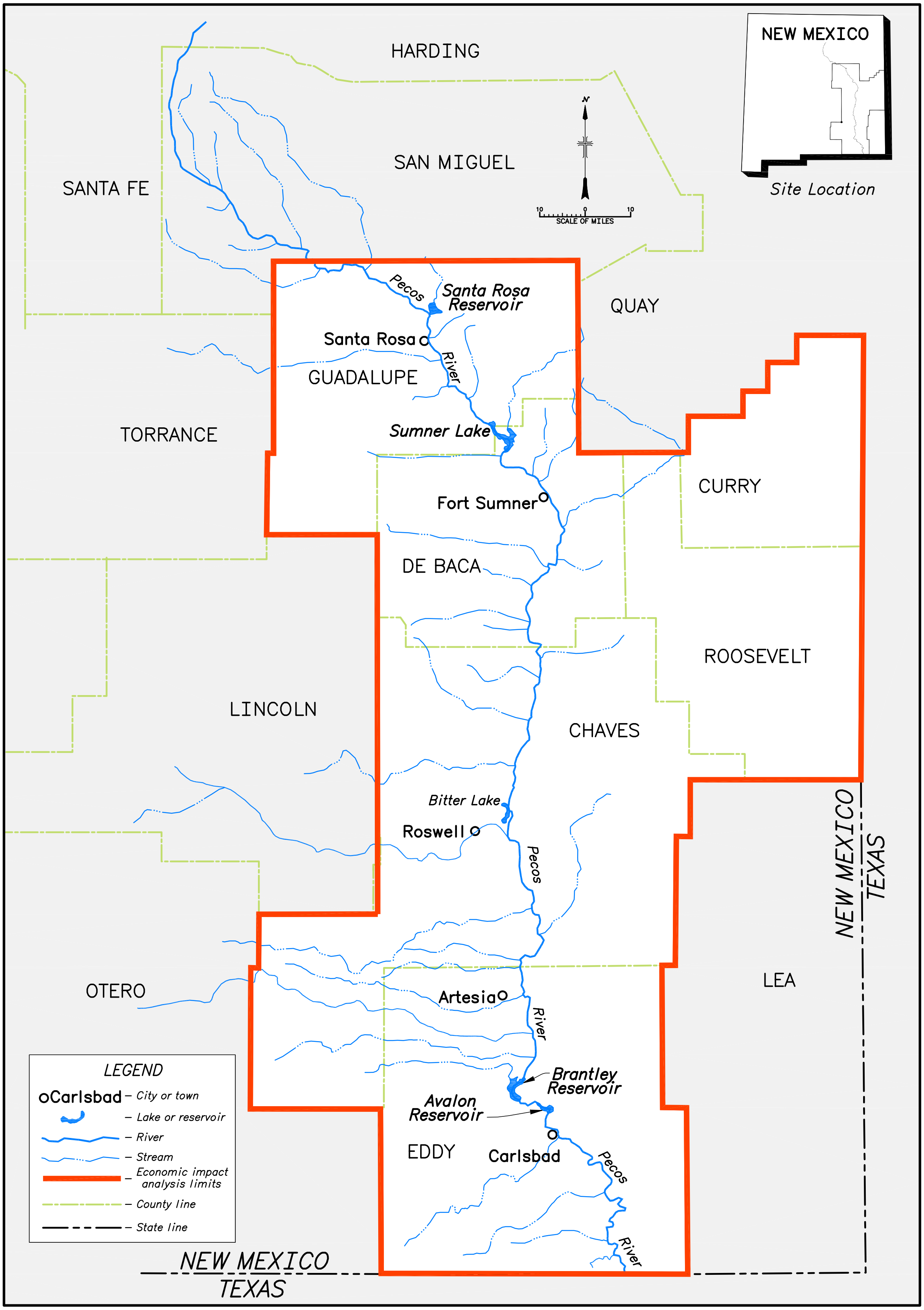
7.3 Population

The 2000 Census estimated a population of 183,022 in the impact area. The region is predominantly rural, with almost 57 percent of the population concentrated in the cities of Roswell, Carlsbad, and Clovis (table 3.9). Nearly 86 percent of the area's total population lives in Chaves, Eddy, and Curry Counties. More than one-half of each county's population resides in their respective county seats. De Baca County is the only county that experienced a population loss from 1990 to 2000 (0.5 percent). Chaves County's population increased approximately 6.1 percent from 1990 to 2000. However, the population of Chaves County actually decreased from 1995 to 2000. The same pattern of growth and decline applies to De Baca, Eddy, and Roosevelt Counties. Eddy County's population increased a net 6.3 percent from 1990 to 2000. Guadalupe County's population fell in 1995 and then rose for a net increase of 12.6 percent by 2000. The regional population increased by 11,251 people for a net 6.5 percent gain for the decade. During this same time period, the State of New Mexico's population increased by more than 20 percent.

Table 3.9 Population of the study area (1990-2000)

County/City/State	1990	1995	2000
Chaves County	57,849	61,539	61,382
Roswell	44,654	47,048	45,293
Curry County	42,207	47,464	45,044
Clovis	30,954	35,150	32,667
De Baca County	2,252	2,355	2,240
Fort Sumner	1,269	1,338	1,249
Eddy County	48,605	52,889	51,658
Carlsbad	24,952	26,822	25,625
Artesia	10,610	11,441	10,692
Guadalupe County	4,156	4,125	4,680
Santa Rosa	2,303	2,295	2,744
Roosevelt County	16,702	18,615	18,018
Portales	10,690	11,444	11,131
Study area counties	171,771	186,987	183,022
New Mexico	1,515,069	1,682,417	1,819,046

Sources: U.S. Census Bureau, 2000.
Bureau of Business and Economic Research, University of New Mexico, 2004.



Map 3.3 Economic impact analysis area

Table 3.10 presents population projections from the New Mexico Bureau of Business and Economic Research for the impact area and New Mexico. As shown, only the population growth rate for Guadalupe County is projected to keep pace with the State growth rate through 2010. The projected growth rates of the other counties are less than one-half that of the State's. From 2000 to 2030, none of the population growth rates of the counties are projected to keep pace with the State's. The percentage change in projected population from 2000 to 2010 and 2000 to 2030 is also shown in figure 3.5.

Table 3.10 Population projections for the study area (2010-2030)

County/ State	2010	2020	2030	% change 2000 to 2010	% change 2000 to 2030
Chaves	64,864	67,591	69,251	5.7	12.8
Curry	46,973	48,190	48,168	4.3	6.9
De Baca	2,289	2,296	2,296	2.2	2.5
Eddy	55,274	58,514	61,066	7.0	18.2
Guadalupe	5,304	5,748	5,989	13.3	28.0
Roosevelt	20,197	22,159	23,773	12.1	31.9
New Mexico	2,112,986	2,383,116	2,626,553	16.2	44.4

Source: Bureau of Business and Economic Research, University of New Mexico, 2004.

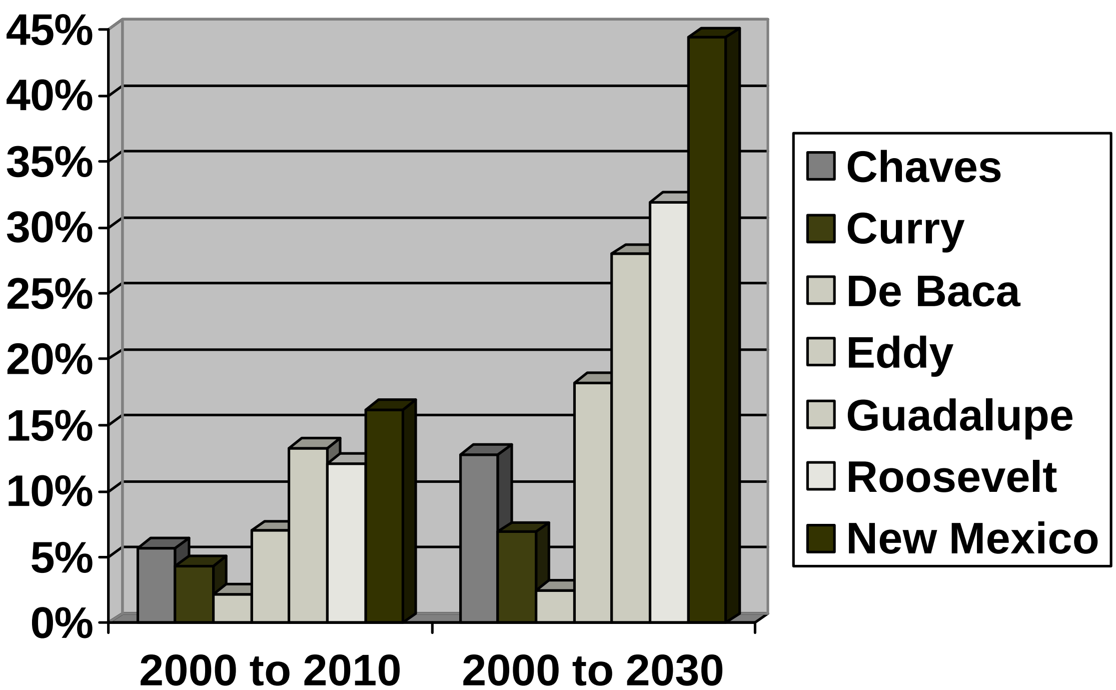


Figure 3.5 Percentage change in projected population.

7.4 Education

Table 3.11 presents the level of education in the impact area, New Mexico, and the United States in 2000. The percentage of high school graduates for the counties in the study area is less than the State and national averages. The percentage of college graduates in New Mexico and the Nation was about 24 percent, while the percentage of college graduates in the study area counties ranged from 10.3 percent to 22.6 percent. Such figures can partially explain the lower incomes and higher than average rates of unemployment and poverty discussed in the following sections.

Table 3.11 Education level 2000 data (percent of total population 25 years and older)

Area	Less than high school graduate (%)	High school graduate or higher (%)	Bachelor's degree or higher (%)	Population 25 years and older
Chaves County	27.4	72.6	16.2	37,811
Curry County	21.6	78.4	15.3	26,403
De Baca County	27.6	72.4	16.3	1,584
Eddy County	25.0	75.0	13.5	32,572
Guadalupe County	31.6	68.4	10.3	3,099
Roosevelt County	24.8	75.2	22.6	10,245
New Mexico	21.2	78.8	23.4	1,134,801
United States	19.6	80.4	24.4	182,211,639

Source: U.S. Census Bureau, 2000.

7.5 Total Personal and Per Capita Income

Table 3.12 presents the household or total personal incomes (TPI) and per capita personal incomes (PCPI) for the impact area, New Mexico, and the United States. Per capita income measures average income per person. In 2002, New Mexico’s TPI was $45.9 billion, accounting for about 0.5 percent of the United States’ TPI. Chaves, Curry, and Eddy Counties each had TPIs of more than $1 billion in 2002. De Baca, Guadalupe, and Roosevelt Counties each had relatively small TPIs compared to the other counties in the study area. Figure 3.6 shows a comparison of 2002 per capita income for the six study area counties, all of New Mexico, and the United States.

Table 3.12 Total personal income and per capita income

Area	1989 total personal income ($)	2002 total personal income ($)	1989 per capita personal income ($)	2002 per capita personal income ($)
Chaves County	778,247,000	1,366,968,000	13,628	22,727
Curry County	580,446,000	1,077,395,000	13,724	23,984
De Baca County	27,107,000	43,400,000	11,978	20,299

Table 3.12 Total personal income and per capita income

Area	1989 total personal income ($)	2002 total personal income ($)	1989 per capita personal income ($)	2002 per capita personal income ($)
Eddy County	666,959,000	1,218,202,000	13,894	23,763
Guadalupe County	41,057,000	65,749,000	9,651	14,415
Roosevelt County	207,074,000	428,834,000	12,572	23,792
New Mexico	21,172,658,000	45,974,027,000	14,078	24,823
United States	4,571,133,000,000	8,900,007,000,000	18,520	30,906

Source: Bureau of Economic Analysis, 2004; U.S. Census Bureau, 2004.

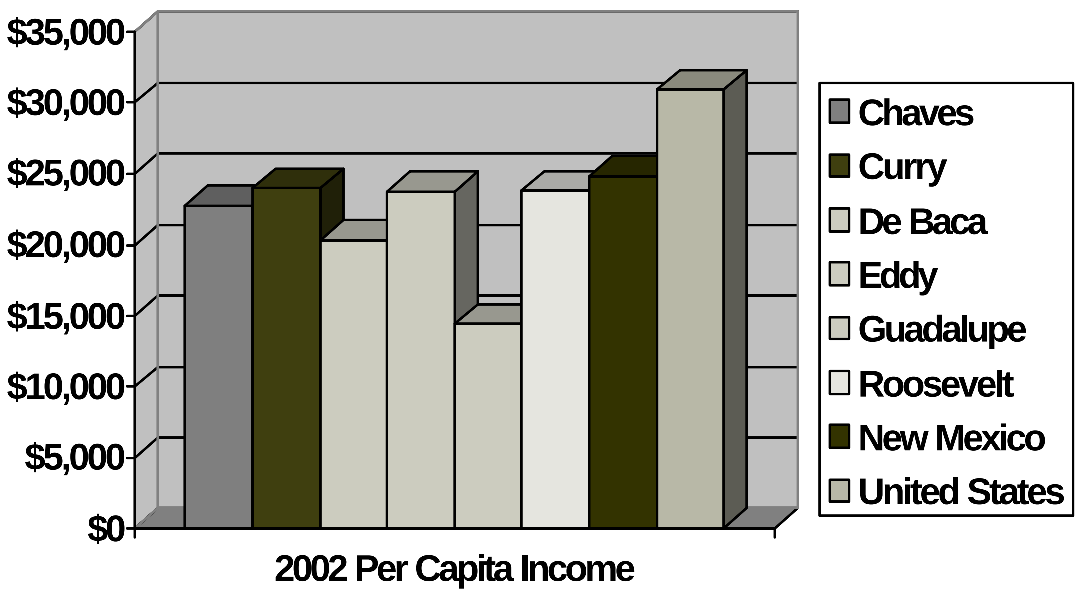


Figure 3.6 2002 per capita income in study area.

New Mexico's 2002 PCPI of about $24,823 was about 80 percent of the national average (nearly $30,906) and ranked New Mexico 46th in the country, just above Montana. The PCPI of each Chaves, De Baca, and Guadalupe Counties was much lower than the State and national averages in both 1989 and 2002. In 2002, the PCPI of Chaves, Curry, Eddy, and Roosevelt Counties was better than the PCPI of the other two counties; however, their PCPIs were less than the State PCPI and the national PCPI. De Baca County's 2002 PCPI was only 66 percent of the national average. Guadalupe County's 2002 PCPI was only 47 percent of the national average. These below-average PCPIs for the six counties continue the pattern observed in 1989. In a State that is near the bottom, nationally, the affected region even falls below the State average. These data indicate that residents in the six-county region are much less financially prosperous than the average individual in New Mexico and the Nation.

7.6 Earnings

Agriculture, government (all levels), services, and retail trade were the most important industry sectors in Chaves, Curry, De Baca, and Roosevelt Counties. These sectors accounted for at least 60 percent of total earnings in 2000 (table 3.13). Agriculture is considerably more important in De Baca and Roosevelt Counties than in the State as a whole. For New Mexico, services, closely followed by government, and, more distantly, by retail trade, accounted for more than one-half of the earnings. Mining, services, government, and transportation and public utilities were all in double figures in terms of earnings for Eddy County. The government sector accounted for about 44 percent of earnings in Curry County and 35 percent of the earnings in De Baca County. Some information is confidential because there are so many firms that it would be possible to estimate earnings for individual firms from the aggregated data. To protect privacy, these data are not presented in the Bureau of Economic Analysis tables.

Table 3.13 Percentage of total earnings by industry (2000)

Industry sector	Chaves County	Curry County	De Baca County	Eddy County	Guadalupe County	Roosevelt County	New Mexico
Farm	12.9	7.6	16.4	2.6	negative earnings	28.3	1.7
Agriculture services, forestry, fishing, and other	2.0	N/A	(D)	0.5	(D)	1.1	0.7
Mining	6.8	N/A	0.8	21.6	0.4	0.9	3.3
Construction	4.8	3.4	6.9	5.9	20.3	4.0	6.5
Manufacturing	11.0	1.8	2.7	6.2	(D)	3.6	7.6
Transportation and public utilities	4.2	11.6	(D)	12.9	24.4	9.7	6.2
Wholesale trade	3.5	2.7	(D)	2.7	(D)	2.2	4.0
Retail trade	11.3	10.4	11.7	9.0	16.3	9.5	10.4
Finance, insurance, real estate	3.6	2.9	2.7	3.0	(D)	1.9	5.2
Services	18.4	14.3	6.9	17.8	12.8	9.7	26.4
Government (Federal, State, local)	21.5	43.7	35.0	17.9	29.6	29.0	27.0
Other	NA	1.6	NA	NA	NA	NA	NA
Total earnings in 2000 ($)	777,479,000	656,193,000	20,955,000	767,881,000	44,057,000	201,686,000	29,196,377,000

(D) = not shown to avoid disclosure of confidential information, but the estimates for this item are included in the totals.
Source: Bureau of Economic Analysis, December 2001.

7.7 Employment/Unemployment

While agriculture provided a large portion of earned income in Chaves County, this sector accounted for less than 8 percent of the jobs in the county in 1999. Government (all levels), services, and retail trade provided more than 6 out of 10 of the total positions in the county. Agriculture was the most important source of jobs in De Baca County (nearly 3 out of 10 employment opportunities). More than 50 percent of all jobs were in the government, services, and retail trade industrial sectors. Farming employed 1.5 of every 10 workers in Guadalupe County. However, retail trade, the primary employer in Guadalupe County, employed 3 of every 10 workers. Services and government each employed approximately 2 of every 10 workers. Agriculture is a relatively important employer in the two sparsely populated counties in the affected area. For Chaves and Eddy Counties, as well as for New Mexico as a whole, agriculture is a much less important employer.

The pattern of unemployment has varied by county (table 3.14). Unemployment in New Mexico has been consistently higher than the national average. Guadalupe County has been hardest hit, with double-digit unemployment throughout the 1990s. The least populated county, De Baca, had consistently lower unemployment than the State or the Nation during this same decade. Since 1990, Eddy and Guadalupe Counties have had higher unemployment rates than the State and Nation. In 2003, Chaves, De Baca, Eddy, and Guadalupe Counties each had an unemployment rate higher than the State and national averages.

Table 3.14 Unemployment for selected years

Area	1990 (%)	1995 (%)	2000 (%)	2003 (%)
Chaves County	5.5	8.0	6.3	8.6
Curry County	5.8	5.2	3.9	3.9
De Baca County	5.0	3.0	4.5	8.7
Eddy County	6.6	7.7	6.7	6.8
Guadalupe County	11.8	11.0	8.4	8.0
Roosevelt County	6.2	5.3	3.4	3.5
New Mexico	6.5	6.3	5.0	6.4
United States	5.6	5.6	4.0	6.0

Source: Bureau of Labor Statistics, 2001, 2002.

7.8 Poverty

Poverty has been a problem for the region and New Mexico for a long time. Table 3.15 presents estimates of people of all ages in poverty for the impact area, New Mexico, and United States for selected years.

Poverty status is measured by the U.S. Census Bureau on a family basis. In other words, either everyone in the family is considered to be in poverty or no one in the family is in poverty. The family characteristics used to determine poverty status are the number of people, number of related children under 18, and whether the primary householder is over age 65. An income threshold is determined given a particular family's set of characteristics; if that family's income is below that threshold, the family is considered to be in poverty.

Table 3.15 Percentage estimates for people of all ages in poverty (selected years)

Area	1989 (%)	1999 (%)
Chaves County	22.4	21.3
Curry County	19.2	19.0
De Baca County	21.9	17.7
Eddy County	20.4	17.2
Guadalupe County	38.5	21.6
Roosevelt County	26.9	22.7
New Mexico	20.6	18.4
United States	13.1	12.4

Source: U.S. Census Bureau, 2004.

For example, the poverty threshold in 1999 for a four-person family with two children under the age of 18, and the householder is under age 65, is $16,895 per year. The threshold for the same family in 1989 was $12,575, and the threshold in 2004 was $19,157. The threshold changes from year to year as a result of changes in the cost of living. As table 3.15 shows, each county in the impact area has had a much higher poverty rate than the national average for all selected years. Poverty rates for the six study area counties, New Mexico, and United States are compared graphically in figure 3.7.

Table 3.16 presents additional income, educational attainment, population age, occupation, and unemployment information for selected counties and towns.

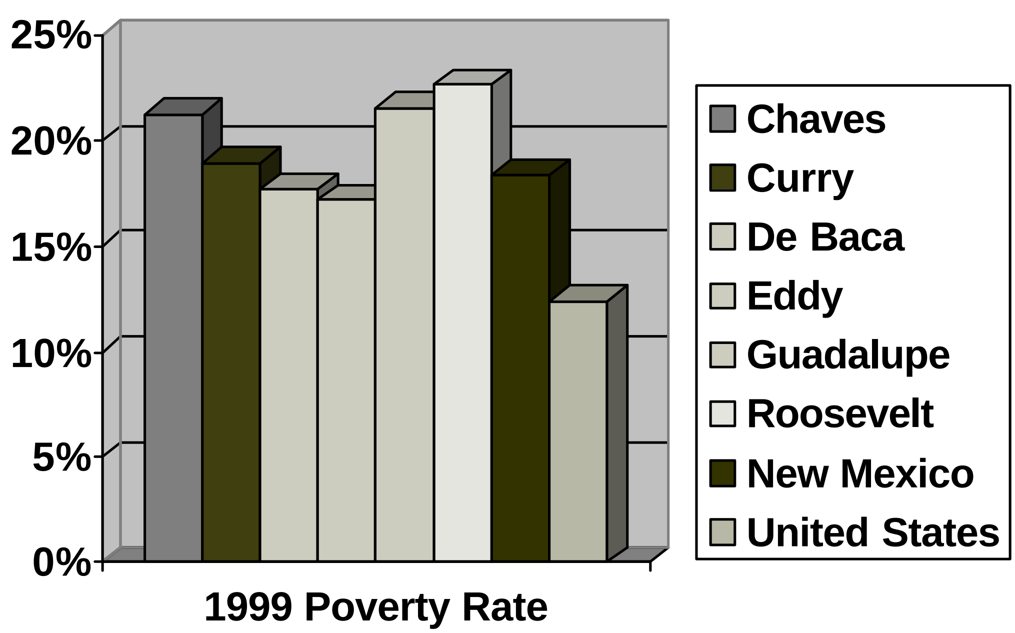


Figure 3.7 Poverty rates in study area counties.

Table 3.16 Socioeconomic data for counties and primary cities and towns in the affected region

2000 data	Eddy County	Artesia	Carlsbad	De Baca County	Fort Sumner	Chaves County	Roswell	Guada-lupe County	Santa Rosa
Population	51,658	10,692	25,625	2,240	1,249	61,382	45,293	4,680	2,744
Per capita income (1999 $)	15,823	13,911	16,496	14,065	13,327	14,990	14,589	11,241	11,168
Median household income (1999 $)	31,998	29,529	30,658	25,441	19,583	28,513	27,252	24,783	25,085
High school graduates or higher (%)	75.0	70.1	77.4	72.3	63.0	72.6	73.8	68.3	71.3
College graduates or higher (%)	13.5	12.1	14.5	16.2	11.8	16.2	16.9	10.3	6.7
Age of population (%)									
0 to 17 years	28.9	30.3	27.1	24.1	22.4	29.1	28.5	24.4	23.1
18 to 64 years	56.4	54.6	55.8	50.5	46.3	56.2	55.5	61.8	64.9
65 years and over	14.7	15.1	17.1	25.4	31.3	14.7	16.0	13.8	12.0
Median age (years)	36.4	35.1	37.70	43.8	45.6	35.2	35.2	37.5	36.3
Occupation (%)									
Managerial/professional	25.1	23.8	25.2	32.7	21.2	27.6	27.3	26.3	22.4
Services	17.1	15.2	19.9	17.1	26.2	16.2	17.4	30.1	35.5
Sales and office	24.9	25.3	26.0	19.3	22.2	24.9	26.3	19.3	21.6
Farming/forestry/ fisheries	2.1	3.1	0.7	6.8	4.0	4.4	2.6	1.0	0.4
Construction, extraction, and maintenance	16.4	14.7	15.5	12.8	13.6	11.1	10.7	13.1	10.7
Production, transportation, and material moving	14.4	18.0	12.5	11.3	12.8	15.8	15.7	10.1	9.3
Unemployment rate	3.9	3.6	3.8	2.9	2.5	5.0	5.2	3.6	2.9

Source: U.S. Census Bureau, 2000.

7.9 Value of Agricultural Production

The six-county impact area contained about 19.6 percent of the farms (2,988 farms) and nearly 20 percent (8,987,074 acres) of the total farm acreage (irrigated and nonirrigated) in New Mexico in 2002 (table 3.17). The 277,337 irrigated acres in the six-county area represent slightly more than 42 percent of the total irrigated cropland in New Mexico. Average-size farms in the six counties range from about 1,354 acres in Curry County to about 7,500 acres in De Baca County.

The median-size farm in each county, except Eddy County, was considerably larger than the median size of 160 acres for the State. In each county, the predominant farm size was 1,000 acres or more. Most of the harvested cropland was on farms with 260 acres or more, emphasizing the importance of large farms for agricultural production.

In 2002, farmers in the six-county region sold $815 million of agricultural products. Livestock production is the predominant agricultural activity in the region, accounting for 86.5 percent of the value of agricultural products sold in 2002 ($704,653,000) for the six-county region (table 3.18). In Guadalupe County, livestock production accounted for nearly 97 percent of the value of agricultural marketing. Livestock production in Roosevelt, Curry, and Chaves Counties ranged from 87 to 89 percent of the value of agricultural products sold. Crop production is most important in Eddy and De Baca Counties, accounting for 24 to 30 percent of the value of agricultural products sold. It should be noted that a large portion of the agricultural value in table 3.18 is not attributable to production that relies on irrigation water.

Table 3.17 Number of farms and acres (2002)

	Chaves County	Curry County	De Baca County	Eddy County	Guadalupe County	Roosevelt County
Farm (number)	604	677	188	510	208	804
Land in farms (acres)	2,515,660	916,320	1,409,434	1,183,073	1,461,766	1,500,821
Average size of farm (acres)	4,165	1,354	7,497	2,320	7,028	1,867
Median size of farm (acres)	335	490	700	161	1,200	432
Percent of harvested cropland: farm size 260 acres or more	89.6%	64.1%	N/A	88.9%	64.1%	97.7%
Percent of harvested cropland: farm size 500 acres or more	80.6%	61.6%	N/A	77.9%	47.3%	93.3%
Number of farms with harvested cropland	295	356	65	317	71	275
Harvested cropland (acres)	61,308	248,081	6,387	45,041	1,394	151,887
Irrigated acreage	59,316	88,717	6,307	43,332	1,142	78,523

N/A = not available.
Source: National Agricultural Statistics Service, 2002.

Table 3.18 Value of agricultural production (2002) in dollars

Area	Crops, including nursery and greenhouse crops	Livestock, poultry, and their products	Total market value of agricultural products sold	No. of farms	Average market value of agricultural products sold per farm
Chaves County	29,989,000	253,960,000	283,949,000	604	470,115
Curry County	26,561,000	206,039,000	232,601,000	677	343,576
De Baca County	3,598,000	11,643,000	15,241,000	188	81,069
Eddy County	24,798,000	57,413,000	82,211,000	510	161,198
Guadalupe County	344,000	10,141,000	10,485,000	208	50,407
Roosevelt County	24,627,000	165,457,000	190,083,000	804	236,422
New Mexico	397,257,000	1,302,773,000	1,700,030,000	15,170	112,065

Source: National Agricultural Statistics Service, 2002.

Farm production expenses represent a measure of the value of output demand directly tied to agricultural activity. Net cash returns from farm production measures net income generated by farming. These data are presented in table 3.19. Chaves, Curry, and Roosevelt Counties account for 86 percent of farm production expenses in the study area and 40 percent of the State total. Approximately 93 percent of the net cash return in the study area occurs in these three counties.

Approximately 39 percent of all New Mexico farms had net positive revenues in 2002. The percentage of farms with net positive revenues is higher than the State average for all of the study area counties except Eddy County. Gains and losses for all of the study area counties are shown in table 3.20. The farms used to estimate gains and losses in table 3.20 include livestock operations and operations with nonirrigated crops that do not represent a high level of water demand.

Table 3.19 Farm production expenses and net cash return (2002)

Area	Farm production expenses	Net cash return[1]	Net cash return per farm[1]
Chaves County	230,377,000	59,276,000	97,978
Curry County	206,114,000	43,911,000	64,861
De Baca County	13,335,000	2,381,000	12,731
Eddy County	75,696,000	7,987,000	15,630
Guadalupe County	9,705,000	1,372,000	6,627
Roosevelt County	160,738,000	42,108,000	52,569
New Mexico	1,500,021,000	294,688,000	19,373

[1] Net cash returns are equal to the total value of agricultural products sold, minus total production expenses. These figures include net cash return from agricultural sales, government payrolls, other farm-related income, direct sales, and Commodity Credit Corporation loans.
Source: National Agricultural Statistics Service, 2002.

Table 3.20 Farms with net gains and net losses (2002)

Area	Number of farms with net gains[1]	Average gain per farm ($)	Number of farms with net losses	Average loss per farm ($)[1]
Chaves County	304	212,582	301	(17,769)
Curry County	426	120,802	251	(30,083)
De Baca County	108	33,007	79	(14,987)
Eddy County	185	70,054	326	(15,255)
Guadalupe County	112	24,211	95	(14,103)
Roosevelt County	496	97,718	305	(20,855)
New Mexico	5,927	68,645	9,284	(12,082)

[1] Net gain refers to an operation where the value of products sold exceeds the costs of production, while a net loss occurs when the value of products sold is less than the costs of production.
Source: National Agricultural Statistics Service, 2002.

7.10 Municipal and Commercial Water Use

Municipal and commercial water use is closely tied to changes in population. Population projections for the affected area and the State are shown in table 3.10. Growth rates for the six counties are considerably below the averages for the entire State, although growth is expected to occur. This growth will translate into greater demands for municipal water. Annual average growth rates are presented in table 3.21. Future municipal and industrial water demand also could be affected by the establishment of future regional water supply systems. Improved water quality and/or reliability could result in greater household use and could attract industrial/business location in the future.

Table 3.21 New Mexico population projection annual growth rates, by county, as of July 1

County/State	2000-05	2005-10	2010-15	2015-20	2020-25	2025-30
Chaves County	0.59	0.49	0.44	0.38	0.28	0.20
Curry County	0.43	0.39	0.32	0.19	0.05	-0.06
De Baca County	0.26	0.17	0.03	0.03	-0.01	0.01
Eddy County	0.68	0.65	0.60	0.54	0.47	0.38
Guadalupe County	1.29	1.14	0.92	0.68	0.48	0.34
Roosevelt County	1.12	1.10	1.01	0.85	0.73	0.67
New Mexico	1.53	1.39	1.27	1.14	1.02	0.93

Source: Bureau of Business and Economic Research, University of New Mexico, 2004.

8. Recreation

8.1 Introduction

The following indicators were selected to evaluate recreation:

- Recreation visitation and associated expenditures at Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir

- Recreation along the Pecos River

These resource indicators are important because visitation is closely related to the development, operations, and maintenance of recreational facilities and to the expenditures (fiscal impacts) and economic value (benefits) of recreation. To provide a context for this indicator, this section describes each facility and its recreational uses. It then discusses current recreation visitation and associated expenditures.

8.2 Recreation Facilities

8.2.1 Santa Rosa Reservoir

In addition to its other purposes, Santa Rosa Reservoir, located on the Pecos River about 7 miles north of Santa Rosa, is a recreation use area. The Corps and the New Mexico State Division of Parks and Recreation share recreation management duties in this area. The State leases 551 acres from the Corps for Santa Rosa Reservoir State Park, which has facilities for boating, camping, fishing, hiking, picnicking, sailing, water-skiing, and wildlife viewing.

The Corps encourages fishing, hiking, and hunting on these lands. Backcountry access is by foot only. Fishing can be poor to excellent, depending on the water level; low water levels result in poor fishing success. Approximately 680 acres of land are managed by the Corps as wildlife habitat. Hunting is allowed on project lands, except within 300-yard “no shooting” zones around camping, recreational, and operational areas.

8.2.2 Sumner Lake

Sumner Lake, located on the Pecos River about 16 miles northwest of Fort Sumner, encompasses approximately 4,500 acres of water surface and 60 miles of shoreline. The New Mexico State Division of Parks and Recreation provides facilities for, and manages recreation at, Sumner Lake State Park.

Although Sumner Lake is primarily used for irrigation, recreation is also a beneficial use. Facilities are provided to support boating, camping, fishing, picnicking, sailing, water-skiing, and wildlife viewing. Visitor use during the summer is affected by extreme water levels above or below the conservation pool.

8.2.3 Brantley Reservoir

Brantley Reservoir is located on the Pecos River, 13 miles upstream of Carlsbad. The New Mexico State Division of Parks and Recreation manages recreation use at the reservoir through Brantley State Park The 3,400-acre reservoir and adjacent land provide access to and facilities for boating, camping, fishing, hiking, hunting, picnicking, water sports, and wildlife viewing.

Brantley Reservoir's importance as a water-based recreational resource is enhanced because of its location in the Chihuahuan Desert in southeastern New Mexico. Water levels fluctuate during the spring and summer because of (1) variations in releases to meet demands for irrigation by CID and (2) large variations in inflows that are primarily from block releases and monsoon season storm inflows. Water levels can fluctuate during the autumn, but generally not with as much deviation. Historic patterns of recreation use observed by Reclamation and New Mexico State Division of Parks and Recreation indicate that recreation use is primarily affected by extreme lake levels above or below the conservation pool during the spring and summer months.

Brantley Wildlife Area consists of 28,000 acres along the Pecos River and Brantley Reservoir. This area is located 15 miles north of Carlsbad and provides boating, camping, fishing, hunting, photography, trapping, and wildlife watching opportunities for the public.

8.2.4 Avalon Reservoir

Avalon Reservoir is located on the Pecos River, 3 miles north of Carlsbad. CID manages recreation under an agreement with Reclamation.

Recreational use of this reservoir is minimal, consisting mostly of day use shoreline fishing and some dispersed camping (Davis, 2002). Boating is not allowed, and there are no developed facilities to support recreation. CID does not collect or keep any records of visitor use at the reservoir. Because recreational use of the reservoir is low, there are few problems with vandalism or trash pickup.

8.2.5 Pecos River and Surrounding Area

The Pecos River from Sumner Dam to the headwaters of Brantley Reservoir is available (with limited access) for public recreation, depending upon the presence of water and rate of flow. Waterfowl hunting is popular along this reach of the river during late fall and winter.

Power Dam Lake is located one mile south of Santa Rosa and is leased by the city's department of game and fish. This 13-acre lake provides opportunities for fishing and picnicking. The water level is maintained at 38 acre-feet.

Bitter Lake National Wildlife Refuge provides more than 24,500 acres of varied habitat, including sinkholes, playa lakes, seeps, gypsum springs, alkaline wetlands, and the 9,620-acre Salt Creek Wilderness. It is an important part of the Central Flyway. This refuge is home to 350 species of birds, 57 mammal species, 50 reptile and amphibian species, and 24 fish species. It serves as the winter home for thousands of geese, lesser sandhill cranes, ducks, and other waterfowl. There is an 8-mile, self-guided auto tour and a developed wildlife viewing area. Wildlife watching and hunting are the primary recreational activities at the refuge.

The W.S. Huey Waterfowl Area encompasses 2,880 acres along both sides of the Pecos River. It is located about 6 miles east of Artesia and 5 miles north of U.S. Highway 82. This area was purchased by Reclamation to mitigate habitat changes caused by the Brantley Dam. Visitors can take a self-guided tour of the area, and waterfowl watching and upland bird hunting opportunities are offered. No boating, camping, or fishing is allowed.

Small watercraft and other flotation devices can be used on the upper reaches of the Pecos River in the spring if flows are sufficient. Fishing, however, appears to be the primary activity on the river. Fishing and other recreational activities depend on the availability of water, as well as public access. Public access below Sumner Dam is provided by the State park. Other public access is available at State and county highway bridges and across public land managed by the Bureau of Land Management (BLM). BLM does not have any developed recreation sites or river access sites along the Pecos River. The area of the river in which the greatest amount of recreational use takes place is likely directly downstream from Sumner Dam. The presence of the State park, with its camping and picnicking facilities, restrooms, and easy access, makes this a popular river recreation area.

8.3 Recreation Visitation and Associated Expenditures

A large portion of the water-oriented recreational facilities and use in the study area is associated with Santa Rosa Reservoir, Sumner Lake, and Brantley Reservoir. Streamside recreation occurs, mainly in the form of fishing, but the reservoirs are the primary water attractions in the region. Each reservoir has a State park on its shores, and these developed facilities provide additional access and encourage recreation use.

Table 3.22 presents the most recent annual visitor use at each of these reservoirs from 1999 through 2003. Most use occurs during the March through September recreation season.

Santa Rosa Reservoir State Park averaged more than 74,000 recreation visits from 1990 to 2001. Visitor use at Sumner Lake ranged from a low of less than 24,000 visits to a high of more than 127,000 visits, with an average of more than 82,000 visits each year.

Although visitation at Sumner Lake State Park has moderately decreased in recent times of drought, visitation fell drastically during 2002 and 2003. This reservoir was completely drained in 2002 for irrigation use. The lack of water and destruction of the fishery resulted in approximately 40,000 fewer visitors to Sumner Lake State Park in 2002 and an additional 40,000 fewer visitors in 2003. The 14-year average is just over 82,000 visits.

Table 3.22 Recreation use (visits per year) at State parks along the Pecos River (1999-2003)

Year	Santa Rosa Reservoir	Sumner Lake	Brantley Reservoir
1999	88,625	127,210	138,995
2000	85,823	104,285	131,192
2001	64,768	100,088	123,817
2002	50,572	61,000	97,029
2003	55,037	23,926	69,461
14-year average (1990-2003)	71,056	82,125	102,234

Source: New Mexico State Park and Recreation Division, 2002 and 2004.

Brantley Reservoir has averaged more than 102,000 visits each year. Brantley Reservoir also continued to experience low water conditions in 2002 and 2003 that substantially impeded recreational use. In 1997, Brantley State Park received more than 134,000 recreation visits, up 28 percent from 1994. Most visitors come to the park during the spring and summer (March through August) and are either local residents or from Texas.

Together, Santa Rosa, Sumner, and Brantley Reservoirs have averaged nearly 248,000 visits annually, which represent an important economic impact for the region. Table 3.23 presents expenditure data, by category, for fishing, hunting, and wildlife watching for New Mexico. The 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, conducted by the Service, only examined three activities. For the purposes of estimating recreation expenditures in the four-county area, it is assumed that expenditures for water contact activities (boating, swimming, and water-skiing) are most similar to expenditures for fishing. Camping, picnicking, sightseeing, and expenditures from other activities are assumed to be similar to those for wildlife watching (nonconsumptive activities). Total visitation is thus allocated as fishing (65 percent), hunting (10 percent), and wildlife watching (nonconsumptive use, 25 percent) to estimate recreation-related expenditures.

Table 3.24 presents the estimated recreation-based expenditures in the four-county region. Recreation at the three Pecos River reservoirs resulted in more than \$11 million in annual expenditures (in 2003 dollars).

In 2001, recreation use at Sumner Lake exceeded 100,000 visits. The estimated economic impact for expenditures for food and lodging, transportation, and other items related to recreation at the park is \$2.7 million. In 2003, visitation to the park dropped to about 24,000, as a result of continuing drought conditions and the draining of the lake in 2002 for irrigation use. The comparable expenditures (without adjusting for inflation and assuming the same expenditure patterns by visitors) for this lower visitation would have been about \$0.8 million, an adverse economic impact of nearly \$2 million. Visitors to parks located on reservoirs have adjusted to water levels fluctuating throughout the irrigation season;

however, when a lake is completely drained and its primary recreation resource is lost (the fishery), annual visitor use is drastically reduced until that lost resource is restored.

Table 3.23 Total and average per visitor day recreation expenditures for selected activities in New Mexico for 2001

Category	Fishing		Hunting		Wildlife watching	
	Total	Per day	Total	Per day	Total	Per day
Food and lodging	$35,924,000	$14.46	$25,697,000	$15.42	$92,938,000	$14.56
Transportation	29,764,000	11.98	18,916,000	11.35	52,514,000	8.23
Other	24,965,000	10.05	15,356,000	9.21	5,564,000	0.87
Equipment, etc.[1]	85,823,000	34.54	93,399,000	56.03	407,274,000	63.83
Total	$176,476,000	$71.02	$153,368,000	92.00	$558,290,000	$87.49

[1] Covers purchase of major equipment items that are durable goods (for example, boats, recreational vehicles, tents, binoculars, backpacks, etc.). These items are usually used on many separate trips and are not considered trip-specific purchases.

Source: Service and U.S. Census Bureau, 2001.

Table 3.24 Estimated annual trip-related recreation expenditures attributable to recreational use of the three Pecos River reservoirs (2003 $)

Category	Santa Rosa Reservoir	Sumner Lake	Brantley Reservoir
Food and lodging	$2,220,659	$1,242,083	$1,545,031
Transportation	1,576,907	935,228	1,163,332
Other	1,005,977	653,380	812,741
Total	$4,803,543	$2,830,691	$3,521,103

Source: NMDGF, 2002a.

Table 3.25 presents data for the Pecos River reaches. NMDGF manages three State wildlife areas located on the Pecos River. NMDGF regulates fishing and hunting and collects some visitor use data for recreation along the Pecos River. Angler days are estimated using a mail survey.

Although recreation visitation numbers are not available for the Pecos River between Sumner Lake and Brantley Reservoir, recreation use has been observed in the reach immediately downstream from Sumner Dam and within the BLM's Roswell and Carlsbad resource areas. As at the reservoirs, extremely high or low water levels affect the recreational use of the river.

BLNWR received an average of 39,500 visitors during the years 1999 through 2001.

Table 3.25 Estimated angler days for the Pecos River

Reach	License year		
	1997-98	1998-99	1999-2000
Santa Rosa Dam to Sumner Lake	6,194	7,807	8,838
Sumner Dam to Roswell	7,540	8,045	14,516
Roswell to Brantley Reservoir	28,697	28,949	20,917
Brantley Dam to Texas border	51,987	78,648	82,612
Total for the Pecos River	94,418	123,449	126,883

Source: NMDGF, 2002a

9. Cultural Resources

9.1 Introduction

The following indicators were selected to evaluate changes to cultural resources:

- The known presence or potential for cultural resources that may be eligible for listing on the *National Register of Historic Places* (NRHP) or locations that are important to Native American or other traditional communities in areas affected by the proposed action

- Riverflow and reservoir storage levels and fluctuation resulting from changes in water operations where there is a potential for directly disturbing resources, increasing access to resources, or exposing submerged resources

- Ground-disturbing activities such as drilling, trenching, grading, or construction where resources may be present; modifications to historic water retention or conveyance infrastructure; or loss or abandonment of historic structures associated with water acquisition options

These resource indicators parallel the requirements of the National Historic Preservation Act of 1966, as amended (NHPA), and other laws, regulations, and Executive orders to take in to account the effects of government actions on significant cultural resources.

In this section, cultural resources are defined and the Area of Potential Effect (APE) is described. (The APE is the physical area where the alternatives and water acquisition options may affect cultural resources.) The regulatory background and data collection and consultation activities are outlined, followed by a summary of known cultural resources.

9.2 Definitions and Area of Potential Effect

Cultural resources are locations of human activity, occupation, or use. They include expressions of human culture and history in the physical environment, such as prehistoric or historic archaeological sites, buildings, structures, objects, districts, or other places. Cultural resources can be natural features, plants, and animals that are considered to be important to a culture, subculture, or community. Cultural resources also include traditional lifeways and practices. Identified cultural resources along the Pecos River reflect the long prehistoric use of the area; attempts to regulate riverflows and irrigate crops; historic era settlement, farming, and grazing activities; and the continuity of Hispanic and Native American cultural traditions and practices.

Cultural resources have been organized into prehistoric resources, historic resources, and traditional cultural properties. These types are not exclusive, and a single cultural resource may have multiple components.

Prehistoric cultural resources refer to any material remains, structures, and items used or modified by people before Europeans established a presence in New Mexico in the early 17th century. Examples of prehistoric cultural resources in the region include room blocks, rock art, water control features, campsites, and scatters of prehistoric artifacts, such as pottery sherds or stone tool-making debris.

Historic cultural resources include material remains and the landscape alterations that have occurred since the arrival of Europeans in the region. Examples include ranching and agricultural features, water control and conveyance features, railroad and road corridors, structural ruins, and scatters of historic artifacts.

Traditional cultural properties are places associated with the cultural practices or beliefs of a living community. These sites are rooted in the community's history and are important in maintaining cultural identity. Examples of traditional cultural properties for Native American and Hispanic communities include natural landscape features, places used for ceremonies and worship, places where plants are gathered to be used in traditional medicines and ceremonies, places where artisan materials are found, and places and features of traditional subsistence systems, such as community-maintained irrigation systems and traditionally used fields, grazing areas, and firewood-gathering sites.

The cultural setting, which is included in the supporting cultural resource technical report (Tetra Tech, Inc., 2004a), includes information from the broad study area to provide background on the regional resource base and to supplement the limited synthesis of cultural resource information from the river corridor. The APE for cultural resources for the proposed changes in water operations includes the existing water channels or active flood zones of the Pecos River corridor and the various reservoir storage pools.

Other actions contemplated in the DEIS include options for acquiring and developing water sources and the consideration of conservation and habitat restoration measures. Some of these actions could affect cultural resources but are not sufficiently defined to determine an APE. These actions may result in construction, ground disturbance, changes to water storage and delivery infrastructure, and land abandonment. Additional cultural resource identification, evaluation, and effects determinations would be required as these undertakings and their locations are defined.

9.3 Regulatory Background

The identification of cultural resources and Federal agency responsibilities regarding cultural resources are addressed by a number of laws, regulations, Executive orders, programmatic agreements, and other requirements listed in the cultural resource technical report (Tetra Tech, Inc., 2004a). The principal Federal law addressing cultural resources is NHPA and its implementing regulations (36 Code of Federal Regulations [CFR] 800). Section 106 of NHPA outlines the process for identifying and evaluating historic properties; for assessing the effects of Federal actions on historic properties; and for consulting to avoid, reduce, or

> ### Cultural Resources Compliance
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> **The National Historic Preservation Act (NHPA)** is the principal Federal law addressing cultural resources. Its implementing regulations at 36 CFR 800 require Federal agencies to review actions that are federally funded, licensed, or occur on Federal or tribal land that may affect a property eligible for listing on the **National Register of Historic Places (NRHP).** The NRHP is a federally maintained register of districts, sites, buildings, structures, architecture, archeology, and traditional cultural places. Properties that meet the eligibility criteria are known as historic properties. Formal nomination and listing on the NRHP is not necessary for consideration under NHPA.
>
> The **section 106 process** is procedure that Federal agencies follow to identify, evaluate, assess effects, and resolve adverse effects of its actions. These actions are conducted in consultation with the **State Historic Preservation Officer (SHPO),** tribes, and other parties. The Identification and evaluation of cultural resources is accomplished by first determining an **Area of Potential Effect (APE)**. The APE is the geographic area within which a project may indirectly or directly cause changes in the character or use of historic properties, if present. Additional studies (for example, archaeological surveys or architectural inventories) are conducted to determine whether there are historic properties within the APE that may be eligible for listing on the NRHP. If historic properties are present, the potential effects of the action are assessed. If there is an adverse effect, the agency works to resolve adverse effects in consultation with the SHPO, tribes, and other consulting parties. Adverse effects are most often resolved by mutual agreement. The **Advisory Council on Historic Preservation (ACHP)** may participate in controversial or precedent-setting situations. ACHP is an independent Federal agency that oversees the section 106 process and has legal responsibility to balance historic preservation concerns with Federal project requirements.

minimize adverse effects. The term "historic properties" refers to cultural resources that meet specific criteria for eligibility for listing on NRHP. This process does not require preservation of historic properties, but it does ensure that the decisions of Federal agencies concerning the treatment of these places result from meaningful consideration of cultural and historic values and the options available to protect the properties.

NHPA is triggered when historic properties may be affected by a federally funded or licensed action or by actions on Federal or tribal land. The identification and evaluation of cultural resources for NRHP eligibility is the responsibility of the lead Federal agency (in this case, Reclamation), with the concurrence of the New Mexico State Historic Preservation Officer (SHPO). The section 106 process to identify and evaluate resources and to address any adverse effects is usually conducted in phases. First, the project APE is determined and the type and level of the identification efforts are defined with consulting parties. Methods used to identify the presence of cultural resources and to determine significance vary among the resource types. When identified, cultural resources are evaluated to determine whether the resource is eligible for listing on the NRHP or is of traditional importance to contemporary communities. Resources that are already listed, that are determined eligible for listing, or that are undetermined are afforded a level of consideration under the section 106 process. Undetermined resources are those for which eligibility cannot be determined, based on current knowledge of the resource and where further work is needed to make an evaluation. Compliance with these and other provisions of the NHPA is required as a separate process that contributes to the analysis of the proposed alternatives and options in this DEIS.

9.4 Data Collection and Consultation

The water channels and active flood zones of the Pecos River corridor and the reservoirs were reviewed for the presence of previously recorded cultural resources and for cultural resources surveys. A 200-meter-wide buffer zone centered on the river corridor was researched on the Internet and in person through the Archaeological Records Management System (ARMS) of the New Mexico Historic Preservation Division in Santa Fe. (The records maintained by ARMS are accessible only to qualified researchers who register annually with the Historic Preservation Division.) A buffer zone of 100 meters around each of the reservoirs was also researched. No field work was conducted. Cultural resources and cultural resources surveys referenced are from previous compliance projects or resources discovered and recorded during the course of other activities. Cultural resource locations are generally confidential, except in the case of historic structures, and are not published, in order to prevent disturbance and unauthorized collecting. In addition to reviewing ARMS records, other data sources were inspected for identifying cultural resources, including NRHP and the New Mexico State *Register*.

The identification and significance of traditional cultural properties, traditional use areas, and sacred sites are determined primarily by consulting with the affected contemporary communities. In November 2002, Reclamation contacted representatives of tribal groups with historic ties to the Pecos River basin or tribal groups who had expressed interest in Reclamation activities. Reclamation contacted these groups on a government-to-government basis to identify any concerns about the potential effects of future Reclamation activities connected with this DEIS on a variety of issues, including cultural resources and traditional cultural properties. In addition, Reclamation contacted various representatives and offices of the Bureau of Indian Affairs (BIA), informing them of the consultation and requesting any feedback that the agency might have regarding the project and possible environmental effects, including the potential to affect cultural resources. A copy of this correspondence and list of recipients is included in Appendix 6, “Consultation Letters.” BIA’s Southern Plains Regional Office declined to offer comments, but confirmed that Reclamation had contacted the appropriate Native American communities and BIA offices. The Mescalero Apache Tribe determined that the project would not affect any objects, sites, or locations important to their traditional culture or religion. No other responses have been received to date.

The SHPO will be consulted on the extent of the APE, the level of the identification effort, and the potential for effects to cultural resources resulting from the actions contemplated. Further consultation with the SHPO and Native American groups will be conducted throughout this process. Additional cultural resource compliance actions and agreements likely would be required in order to implement some water acquisition options and conservation and habitat restoration measures.

9.5 Existing Conditions

The record search identified more than 30 surveys or other cultural resource studies that include portions of the buffer zone. There has been very little systematic archaeological survey coverage overall, with even fewer of the surveys covering large blocks of land. The exception is lands surrounding the reservoirs, where cultural resource compliance projects have been conducted. Many resources near the reservoirs have been examined on multiple occasions, and site records have been updated. With much of the land adjacent to the river in private hands and undeveloped, few surveys have been conducted along the length of the river. In many areas, dense non-native vegetation inhibits survey access and visibility. Sites in the immediate vicinity of the river or in flood zones would be subject to disturbances that would reduce the likelihood of their preservation or their visibility. Few existing studies address the built environment. Because the buffer area has not been systematically studied, any patterns of resources observed reflect survey coverage and site preservation, rather than necessarily representing the potential entire range of resources present or their distribution in the vicinity of the river. However, this record search provides the best available sample of resources likely to be present along the Pecos River and reservoirs. Additional information on the results of the record search and the cultural setting are included in the cultural resource technical report (Tetra Tech, Inc., 2004a). The record search identified 250 cultural resources in the buffer zones. Almost all of these cultural resources are archaeological sites or structural ruins, except for intact bridges and water conveyance features. Of these 250 cultural resources, 70 are prehistoric, 63 are historic, and 18 have both prehistoric and historic components. Ninety-nine resources are recorded as unknown or temporally undetermined. In most cases, these sites include artifacts or features that generally would be assigned to prehistoric sites but have not, or could not, be definitely attributed to that period because of the continuity of these artifact sets or features into the historic period. In other cases, the material remains are very ambiguous or the records are insufficient to determine temporal placement.

The most common resource types recorded include some structural remains with either multiple features, components, or artifact sets (65) or structural remains with single features, components, or limited artifact sets (64). Artifact scatters consisting of more than two artifact types represent the next largest category (36), followed by lithic (chipped stone) scatters (31), and 9 other types. The records for 20 sites have not been finalized by the researchers. For these sites, only the era and location have been registered while the site forms are being completed.

The NRHP eligibility status of 187 of these resources has not been determined in concurrence with SHPO. Forty-two resources have been determined eligible for listing on the NRHP for their scientific information potential. Four have been determined eligible without specifying a criterion, and one has been determined eligible for its association with historic events. Thirteen have been evaluated and are not eligible.

Three properties are listed on the NRHP. The Fort Sumner Railroad Bridge crosses the Pecos River 2 miles west of the village of Fort Sumner. It was listed in 1979 for its association with historic events and for its architectural and engineering significance. The ruins of Fort Sumner are adjacent to the Pecos River, west of the village. Fort Sumner was listed on the NRHP in 1974 for its association with historic events and its information potential as an archaeological site. CID facilities constructed between 1888 and 1949 as part of the Carlsbad Irrigation Project or Improvement Company are a National Historic Landmark (NHL). CID was listed in 1964 as an excellent surviving representation of a large, turn-of-the-century reclamation system. Contributing elements of the NHL are along 28 miles of the Pecos River upstream of and downstream from Carlsbad. Ownership of the distribution system and other contributing elements of the NHL were transferred in 2000 from Reclamation to CID under the terms of a memorandum of understanding, which ensures continued cultural resource protection.

No traditional cultural properties have been identified, based on the initial consultation with tribal groups. Additional consultation will continue throughout the EIS process.

10. Indian Trust and Treaty Assets

10.1 Introduction

The following indicator was selected to evaluate Indian trust and treaty assets:

- The presence or potential for Indian real property, physical assets, or intangible property rights that could be affected by the alternatives and water acquisition options

To provide a context for this indicator, this section defines ITAs and the region of influence (ROI) and describes the methods of evaluation, including regulatory background and identifying techniques.

10.2 Definition and Region of Influence

Indian trust assets are legal interests in assets held in trust by the Federal Government for federally recognized Indian tribes or nations or for individual Indians. Assets are anything owned that has monetary value. A legal interest refers to a property interest for which a legal remedy, such as compensation or injunction, may be obtained if there is improper interference. A trust has three components: the trustee, the beneficiary, and the trust asset. The beneficiary is also sometimes referred to as the beneficial owner of the trust asset. In the Indian trust relationship, the United States is the trustee and holds title to these assets for the benefit of an Indian tribe or nation or for an individual Indian.

These assets can be real property, physical assets, or intangible property rights. Examples include lands, minerals, water rights, hunting and fishing rights, other natural resources, money, or claims. They need not be owned outright, but can include other types of property interest, such as a lease or a right to use something. ITAs cannot be sold, leased, or otherwise alienated without Federal approval. While most ITAs are on Indian reservations, they can be off reservations.

ITAs do not include things in which a tribe has no legal interest. Without a treaty or act of Congress specifying otherwise, land ownership can affect the determination of whether or not a resource is an ITA. For example, off-reservation sacred sites in which a tribe has no legal property interest generally are not considered ITAs. In this case, if religious or cultural resources could be affected by the Federal action, these interests would be addressed as part of the cultural resources or social impact assessment because of the lack of legal property interest. The same resource on a reservation, trust, or ceded land may be an ITA, as determined on a case-by-case basis (Reclamation, 1993).

The ROI for ITAs is the Pecos River basin, from Santa Rosa Reservoir to the New Mexico-Texas State line. Reclamation has contacted several tribal groups and the

Bureau of Indian Affairs in the Southwest, Texas, and Oklahoma to identify any tribal trust or treaty interests in the Pecos River basin.

10.3 Regulatory Background

The Indian trust responsibility is a legal duty on the part of the United States to protect and maintain rights reserved by, or granted to, Indian tribes or individuals. Trust relationships are established through a congressional act or Executive order and through provisions identified in historical treaties. These rights have been further interpreted through court decisions and regulation. This trust responsibility requires Federal agencies, such as Reclamation, to take actions reasonably necessary to protect ITAs and to fulfill treaty obligations. Agencies must respect the inherent governmental authority of Indian tribes, which is derived from their original sovereignty and is a recognized principle in U.S. constitutional law.

The Department of Interior, Departmental Manual Part 303: Indian Trust Assets, defines general Interior policy and principles for managing ITAs. Agencies are required to protect and preserve ITAs, to ensure their use promotes the interests of the beneficial owner, to enforce leases, to promote tribal control, to manage and distribute income, to maintain good records, and to protect treaty-based fishing, hunting, gathering, and similar rights of access and resource use on traditional tribal lands (Interior, 2003).

Reclamation ITA policy states, “Reclamation will carry on its activities in a manner which protects ITAs and avoids adverse impacts to ITAs when possible. When Reclamation cannot avoid adverse impacts, it will provide appropriate mitigation or compensation.” The policy requires explicit evaluation in NEPA analyses of potential effects of proposed actions on trust assets (Reclamation, 1993).

10.4 Identification

ITAs are identified primarily through consultations with federally recognized Indian tribes on a government-to-government basis (Executive Order 13084 and the Executive Memorandum of April 29, 1994, on Government-to-Government Relations with Native American Tribal Governments). The tribal government is the primary point of contact in most cases, but BIA and the Office of American Indian Trust are also consulted. The Office of American Indian Trust helps BIA develop inventory listings for ITAs for tribes. There is no comprehensive list of all ITAs for tribes and individual Indians. If ITAs could be present at a project site, and if a proposed action could conflict with Indian lands and ITAs, there must be government–to-government consultation with the recognized tribal government having jurisdiction over the affected ITAs, BIA, and Reclamation’s solicitor to determine interests, concerns, effects, and appropriate priorities for management and mitigation. Further information on the nature of the trust asset is determined by examining government documents, such as treaties, court decisions, water rights adjudication proceedings, and proclamations establishing reservations. In some cases, the measure of impact significance on ITAs may be estimated based on the monetary value of the assets to the Indian tribe, but ITAs may have social and cultural values that need to be considered in addition to their economic value.

10.5 Existing Conditions

There are no reservations, trust, or ceded lands in the ROI. In November 2002, Reclamation contacted representatives of tribal groups with historic ties to the Pecos River basin and tribal groups who had expressed interest in Reclamation activities. Reclamation contacted these groups on a government-to-government basis to identify any concerns about the potential effects of future Reclamation activities connected with this DEIS on trust assets, cultural and biological resources, or tribal health and safety. In addition, Reclamation contacted various representatives and offices of BIA, informing them of the consultation and requesting any feedback that the agency might have regarding the project and possible environmental effects, including the potential to affect ITAs or cultural resources. A copy of this correspondence and list of recipients is included in Appendix 6, "Consultation Letters." BIA's Southern Plains Regional Office declined to offer comments, but confirmed that Reclamation had contacted the appropriate Native American communities and BIA offices. The Mescalero Apache Tribe determined that the project would not affect any objects, sites, or locations important to its traditional culture or religion. No other responses have been received to date.

No ITAs have been identified on the basis of this initial consultation. Additional contacts will be made to update the tribes on the progress of the DEIS, to provide information on the alternatives under consideration, and to solicit any concerns relative to trust assets, cultural or biological resources, or tribal health and safety. Consultation to identify any trust issues will continue throughout the EIS process.

11. Environmental Justice

The following indicator was selected to evaluate environmental justice:

- The proportion of physical or economic impacts compared to the distribution of specific population characteristics

An evaluation of environmental justice impacts is mandated by Executive Order 12898 on Environmental Justice (February 11, 1994). Environmental justice addresses the fair treatment of people of all races and incomes with respect to Federal actions that affect the environment. Fair treatment implies that no group of people should bear a disproportionate share of negative impacts from an action. The impacts of an action can be considered disproportionately distributed if the percentage of total impacts imposed on a specific group is greater than the percentage of the total population represented by that group. A group can be defined by race, ethnicity, income, community, or some other grouping.

Evaluating potential environmental justice concerns requires an understanding of where the project impacts are likely to occur and where potentially affected groups are located. The analysis relies on demographic data from sources such as the U.S. Census Bureau, individual counties and municipalities, and local school districts to determine the location of different groups of people. Identifying the location of specific groups can be difficult when nonpermanent residents, such as migrant workers, are in the affected area. Demographic data are poor for these groups of people. Census data do not account for all nonpermanent residents because some cannot be contacted or some may not want to be counted. In addition, the Census has a tendency to undercount the number of people in rural areas, due to difficulties encountered with contacting residents in sparsely populated regions. However, Census data are typically the most complete and comparable demographic and economic data available for individuals and households.

Income data are presented in Section 7, "Regional Economy." The data in table 3.12 indicate that the per capita income in the economic impact area is lower than the average for all of New Mexico and for the entire United States. The per capita income of Guadalupe County was much lower than for the rest of the study area. Therefore, any alternatives that have a disproportionate adverse effect on Guadalupe County may have environmental justice issues. Per capita income for 2002 is shown graphically in figure 3.8.

U.S. Census Bureau data also are available for race and Hispanic origin. Table 3.26 presents these data. These data indicate the distribution of population by race is similar for each of the study area counties, except for Guadalupe County, which has a very large percentage of Hispanics or Latinos. Chapter 4 describes any potential inter-related socioeconomic impacts to both the total affected population and to the low-income and/or minority communities of concern evaluated.

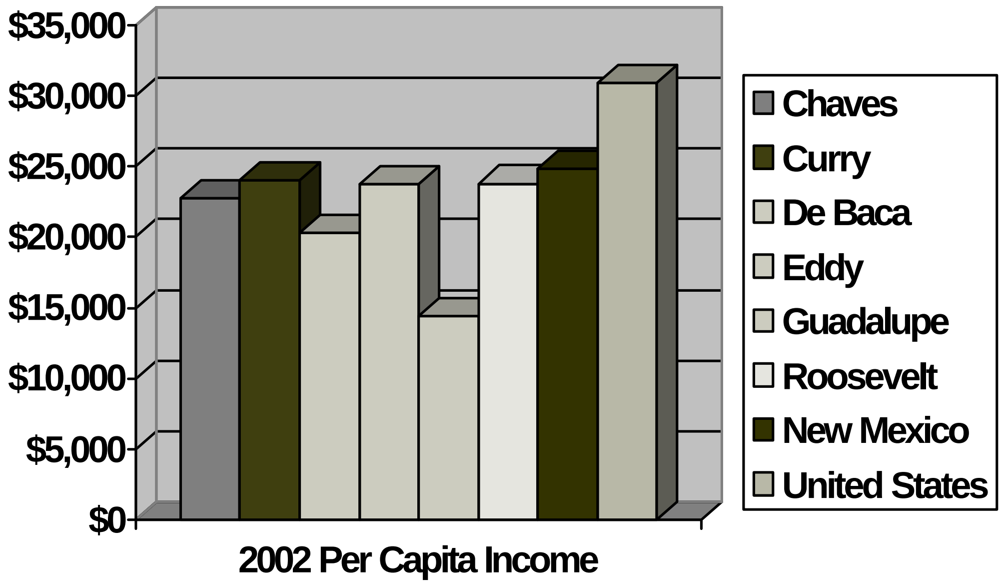


Figure 3.8. 2002 per capita income in study area.

Table 3.26 Population of study area by race

Race and Hispanic origin	Chaves County		De Baca County		Eddy County		Guadalupe County		Four-county Region	
	Total	Percent of total	Total	Percent of total	Total	Percent of total	Total	Percent of total	Total	Percent of total
White	44,167	72.0	1,882	84.0	39,438	76.3	2,530	54.1	88,017	73.4
Black or African American	1,209	2.0	1	0.0	805	1.6	62	1.3	2,077	1.7
American Indian and Alaskan native	694	1.1	21	0.9	646	1.3	53	1.1	1,414	1.2
Asian	323	0.5	5	0,2	231	0.4	25	0.5	584	0.5
Native Hawaiian and other Pacific races	34	0.1	0	0,0	47	0.1	2	0.0	83	0.1
Other race	13,042	21.2	281	12.5	9,129	17.7	1,828	39.1	24,280	20.2
Two or more races	1,913	3.1	50	2.2	1,362	2.6	180	3.8	3,505	2.9
Hispanic or Latino	26,904	43.8	790	35.3	20,023	38.8	3,801	81.2	51,518	42.9

Source: U.S. Census Bureau, 2005.

Chapter 4

Environmental Consequences

Chapter 4
Environmental Consequences

This chapter describes the impacts of the alternatives and other management actions on the resource indicators listed in chapter 3. As discussed in chapter 3, these analyses of impacts on resource indicators are considered adequate to address all potentially significant effects on each resource, including water, biology, and the regional economy. Each resource discussion begins with a list of the resource indicators and a summary of the expected impacts by alternative. The summary is followed by a description of the scope and methods used in the impact analysis, a description of the expected impacts by alternative, followed by the impacts of the Carlsbad Project water acquisition (CPWA) and additional water acquisition (AWA) options. Mitigation measures and residual impacts are discussed at the end of each section. As discussed in the following section, the impact analysis for most resources is tiered from the water resource analysis, which is based on computer modeling.

1. Impact Analysis Overview

Impact analyses are conducted to estimate the change that may occur to a given resource. Impacts of the alternatives on resources are analyzed using one of several types of methods. Selecting a method for this purpose may include many considerations, including:

- How much change is expected?
- Will the change be negative or beneficial?
- What is the reliability of results and the expense of the method?
- Perhaps most importantly, how complex is the system?

Systems that are more complex are influenced by many factors, meaning that the effects are dependent upon the relationships of many things. For instance, the Pecos River basin itself is a complex system. The amount of flow present in the river at any given point and time is the result of many different factors. Those factors, discussed in detail in chapter 3, include rainfall; snowpack; status of drought or moisture deficit; evaporative losses due to wind, heat, or seepage; riverbed forms and substrate; local geology affecting surface and ground-water systems; diversions from both surface and ground-water sources; and return flows from irrigation or municipal uses. With this level of complexity, computer models are excellent tools to estimate the amount of change that might be expected from implementation of a proposed action.

Initial Model Conditions

The following table provides input reservoir storages and reach flows for the Pecos River RiverWare surface water model. Many other initial conditions were input into the RiverWare model, including storm inflows, diversion acreages, and base inflows. Other model (CAGW and RABGW)[1] initial conditions are so numerous that they also cannot be listed here. They include starting heads, starting aquifer storages, and recharge estimates.

	Initial model condition	Value
Reservoir Storages	Santa Rosa Reservoir storage	20,000 acre-feet
	Sumner Lake storage	20,000 acre-feet
	Brantley Reservoir storage	16,000 acre-feet
	Avalon Reservoir Storage	1,200 acre-feet
Reach Flows	Inflow in the Sumner Lake to Taiban reach	17 cubic feet per second
	Inflow in the Taiban to Near Dunlap reach	13 cubic feet per second
	Inflow in the Near Dunlap to Near Acme reach	11 and 8 cubic feet per second
	Outflow in the Near Acme to Hagerman reach	10 cubic feet per second
	Outflow in the Hagerman to Lake Arthur reach	6 cubic feet per second
	Outflow in the Lake Arthur to Near Artesia reach	60 cubic feet per second
	Outflow in the Near Artesia to Kaiser channel reach	60 cubic feet per second
	Inflow in the Brantley to Dam Site 3 Reach	20 cubic feet per second

[1] CAGW = Carlsbad Area Ground Water model; RABGW = Roswell Artesia Basin Ground Water model

1.1 Use of Computer Models for Impact Analysis

A suite of computer models were developed for use in this draft environmental impact statement (DEIS) for impact analysis. The models can also be used for other projects in the future. The computer models use the best available science, have been developed and refined over several years, and are the result of interagency work and cooperation. For this DEIS, the models were used entirely for the analysis of impacts on water resources; in support of analysis of impacts on water quality, agricultural soil and land, biological, and recreation resources; and as an intermediate step for analyzing impacts on the regional economy and environmental justice. Impacts of proposed actions on affected resources were analyzed on the basis of output from computer model simulations. Results from these simulations provided necessary information to evaluate the expected impacts of alternatives on most indicators identified in chapter 3. For each affected resource, expected impacts on identified indicators are presented separately for each alternative.

1.2 Pecos River Decision Support System

The models are referred to as the Pecos River Decision Support System (PRDSS). PRDSS is a suite of four surface and ground-water flow models that interact with one another: Pecos River RiverWare surface water model; two regional ground water flow models—Roswell Artesia Basin Ground Water model (RABGW) and the Carlsbad Area Ground Water model (CAGW); and an accounting model for the surface flows out of New Mexico into Texas. (See map 4.1.) Overview documents on PRDSS and its application to water resources issues in the Pecos River basin and documents describing details of each of these component models were prepared for this study and are included in the study administrative record (Hydrosphere Resource Consultants [HRC], 2003a, 2003b, 2003c; Barroll, et al., 2004; Tetra Tech, Inc., 2000b, 2003b, 2003c), and other public domain literature (e.g., Boroughs and Abt, 2003; Longworth and Carron, 2003a and 2003b; Liu et al., 2003). In summary, PRDSS simulates hydrologic response to changes in parameters, such as reservoir operations or water diversions, based on defined physical characteristics of the system. Therefore, the foundation work of developing a model is defining those physical characteristics. The better these characteristics are defined, the better are the results from the model. However, as with all models, there are limitations to the use of the model's results, which begin with an understanding of the model's construction, followed by its inputs and rules.

The Pecos River RiverWare surface water model does not simulate flows downstream from Avalon Dam, so additional modeling tools were developed to model ground-water conditions in the Carlsbad area and Pecos River flows from Avalon Dam to the State line. The CAGW model (Barroll et al., 2004) simulates the effect of Carlsbad Irrigation District (CID) operations on ground-water conditions in the Carlsbad area, including CID return flows to the river, and the impacts of supplemental irrigation well pumping. The Red Bluff accounting model (HRC, 2001b) simulates average monthly flows in the river, including spills and releases from Avalon Dam in conjunction with base inflows (output from CAGW) and tributary inflows. A data processing tool was created to link these models with the RiverWare model (HRC, 2001a).

1.2.1 General Limitations of Model Results

Limitations should be considered when referencing model results. Three key assumptions involve the following: (1) computed transmission losses due to evaporation, seepage, and transpiration from riparian vegetation; (2) estimates for ground-water base inflows from artesian ground-water basins; and (3) assumed inflows from runoff from monsoon season rainfall events and snowmelt. The model uses a strict logic (such as when to initiate bypass flows) that may not always represent actual daily operations decisionmaking. In addition, model results are subject to uncertainty in interpretation of output data. The Pecos River RiverWare model was developed to represent expected flows based on average historical conditions. Data with substantial errors were eliminated from the database, but undetected minor errors could still affect model results. Because the ground-water models were used to estimate ground-water base inflows to the Pecos River, these models were calibrated to gaged streamflows, so the model results would include the same uncertainty as the historical gage data. The most prudent use of the modeled results in this document would be to compare the

> **Pre-1991 Baseline**
>
> Under the requirements of the National Environmental Policy Act (NEPA), the impacts of action alternatives are compared to a No Action Alternative. The No Action Alternative represents a continuation of ongoing activities.
>
> In this DEIS, the No Action Alternative represents conditions since 1991, when experimental water operations were initiated to provide additional water for the Pecos bluntnose shiner. Before 1991, river operations were focused solely on providing irrigation water for agriculture. Therefore, the pre-1991 baseline is used to compare the impacts of the action alternatives, including the No Action Alternative, to the operating conditions before changes were made for the shiner. Comparisons with the pre-1991 baseline are used for comparison of water resources, water quality, agricultural soil and land resources, biological resources, and regional economy.

alternatives only. The results cannot be used to exactly predict future conditions and are not intended for actual implementation.

1.2.2 Results for Specific Locations Along the River

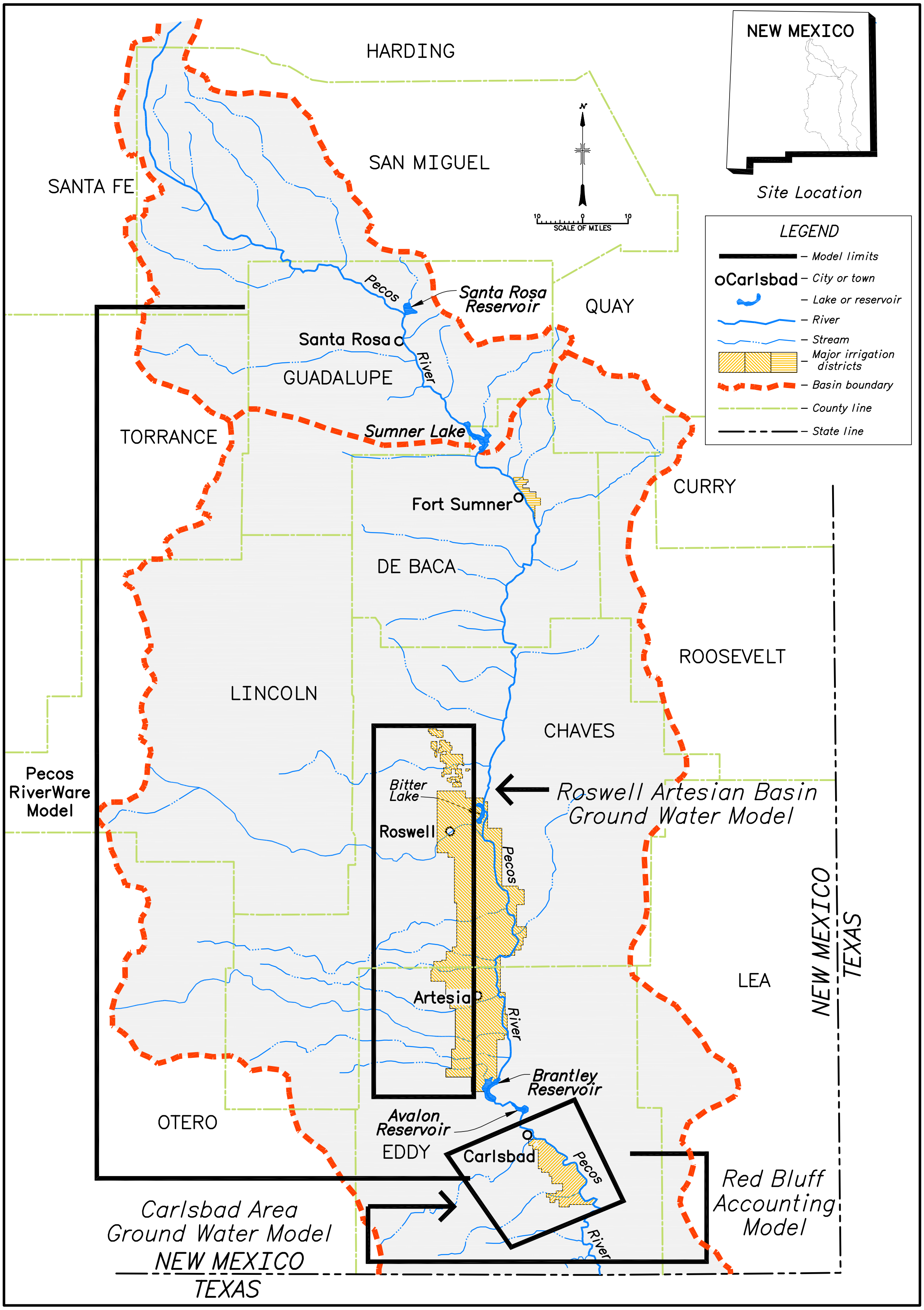
The RiverWare model provides results for riverflows at nodes (specific locations, map 2.1) along the river at U.S. Geological Survey (USGS) stream gages. The model simulated historical operations, and the resulting riverflows were compared to historical gage data to evaluate the model. As discussed in chapter 3, actual historical Near Acme gage records indicate 11 percent river intermittency. The pre-1991 baseline as modeled represents 1.2 percent intermittency (discussed in detail in section 4.3). The difference between actual and modeled flows is due to operational changes, new infrastructure, gage error, and modeling assumptions about future operations.

While it cannot be used to exactly predict future conditions, the model is sufficient for comparing alternatives and other management actions and evaluating expected differences. However, because resulting flows are only provided for key nodes along the river, the model cannot be used to estimate flows at other locations along the river.

1.2.3 Consideration of Rules for River Operations

There are two aspects to a RiverWare simulation. First, the model represents all the processes that affect surface water, such as reservoir evaporation and conveyance losses (such as seepage and evaporative losses to water flowing from Sumner Lake to Brantley Reservoir). Second, the simulation is rule based; operational policy is coded into rules that dictate how dams and diversions are operated (Tetra Tech, Inc., 2003c). Separate operational policies were used for each alternative, including the pre-1991 baseline and No Action Alternative.

One of the key policy assumptions pertains to the storage level triggers for initiating and stopping block releases (Tetra Tech, Inc., 2003c). These rigid triggers do not account for some of the more subjective factors affecting operational policy. For example, the policy does not directly include rules for adjusting the timing of block releases to improve water quality or to avoid a conservation spill. Another policy issue pertains to predicted diversions to the CID main canal at Avalon Dam and diversions by river pumpers. The modeled



Map 4.1 Pecos River Decision Support System (PRDSS)

diversions replicate an average diversion record based on historical data, so the diversions simulated in the model do not include variability related to factors such as weather, crop economics, fuel prices, pest problems, and other related conditions; thus, the RiverWare model does not predict the variability in irrigation demand from year to year.

Modeling Assumptions and Limitations

Many assumptions are made when analyzing the impacts of proposed actions using the computer models developed for the basin.

- All of the model results represent conditions resulting from the simulated **60-year hydrologic period**. While conditions over the past 60 years will not exactly mimic the next 60 years, these historical data provide the best information for estimating conditions for the next 60 years. In some cases, historically estimated data were used rather than actual measures. The models use average loss coefficients.

- The model results provide information for expected conditions at **specific locations** along the river corresponding to reservoirs and USGS gages, but they cannot be used to analyze conditions at other locations. Model results are only available for key locations along the river.

Surface Water Modeling

- The key assumption made when using the surface water model pertains to predicted losses and gains of riverflows due to evaporation, seepage, and transpiration. The losses computed in the model represent the **average expected losses** that would occur as a function of flow and season.

- The model includes many assumptions regarding **operational policy** (daily river operations). One of the key assumptions with this aspect of the model pertains to the storage level triggers for initiating and stopping block releases. These rigid triggers do not account for some of the more subjective factors affecting operational policy. For example, the policy does not directly include rules for adjusting the timing of block releases to improve water quality.

Ground-Water Modeling

- Ground-water modeling tools were used to approximate the **relative direction and magnitude of impacts** of proposed actions on water resources indicators; however, these models do not exactly predict future conditions.

- The limitations of the ground-water models are primarily linked to the uncertainty in the **data referenced** during model development. There is additional complexity in modeling ground water that interacts with a river system. The limitations of the models relate to similar issues, such as the accuracy of well measurement data, stream gage error, pumping errors, the spatial and temporal distribution of ground-water pumping, average diversion patterns, and evaporation and evapotranspiration from the aquifers through capillary rise.

- The assumed geology covers a large area, and specific geology is unknown.

Interpretation of Results

- Model results can be subject to different interpretations. For example, calculations of average net depletions have limitations in fully portraying hydrologic conditions over the 60-year period.

1.2.4 Modeling Period

As discussed previously, PRDSS was used to help evaluate the impacts on water resources, water quality, agricultural soil and land resources, regional economy, recreation, and environmental justice. In each of these applications, model results are based upon historical averages simulated over a 60-year period of record (1940-99) and are most useful in their comparisons to one another or against a defined baseline. The 60-year modeling period includes both extended wet periods (early 1940s, mid 1980s through mid 1990s) and dry periods (1950s, mid-1960s, early 1970s), so the effects of proposed actions during such periods are captured. These data provide a baseline of hydrologic conditions in the lower Pecos River basin (referred to in this document as the pre-1991 baseline). For some resources, the effects of the alternatives are compared to the pre-1991 baseline data in addition to the No Action Alternative. While future conditions will not replicate the past 60 years, the historical data provide the necessary information for evaluating expected changes for different hydrologic conditions. Each set of results has associated minimum, maximum, and average values. How important those variations in results may or may not be for each resource is discussed in each resource section, along with how best to interpret the results presented.

2. Analyses of Proposed Actions and Use of Model Results for Impact Analyses

The impacts of proposed actions were analyzed using information from three separate tasks: (1) model simulations of the alternatives with no water acquisitions, (2) model simulations of alternatives with the addition of CPWA options identified in chapter 2, and (3) modeled AWA. Different output parameters were used to evaluate impacts of proposed actions on the different affected resources, but the focus was on changes to streamflows, the amount of water in storage, and diversions by water users. Impacts on agricultural soil and land resources would predominantly be a function of the selected AWA options. In the case of recreation, the interest is predominantly on expected changes to reservoir levels. Other resources, such as cultural resources, Indian trust and treaty assets (ITA), the regional economy, and environmental justice, would have localized impacts related to riverflows and potential regional impacts in areas away from the river and reservoirs. An overview of specific parameters follows for the indicators related to water resources, water quality, biological resources, and the regional economy. The respective resource sections provide more detailed information on specific modeling and analytical methodologies.

2.1 Water Resources

Water resources indicators were evaluated using model results for flows at the Near Acme gage, the amount of water in storage in each reservoir, diversions to the CID main canal at Avalon Dam, and flows at the New Mexico-Texas State line. Information for these parameters was used to evaluate the impact of proposed actions on flows in critical habitat for the Pecos bluntnose shiner (shiner) and to compute average annual net depletions to the Carlsbad Project water supply and State-line flows. Base inflows along the reach between the Near Acme and Near Artesia gages were also calculated. Model results for the Taiban Constant and Acme Constant Alternatives with and without water acquisition options were used, along with specific details about each water acquisition option to compute corresponding efficiencies for effectively keeping the Carlsbad Project water supply whole.

2.2 Water Quality

Proposed actions may affect total dissolved solids (TDS) and specific electrical conductance (EC), which are related to the flow rate in the river. Streamflows downstream from Sumner Dam for wet, normal, and dry year types were the primary parameters used to evaluate impacts on water quality. Changes in water quality are key because they could affect crop production.

2.3 Biological Resources

Impacts on biological resources are primarily a function of resulting flows in the river or changes to reservoir levels. Model results were used to evaluate whether or not flows would be sufficient to conserve and protect the shiner and, specifically, to review the expected occurrence of intermittency (or 0-cubic-foot-per-second (cfs) flow) at the Near Acme gage. Flows also were needed to evaluate the timing and duration of block releases and the subsequent impacts on the different life stages of the shiner. Information on reservoir levels was needed to evaluate the impact of pool elevation changes on reservoir fish species and nesting conditions for the interior least tern.

2.4 Regional Economy

Impacts on the regional economy are predominantly a function of selected CPWA or AWA options, which are linked to the resulting net depletions for an alternative; thus, resulting average annual net depletions to the Carlsbad Project water supply were indirectly needed to evaluate this resource. If water rights are to be retired as a water acquisition option, economic impacts were determined related to crop production, farm income, maintenance costs, and property taxes.

3. Water Resources

As discussed in chapter 3, the following indicators were selected to evaluate water resources:

- Flow frequency at the Near Acme gage
- Additional water needed (AWN) to meet target flows
- Carlsbad Project water supply
- Pecos River flows at the New Mexico-Texas State line
- Base inflows in the Acme to Artesia reach of the Pecos River
- Carlsbad Project water acquisition option efficiencies

3.1 Summary of Impacts

Table 4.1 summarizes the impacts of the alternatives on (1) flow frequency at the Near Acme gage, (2) AWN to meet target flows, (3) net depletions to the Carlsbad Project water supply, and (4) average annual flows at the New-Mexico State line. A narrative summary discussion follows.

Table 4.1 Summary of impacts of alternatives on water resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Difference in percent of time modeled flows of 10 cfs at the Near Acme gage are exceeded	10 percent more frequently than under pre-1991 baseline	3 percent less frequently than under No Action	3 percent less to 4 percent more frequently than under No Action	7 percent more frequently than under No Action	5 percent more frequently than under No Action	2 percent less frequently than under No Action
Difference in percent of time modeled flows of 20 cfs at the Near Acme gage are exceeded	19 percent more frequently than under pre-1991 baseline	10 percent less frequently than under No Action	8 to 9 percent less frequently than under No Action.	10 percent more frequently than under No Action	3 percent more frequently than under No Action	6 percent less frequently than under No Action
Difference in percent of time modeled flows of 30 cfs at the Near Acme gage are exceeded	24 percent more frequently than under pre-1991 baseline	23 percent less frequently than under No Action	23 percent less frequently than under No Action.	8 percent more frequently than under No Action	0.6 percent more frequently than under No Action	23 percent less frequently than under No Action

Table 4.1 Summary of impacts of alternatives on water resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Difference in frequency of modeled intermittency at the Near Acme gage	0.3 percent less frequently than under pre-1991 baseline	0.04 percent less frequently than under No Action	0.08 to 0.3 percent less frequently than under No Action	0.3 percent less frequently than under No Action	0.3 percent less frequently than under No Action	0.1 percent more frequently than under No Action
Additional water needed (AWN) to meet target flows	Average of 2,900 acre-feet per year more than under pre-1991 baseline	Average of 720 acre-feet per year more than under pre-1991 baseline	Average of 1,400 to 4,200 acre-feet per year more than under pre-1991 baseline	Average of 9,500 acre-feet per year more than under pre-1991 baseline	Average of 5,300 acre-feet per year more than under pre-1991 baseline	Average of 620 acre-feet per year more than under pre-1991 baseline
Modeled average annual depletions (net depletions) to Carlsbad Project water supply	Average of 1,600 acre-feet per year greater than under pre-1991 baseline	Average of 1,200 acre-feet per year greater than under pre-1991 baseline	Average of 1,200 to 1,700 acre-feet per year greater than under pre-1991 baseline	Average of 3,900 acre-feet per year greater than under pre-1991 baseline	Average of 3,000 acre-feet per year greater than under pre-1991 baseline	Average of 1,200 acre-feet per year greater than under pre-1991 baseline
Modeled average annual flows at the New-Mexico State line	1,200 acre-feet per year lower than under pre-1991 baseline	440 acre-feet per year lower than under pre-1991 baseline	690 to 1,600 acre-feet per year lower than under pre-1991 baseline	2,100 acre-feet per year lower than under pre-1991 baseline	1,600 acre-feet per year lower than under pre-1991 baseline	530 acre-feet per year lower than under pre-1991 baseline

Flow exceedance curves were developed to compare Pecos River flows at the Near Acme gage between the alternatives and the pre-1991 baseline. The pre-1991 baseline represents water operations on the river before they were modified for the benefit of the Pecos bluntnose shiner. The pre-1991 baseline was primarily used to compare resource indicators to a period when operations were focused on operating the Pecos River system for maximum efficiency. The pre-1991 baseline provided a means to determine net depletions resulting from changes in Carlsbad Project operations as well a means to compare the relative improvement in flow conditions for the shiner. The results of these analyses provide detailed information on how the changes in Carlsbad Project operations to include bypass flows would affect flows in the critical habitat for the shiner. Flows at the Near Acme gage are important because of the gage's location near the lower end of the upper critical habitat reach.

Under each alternative, bypass flows would provide additional water in the river (figure 4.1). Model results show that flows of 10 cfs at the Near Acme gage are exceeded 75 percent of the time under the pre-1991 baseline compared to 82 percent, 85 percent, and 93 percent of the time under the Taiban Constant, No Action, and Acme Constant Alternatives, respectively. For these three alternatives, flows of 20 cfs at the Near Acme gage are exceeded 66 percent, 71 percent, and 81 percent of the time, respectively, and exceeded only 51 percent of the time under the pre-1991 baseline. The results could also be reviewed with focus on a specific percent exceedance. For example, under the pre-1991 baseline, model results show that flows of 12 cfs are exceeded 70 percent of the time, but under the Taiban Constant, No Action, and Acme Constant Alternatives, flows of 19, 20, and 33 cfs, respectively, are exceeded 70 percent of the time. The flow exceedance curve for the Acme Variable Alternative lies between the curves for the Acme Constant and No Action Alternatives; the Critical Habitat Alternative curve is close to the Taiban Constant Alternative curve; and the Taiban Variable Alternative curve is between the curves for the Taiban Constant and Acme Variable Alternatives.

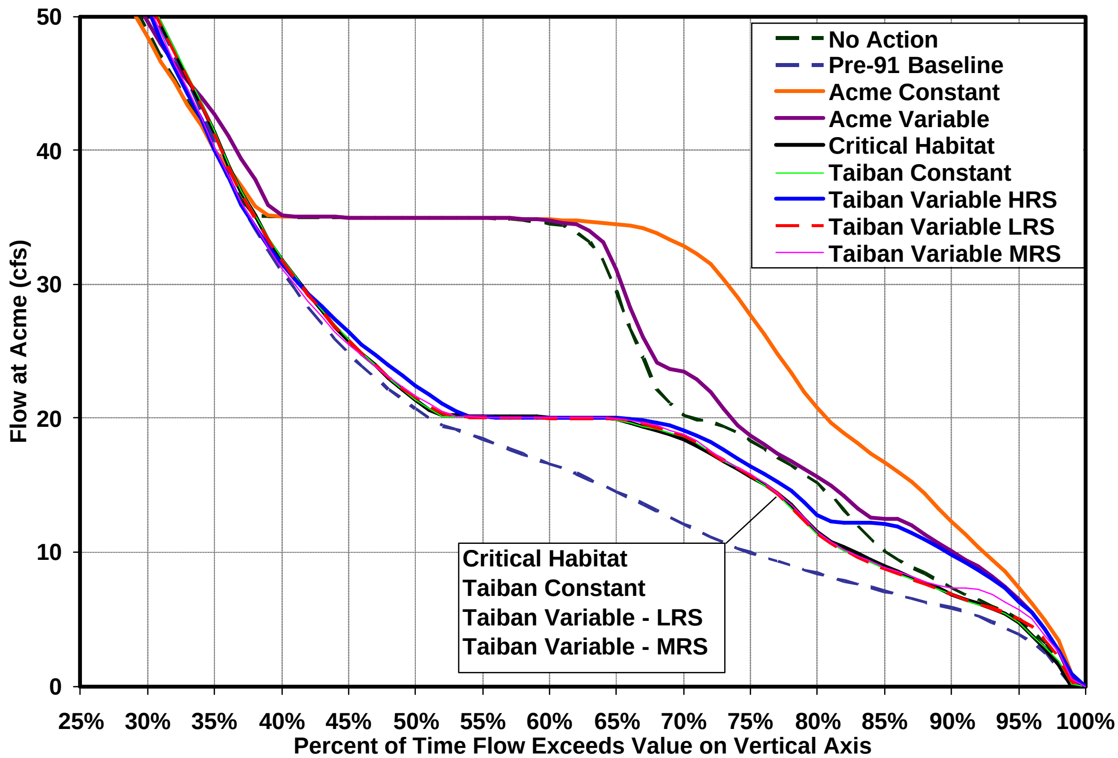


Figure 4.1 Flow exceedance curves under each alternative at the Near Acme gage.

The distinct "plateaus" in the flow exceedance curves presented in figure 4.1 generally correspond to the alternative's nonirrigation season target flows at the Near Acme gage or flows at the Near Acme gage resulting from target flows at the Taiban gage.[1] For example, the Acme Constant Alternative has target flows of 35 cfs at the Near Acme gage at all times, and the flow exceedance curve for this alternative exhibits a clear plateau at 35 cfs. The Taiban Constant Alternative has a plateau at 20 cfs, which corresponds to target flows of 35 cfs at the Taiban gage during the nonirrigation season. Conversely, the Taiban Constant Alternative has no plateau at 2 cfs, which corresponds to target flows of 35 cfs at the Taiban gage during the irrigation season. During the nonirrigation season, sufficient water is available for bypass flows; consequently, the flow frequency is

[1] The USGS gage Below Taiban Creek Near Fort Sumner is referred to as the Taiban gage in this document.

improved greatly in these ranges. During the irrigation season, however, sufficient water is not always available for bypass flows. This is demonstrated both by the fact that the Taiban Constant plateau is only present at 20 cfs, and by the Acme Variable curve, which has very small plateaus at 12 and 24 cfs (dry and average hydrologic conditions target flows). Note that at 48 cfs (wet hydrologic condition target flows), no plateau is evident, illustrating that water for bypass flows was unavailable during the irrigation season to meet this target. As evidenced by the Acme Constant and Taiban Constant flow exceedance curves, alternatives with higher target flows achieve a greater percentage of higher flows at the Near Acme gage than alternatives with lower target flows. The portions of the curve where there are no plateaus are either periods when the target flows are not fully achieved (flows below the target caused by a lack of local inflows available for bypass) or periods when the target flows are exceeded because of influences such as inflows downstream from Sumner Dam, including Fort Sumner Irrigation District (FSID) return flows and local storm inflows, or releases from Sumner Dam for flood bypasses and block releases.

Flow exceedance curves also provide information about the frequency of intermittency (river drying). Model results show that intermittency occurs less frequently under each alternative than under the pre-1991 baseline, but intermittency is not completely eliminated under any alternative because bypass flows are often unavailable during the same periods that zero flows occur at the Near Acme gage. Model results also indicate intermittency in the 1951-81 period. In that 30-year period, intermittency events occurred within 6 years, under Taiban Variable high-range summer (HRS; 55 cfs) and Acme Constant Alternatives, to within 11 years under the Critical Habitat Alternative.

The results presented in figure 4.1 do not include the effects of AWA options (section 3.5), which may further augment flows in the 0- to 50-cfs range. The results also do not include the addition of CPWA options (section 3.4) to augment the Carlsbad Project water supply. Also, the flow exceedance curves focus on low flows in the 0- to 50-cfs range, but model results show that higher flows—in the block release range of 1,000 to 1,400 cfs—occur slightly less frequently under the alternatives than under the pre-1991 baseline. These higher flows occur less frequently because, under the alternatives, water that typically would have been stored in the reservoirs and released later in a block release at a much greater discharge instead would be bypassed through the reservoirs at a much lower flow. The effect on flow frequency is a redistribution of water in the block release range (not shown in figure 4.1.) of flows to a lower range of target flows.

Figure 4.2 depicts average annual net depletions to the Carlsbad Project water supply under each alternative resulting from the combined effect of conveyance losses, reservoir evaporation, and spills (Tetra Tech, Inc., 2003e, 2005a). The impacts of other processes (such as seepage from Avalon Reservoir) are included, but the magnitudes are small in comparison to the additional losses to the three key processes. The net depletions to the Carlsbad Project water supply are

Net Depletions to the Carlsbad Project Water Supply

A key concept related to the water supply in the Pecos River basin is net depletions to the Carlsbad Project water supply. Depletions refer to losses of water from the system from many processes, including evaporation, seepage, bank sorption, and transpiration by vegetation. Changes in Carlsbad Project operations, as prescribed by each alternative, typically result in changes in depletions or net depletions. Depending on the alternative, the various depletion components can either increase or decrease, and the sum of the changes in depletion components is considered the net depletion. In general, net depletions to the Carlsbad Project water supply are primarily caused by the lower conveyance efficiency of bypassing flows, in addition to bypasses for FSID's diversion right, to augment flows in the Pecos River for the shiner, rather than diverting those flows to storage and later releasing that water in more efficient block releases. In addition to higher conveyance losses, changes in depletions may also occur because of changes in reservoir evaporation and/or spills from Brantley Dam (and then Avalon Dam) when conservation storage limits are exceeded.

Net Depletions to Flows at the State Line

Changes in surface water delivery to CID would affect return flows to the river downstream from Avalon Dam and could affect supplemental irrigation well pumping regime in the district, which, in turn, would affect conditions in the Carlsbad ground-water basin. Thus, both of these hydrologic components (i.e., surface water delivery to CID and supplemental well pumping) would affect base inflows to the Pecos River downstream from Avalon Dam and, ultimately, flows at the State line. These changes, along with changes in spills from Avalon Dam, could substantially impact the State's ability to meet its delivery obligation under the Compact. These changes are measured using net depletions to flows at the State line.

presented in figure 4.2 without the addition of CPWA needed to augment the Carlsbad Project water supply. These results indicate that the highest average annual net depletions occur under Acme Constant and Acme Variable Alternatives, and the lowest average annual net depletions occur under the Taiban Constant, Critical Habitat, and Taiban Variable low-range summer (LRS; 40 cfs) Alternatives.

The State of New Mexico is obligated under the Pecos River Compact (Compact) to deliver an amount of water to the New Mexico-Texas State line proportional to riverflows downstream from Sumner Dam; therefore, impacts on flows at the State line were analyzed as a water resources indicator. The primary contributors to flows at the State line are spills from Avalon Dam, irrigation return flows from CID, and runoff from storm events downstream from Avalon Dam.

Flows at the New Mexico-Texas State line are measured at the Red Bluff gage, and, for this reason, modeled flows at the Red Bluff gage were used to compare relative impacts on State-line Compact deliveries. Average annual net depletions to State-line flows were determined for each alternative without CPWA (figure 4.3).

To mitigate for net depletions to the Carlsbad Project water supply, the Bureau of Reclamation (Reclamation) would acquire CPWA from one or more potential sources. Efficiencies for CPWA options were computed to determine the amount of water needed

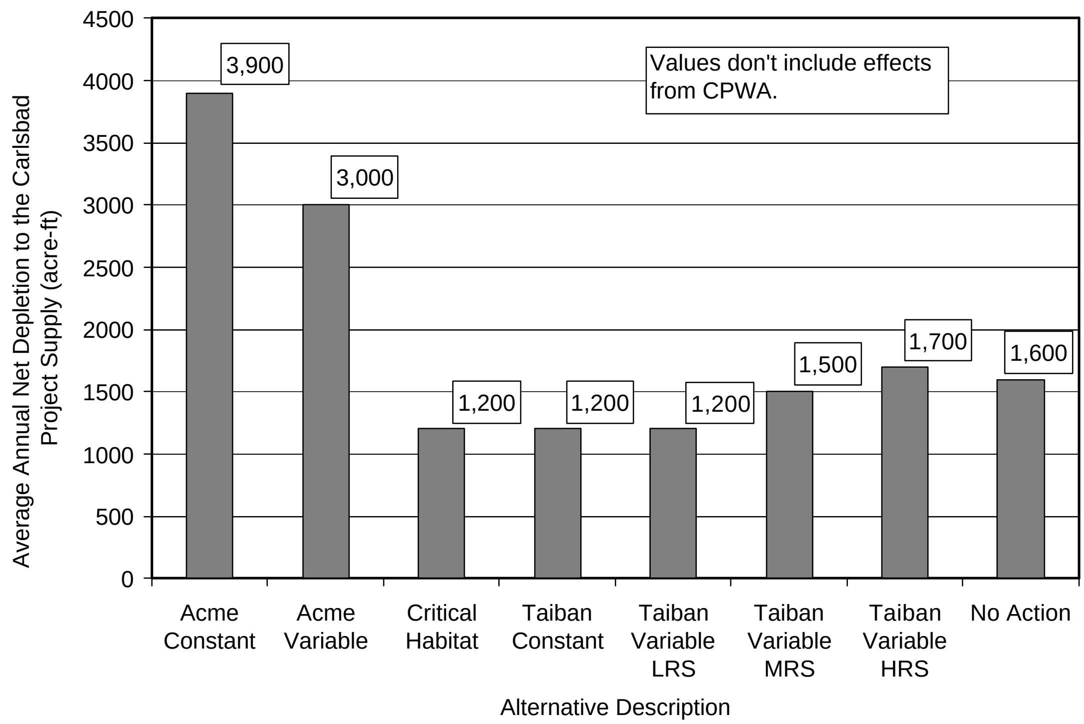


Figure 4.2 Average annual net depletions to the Carlsbad Project water supply under each alternative without CPWA.

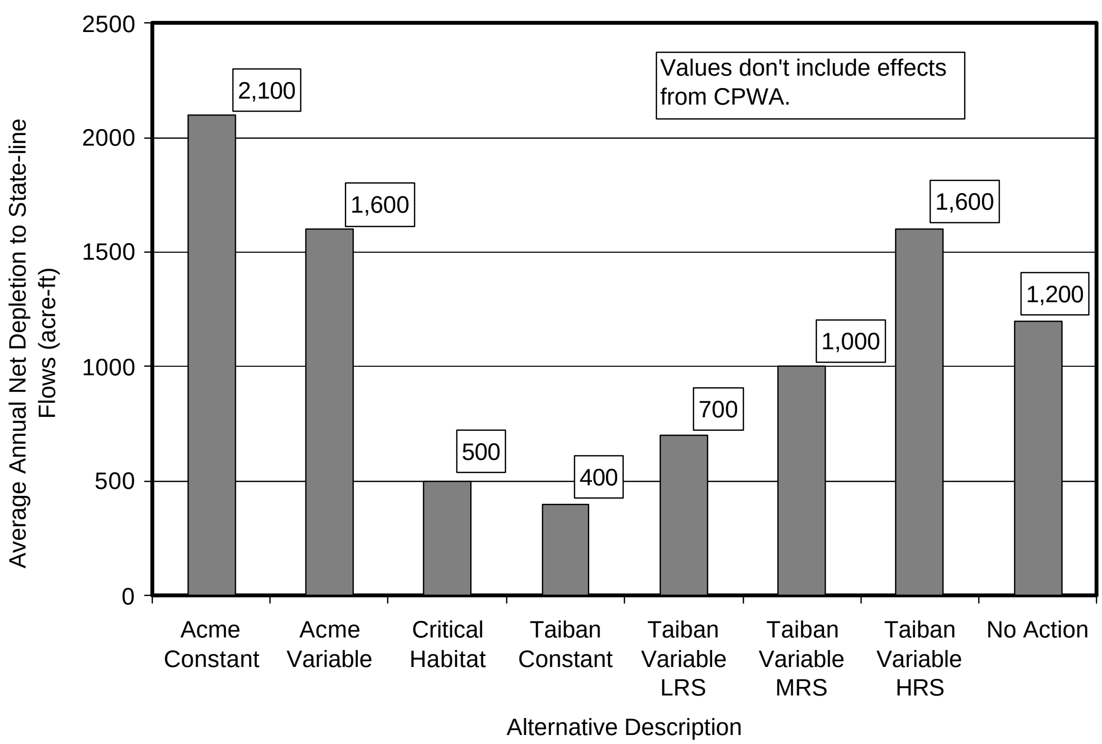


Figure 4.3 Average annual net depletions to State-line flows under each alternative without CPWA.

to augment the Carlsbad Project water supply and reduce or eliminate net depletions under an alternative (Tetra Tech, Inc., 2005a). These amounts of water also were converted to acreages (section 3.4.6) to provide a bridge to the economics work in section 7 of this chapter. In addition to water acquisition options for reducing net depletions, AWA options were reviewed to determine those that would directly augment flows in critical habitat for the shiner (Tetra Tech, Inc., 2005b). An analysis of additional water needed (AWN) to always meet target flows also was conducted (HRC, 2005b; Tetra Tech, Inc., 2004b). AWN is shown in section 3.3; CPWA efficiencies and retired acreages are shown in section 3.4; and AWA impacts are shown in section 3.5.

Flows at the State line were also analyzed with the addition of CPWA water (HRC, 2005c). These results are presented in section 3.4. Generally, if a water acquisition option would reduce or eliminate net depletions to the Carlsbad Project water supply, it also would reduce or eliminate net depletions to flows at the State line, unless the water acquisition source were directly from retirement of water rights within CID or changes to CID cropping patterns. In those cases, more spills may occur; however, the additional spills may not compensate for the reduction in CID irrigation return flows downstream from Avalon Dam.

In summary, the analysis indicates that the highest average annual net depletions to both the Carlsbad Project water supply and to State-line flows would occur under the Acme Constant and Acme Variable Alternatives, and the lowest net depletions would occur under the Taiban Constant and Critical Habitat Alternatives. A strong correlation exists between an alternative's net depletions to the Carlsbad Project water supply and the magnitude of its target flows. A similar correlation exists between an alternative's net depletions to State-line flows and the magnitude of its target flows. Figure 4.4 demonstrates this relationship for net depletions to the Carlsbad Project water supply. In the figure, representative target flows at the Near Acme gage (Taiban gage target flows converted to representative Near Acme gage target flows) for each alternative are plotted on the x-axis (horizontal), and net depletions to the Carlsbad Project water supply are plotted on the y-axis (vertical). As figure 4.4 shows, as representative target flows increase, so do net depletions to the Carlsbad Project water supply.

Flow exceedance curves indicate that higher flows occur more frequently under alternatives with higher target flows. Model results show that intermittency occurs less frequently under every alternative than under the pre-1991 baseline. Intermittency is entirely due to the lack of available inflows to bypass for the Pecos bluntnose shiner during the irrigation season, and the greatest positive change to flow frequency and intermittency is in the nonirrigation season when available inflows are plentiful. Differences in the frequency of intermittency among the alternatives are quite small and may be considered insignificant.

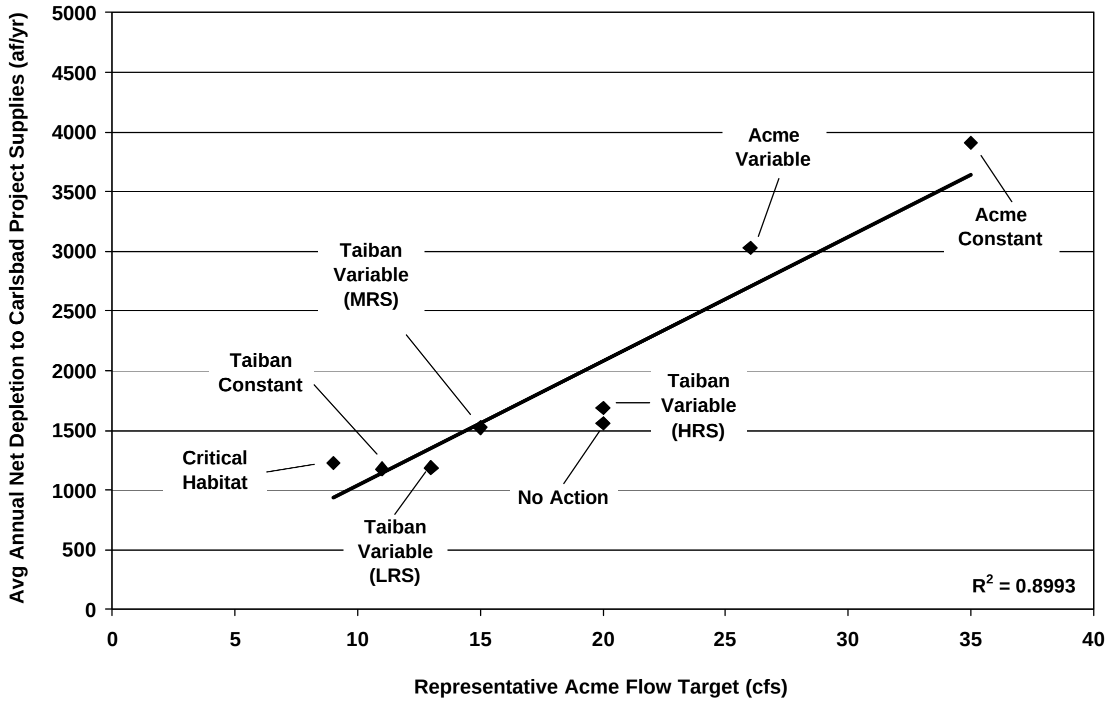


Figure 4.4 Relationship between net depletions to the Carlsbad Project water supply and representative target flows under each alternative with no CPWA.

3.2 Scope and Methods

The evaluation of impacts on water resources indicators included four separate tasks:

- Simulation of alternatives, including bypass flows, to meet target flows in the upper critical habitat for the shiner (Briggs and HWG, 2004; HRC, 2005b).
- Simulation of alternatives with CPWA water added (Tetra Tech, Inc., 2005a; HRC, 2005c)
- Estimation of AWN (Tetra Tech, Inc., 2004; HRC, 2005b)
- Simulation of AWA to further augment flows (Tetra Tech, Inc., 2005b).

Results from these simulations and estimates were used to conduct an in-depth analysis of the potential impacts of proposed actions on affected water resources indicators. Results were used to develop flow exceedance curves, compute net depletions to the Carlsbad Project water supply and State-line flows, and calculate efficiencies of water acquisition options. This information was then used to evaluate how bypass flows, the addition of water acquisition options, and block release constraints would affect water resources indicators.

All RiverWare simulations of alternatives (including with bypass flows only as well as water acquisition option model runs) used as a hydrologic input the 60-year historic record of mainstem and tributary inflows (1940 to 2000). In adopting these historic flows as inflows to the model, it was assumed that they are representative of the future expected range of inflows to the system.

3.2.1 Simulation of Alternatives with Bypass Flows Only

One action common to all alternatives is bypassing available[1] water through Sumner Dam to meet the target flows called for under the alternatives. First, bypass operations for each alternative were modeled. The results of these model runs were analyzed with respect to the indicators of flow and Carlsbad Project water supply depletions to help evaluate the effectiveness of the bypass flows.

To analyze the effects on Pecos River flows resulting from changes in Carlsbad Project operations, the RiverWare model was used to produce output that represented conditions under each alternative at selected locations on the river. This modeled flow output was compared using flow exceedance curves to infer the impacts of the alternatives on flows.

Average net depletions resulting from an alternative, with no CPWA added, were determined using modeled diversion and storage amounts from the RiverWare model. Average net depletions were computed from model output as the depletion under an alternative minus the depletions under the pre-1991 baseline. Net depletions were computed for a calendar year based on two components: (1) a comparison of the difference in stored water and (2) the difference in diversions to the Carlsbad Project water supply between an alternative and the pre-1991 baseline (Tetra Tech, Inc., 2003e). The total amount of water in storage was computed as effective Brantley storage. Effective Brantley storage accounts for the location of the water and the historical efficiency for conveying water in upstream reservoirs to the main CID diversion at Avalon Dam. Average annual values for net depletions to the Carlsbad Project water supply were computed, as well as maximum and minimum transmission depletions (the primary process affecting net depletions) for the reach from Sumner Dam to Brantley Reservoir.

If the delivery of water to CID would be affected under an alternative, CID return flows also would be affected. If the average spills from Avalon Dam, as conservation storage limits are exceeded, would be affected under an alternative, State-line flows also would be affected. Average annual net depletions to State-line flows under each alternative were determined by comparing the modeled annual flow volume at the State line to the corresponding flow volume under the pre-1991 baseline.

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[1] Water available for bypass is that amount flowing into Sumner Lake that exceeds the downstream diversion right of FSID.

3.2.2 Simulation of Alternatives with CPWA Options Added

To address the effects of greater net depletions to the Carlsbad Project water supply, Reclamation would acquire CPWA from one or more potential sources or water acquisition options. This CPWA may also reduce or eliminate all or part of the net depletions to State-line flows. These water acquisition options were modeled only with the Taiban Constant and Acme Constant Alternatives (which represent the two extremes for expected net depletions to the Carlsbad Project water supply) to limit the amount of modeling to an acceptable level. To compare the effectiveness of the water acquisition options, model results were used to evaluate their efficiencies. These efficiencies were defined as the percentage of water acquired at the source that would effectively reach Brantley Reservoir. These efficiencies were used to determine the amount of water needed to keep the Carlsbad Project water supply whole.

AWN and AWA

Additional water needed (AWN) should not be confused with additional water acquisition (AWA). AWN is the total amount of water needed (at Sumner Dam) to always meet target flows after all available inflows above FSID's diversion right have been bypassed. AWA is limited to the additional water that would be acquired to mitigate for the lack of inflows available for bypass or to use in place of bypasses.

3.2.3 Estimation of AWN to Meet Target Flows

Model results for the alternatives with no CPWA or AWA options were postprocessed to compute the AWN to meet target flows after all the available bypass water was used. Figure 4.5 illustrates how model results for bypass flows only could be used to compute AWN to meet target flows at the Near Acme gage for sample constant target flows of 35 cfs. As shown on the figure, bypassing inflows above FSID's diversion right would substantially augment flows at the Near Acme gage as compared to the pre-1991 baseline and how AWN water is estimated. Additionally, as shown on figure 4.5, AWN does not quite meet all of the target flows because the curve does not intercept the y-axis at 35 cfs, where the x-axis is 100 percent. Variable travel times and an inability to perfectly predict FSID irrigation return flows result in an inability to achieve target flows 100 percent of the time. In other words, it is impossible to always distribute the AWN precisely when it is needed. This situation also is illustrated by the portion of the curve in figure 4.5 that was augmented by the AWN above the target flows of 35 cfs. A fish conservation pool (FCP) would be used to augment bypass flows to help meet AWN requirements for a given alternative.

3.2.4 Simulation of AWA to Further Augment Flows

While CPWA options are acquisitions to mitigate for increased depletions resulting from changes in Carlsbad Project operations designed to benefit the shiner, AWA options are acquisitions to augment flows in upper critical habitat for the shiner (as characterized by the prescribed target flows of the alternatives). AWA would be specifically included to provide water for the shiner in periods when the local inflow supply available for bypass is insufficient to meet target demands. To limit the number of computer simulations, only the Taiban Constant and Acme Constant Alternatives were modeled with AWA. These two alternatives were modeled because they represent low- and high-magnitude bypass flow operations.

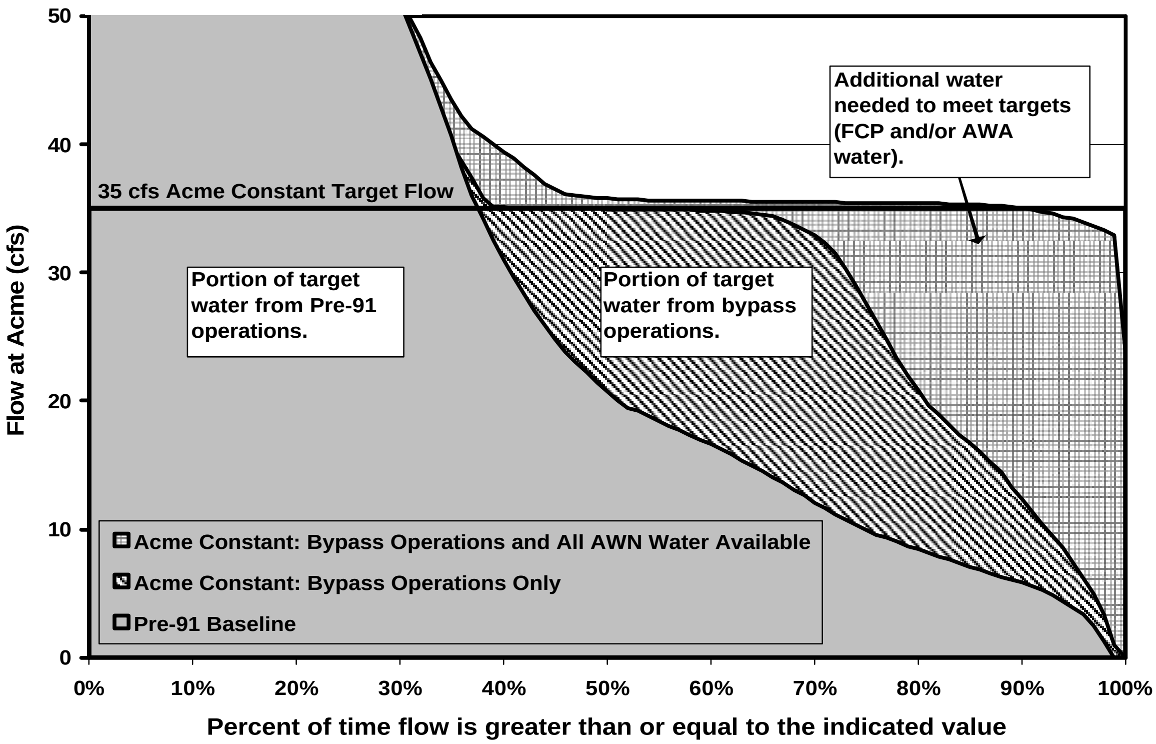

Figure 4.5 Flow exceedance curves resulting from bypass flows and AWN (example: constant target flows of 35 cfs) at the Near Acme gage.

Four scenarios for the Taiban Constant and Acme Constant Alternatives with AWA were modeled. These four scenarios were intended to encompass all of the hydrologic routing possibilities on the AWA "A" list described in chapter 2. Changes to CID cropping patterns were not modeled because it was unlikely that exchanging saved cropping pattern water for AWA would be used in place of bypass flows because this water would be subject to the same inflow availability. Changes to FSID cropping patterns were not modeled specifically because FSID forbearance modeling is a similar scenario (forbearance with reduced irrigation return flow). The four modeled scenarios included:

- From FSID: located downstream from Sumner Dam but with supply originating above the dam

- From various upstream acequia districts: diverters located upstream of Sumner Dam along the reach between the Below Santa Rosa Dam and Near Puerto de Luna gages

- From the Fort Sumner well field: located downstream from Sumner Dam

- Through FSID gravel pit pumping

3.3 Impact Analysis

The results of the analysis of the impacts of proposed actions on water resources indicators are presented individually for each alternative. The summary for each alternative includes details on flows in the upper critical habitat for the shiner. The results include flow exceedance curves and predictions on the frequency of river drying (or intermittency) at the Near Acme gage, AWN to always meet designated target flows after all available bypass water has been used, net depletions to the Carlsbad Project water supply, and net depletions to Pecos River flows at the State line.

3.3.1 No Action Alternative

The No Action Alternative represents current management and includes operations stipulated in the Final Biological Opinion for the Bureau of Reclamation's Proposed Pecos River Dam Operations, March 1, 2003, through February 28, 2006, dated June 18, 2003 (BO; Fish and Wildlife Service [Service], 2003). Targets for augmenting flows in critical habitat for the shiner are between the extremes that were analyzed for other alternatives. Likewise, the resulting average annual net depletions to the Carlsbad Project (1,600 acre-feet per year) and flows at the State line (1,200 acre-feet per year) are in the middle of the extremes determined for all the alternatives. The average additional transmission loss in all river reaches is 2,200 acre-feet, and the annual average amount of water lost to spills is negligible. Model results show that the maximum additional annual transmission loss to the Carlsbad Project water supply is 5,400 acre-feet per year, and the maximum annual net depletion to State-line flows is 3,000 acre-feet per year. The average annual bypass volume is 7,800 acre-feet per year, the average annual volume released in block releases is approximately 7,100 acre-feet per year less than under the pre-1991 baseline; and losses to evaporation are 690 acre-feet per year less. Model results show that the average annual AWN to always meet this alternative's target flows is 2,900 acre-feet per year.

The No Action Alternative was designed to prevent the occurrence of intermittency in the upper critical habitat during dry times; 205 days of no flow were modeled at the Near Acme node over the 60-year modeling period (0.94 percent of the time). Table 4.2 presents values for these and other water resources indicators under the No Action Alternative and pre-1991 baseline. The level of flow augmentation is depicted by the flow exceedance curves presented in figure 4.6**,** which focuses on lower flows. Higher flows would occur slightly less frequently under the alternatives than under the pre-1991 baseline because some of the inflows above FSID's diversion right would be bypassed rather than diverted to storage and released later in block releases.

How to Read the Summary Tables – Part I

The summary water resource impact tables are filled with modeled values for all of the resource indicators relevant for alternative impact analysis. This informational box provides additional information about the table and terms used in it.

Modeled intermittency at the Near Acme gage: This section of the table provides the modeled total percentage, number of days, and number of occurrences for single or consecutive events of river drying (during the 60-year modeling period) at the Near Acme gage under the given alternative, compared with the same values under the No Action Alternative and the pre-1991 baseline.

Water needed to meet target flows: In this portion of the table, the columns to the left, under the heading "60-year annual average," are from left to right:

- Total water needed: the total modeled amount of water needed (in acre-feet) to achieve all of the target flows for an alternative. The sum of bypassed water and AWN is equal to the total water needed.

- Available water bypassed: the modeled amount of available inflow (in acre-feet) that was bypassed in order to achieve the target specified by an alternative.

- Additional water needed (AWN): the modeled amount of additional water required (in acre-feet), due to the lack of available bypass supply, to achieve all of the specified target flows for an alternative.

The columns to the right under the heading "Maximum and minimum additional water needed" from left to right tabulate:

- Maximum AWN: the maximum annual modeled amount of AWN (in acre-feet) required by an alternative. The column to the right indicates the modeled year this maximum occurred.

- Minimum AWN: the minimum annual modeled amount of AWN (in acre-feet) required by an alternative. The column to the right indicates the modeled year this minimum occurred.

Why are all the values for AWN and net depletions zero for the pre-1991 baseline? These were presented along with the intermittency numbers (that contain non-zero values) to indicate how the net depletions are determined. The pre-1991 baseline represents when the river system was operated solely for efficiency.

Net depletions to the Carlsbad Project water supply without CPWA: This section of the table presents the impacts of the alternatives without the addition of CPWA water used to keep the project supply and, subsequently, the State-line whole. To the left, underneath the heading "60-year averages," the columns from left to right are:

- Total net depletions: the modeled total average annual loss of water from the Carlsbad Project water supply caused by an alternative without the addition of CPWA.

- Additional transmission loss (all reaches): the modeled average annual additional transmission loss due to an alternative in all of the modeled reaches upstream of CID.

- Saved evaporation: the modeled annual average of water that was saved from reservoir evaporation due to bypass operations specified by an alternative. Bypassing inflows through the reservoirs saves water from evaporating.

- Water lost to additional conservation spills: the additional annual average volume of water that spilled from the reservoirs due to an alternative and, subsequently, becomes unavailable for use in the Carlsbad Project.

How to Read the Summary Tables – Part II

The summary water resource impact tables are filled with modeled values for all of the resource indicators relevant for alternative impact analysis. This informational box provides additional information about the table and terms used in it.

Net depletions to the Carlsbad Project water supply without CPWA (continued): To the right, underneath the heading "Additional transmission loss – Sumner to Brantley," the columns from left to right contain:

- Average additional transmission loss: the modeled average annual amount of additional water lost in transit in between Sumner Lake and Brantley Reservoir under an alternative. This additional loss is mostly due to bypass operations.

- Maximum additional transmission loss: the maximum annual amount of additional water lost in transit between Sumner Lake and Brantley Reservoirs due to an alternative's bypass operations. This modeled maximum is only due to the effects of bypass operations. The modeled year this maximum occurred appears in the next column to the right.

- Minimum additional transmission loss: the minimum annual amount of additional water lost in transit between Sumner Lake and Brantley Reservoir due to an alternative's bypass operations. This modeled minimum is only due to the effects of bypass operations. The modeled year this minimum occurred appears in the next column to the right.

Net depletions to State-line flows: This section of the table shows the impacts of the alternatives without CPWA on State-line flows. To the left, underneath the heading "60-year averages," columns are described from left to right:

- Total net depletion: the average annual modeled reduction to flows passing the State line due to an alternative.

- Reduction in CID return flows and ground-water inflows: the modeled average annual amount of loss to return flows from CID and ground-water inflows in the Carlsbad area due to an alternative.

- Water gained from additional conservation spills: water that contributes to State-line flows from additional conservation spills due to an alternative.

To the right, underneath the heading "Maximum and minimum total State-line flow net depletions," the columns from left to right tabulate:

- Maximum net depletions to State-line flow: the maximum annual modeled reduction to flows passing the State line due to an alternative. The modeled year this maximum occurred is shown in the next column to the right.

- Minimum net depletions to State-line flow: the minimum annual modeled reduction to flows passing the State line due to an alternative. The modeled year this minimum occurred is shown in the next column to the right.

Negative "net depletion" values: Negative net depletion values (whether they are to the Carlsbad Project water supply or State-line flows) indicate a net *accretion*. Instead of water being lost to the resource indicator or process due to an alternative, it is gained. The converse is also true for table entries that present results in terms of additional water gained from an alternative.

Table 4.2 Summary of impacts on water resources indicators for the No Action Alternative

Alternative/ Baseline	Modeled intermittency at the Near Acme gage							
	Total intermittency		Number of occurrences over 60-years - for single or consecutive days of intermittency					
	Percent of time	Number of days (out of 60 years)	1 day	2 to 5 days	6 to 10 days	11 to 20 days	21 to 30 days	Greater than 30 days
Pre-1991	1.20 percent	263	4	8	9	3	5	0
No Action	0.94 percent	205	1	10	5	2	3	1

Alternative/ Baseline	Water needed to meet target flows						
	60-year annual averages			Maximum and minimum additional water needed			
	Total water needed (acre-feet per year)	Available water bypassed (acre-feet per year)	Additional water needed (AWN) (acre-feet per year)	Maximum AWN (acre-feet)	Maximum occurs in modeled year	Minimum AWN (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	11,000	7,800	2,900	11,000	1956	150	1957

Alternative/ Baseline	Net depletions to the Carlsbad Project water supply without CPWA								
	60-year averages				Additional transmission loss – Sumner to Brantley				
	Total net depletions (acre-feet per year)	Additional trans-mission loss (all reaches; acre-feet per year)	Saved evaporation (all reser-voirs; acre-feet per year)	Water lost to additional conserva-tion spills (acre-feet per year)	Average additional trans-mission loss (acre-feet per year)	Maximum additional trans-mission loss (acre-feet)	Maximum occurs in modeled year	Minimum additional trans-mission loss (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	0	0	---	0	---
No Action	1,600	2,200	690	-13	2,200	5,400	1943	270	1991

Alternative/ Baseline	Net depletions to State-line flows without CPWA						
	60-year averages			Maximum and minimum total State-line flow net depletions			
	Total net depletions (acre-feet per year)	Reduction in CID return flows and ground-water inflows (acre-feet per year)	Water gained from additional conservation spills (acre-feet per year)	Maximum net depletions to State-line flow (acre-feet)	Maximum occurs in modeled year	Minimum net depletions to State-line flow (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	1,200	1,200	-13	3,000	1975	-440	1941

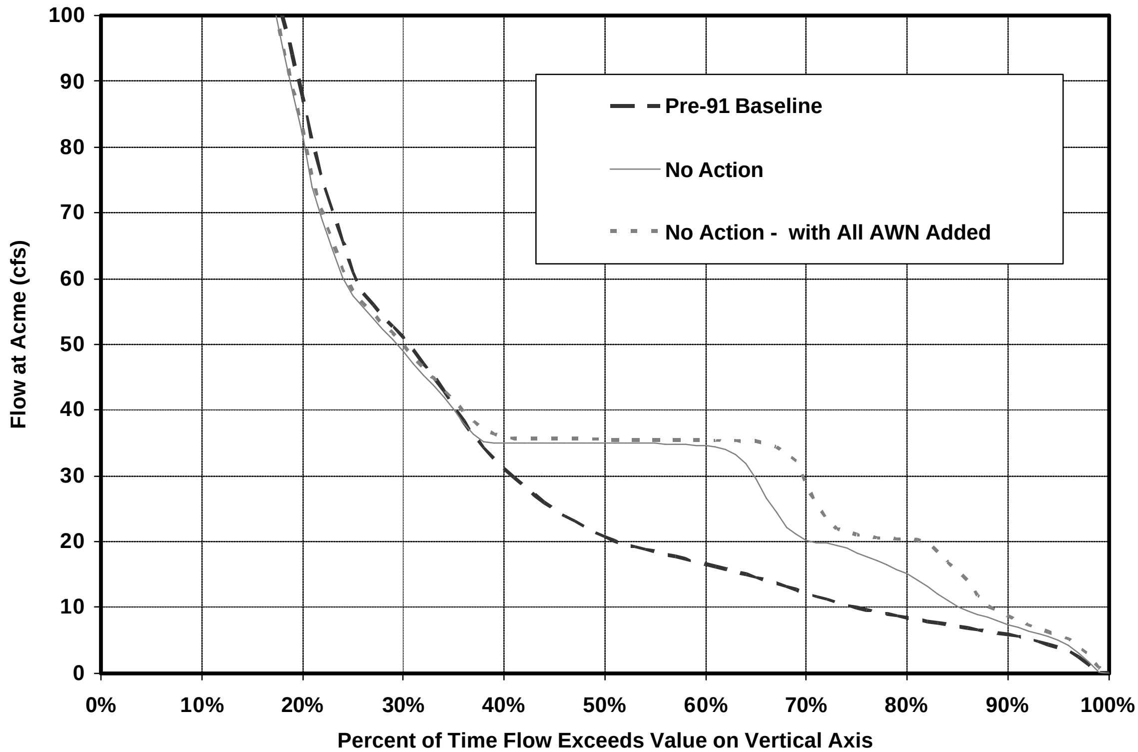

Figure 4.6 Impact of No Action Alternative on flows at the Near Acme gage.

3.3.2 Taiban Constant Alternative

Model results show average annual net depletions of 1,200 acre-feet per year to the Carlsbad Project water supply under the Taiban Constant Alternative, resulting from constant target flows of 35 cfs at the Taiban gage. Although these depletions equal those under Taiban Variable (40 cfs) and Critical Habitat Alternatives, net depletions to State-line flows (440 acre-feet per year) under the Taiban Constant Alternative are the lowest of all the alternatives. The average additional transmission loss is 860 acre-feet per year, and the annual average amount of water lost to spills is 660 acre-feet per year. The maximum annual additional transmission loss to the Carlsbad Project water supply is 1,700 acre-feet per year, and maximum annual net depletions to State-line flows are 4,000 acre-feet per year. With 450 acre-feet per year of saved evaporation and an average annual bypass volume of 1,900 acre-feet per year, the average annual volume of block releases is approximately 1,500 acre-feet per year less than under the pre-1991 baseline. The average annual AWN is 720 acre-feet per year.

Model results show that intermittency occurs less frequently under the Taiban Constant Alternative (0.89 percent of the time, or 196 days over the 60-year modeling period). Table 4.3 presents values for these and other water resources indicators for the Taiban Constant and No Action Alternatives and pre-1991 baseline. Figure 4.7 presents flow exceedance curves.

Table 4.3 Summary of impacts on water resources indicators for the Taiban Constant Alternative

Alternative/ Baseline	Modeled intermittency at the Near Acme Gage							
	Total intermittency		Number of occurrences over 60-years – for single or consecutive days of intermittency					
	Percent of time	Number of days (out of 60 years)	1 day	2 to 5 days	6 to 10 days	11 to 20 days	21 to 30 days	Greater than 30 days
Pre-1991	1.20 percent	263	4	8	9	3	5	0
No Action	0.94 percent	205	1	10	5	2	3	1
Taiban Constant	0.89 percent	196	6	5	6	2	4	0

Alternative/ Baseline	Water needed to meet target flows						
	60-year annual averages			Maximum and minimum additional water needed			
	Total water needed (acre-feet per year)	Available water bypassed (acre-feet per year)	AWN (acre-feet per year)	Maximum AWN (acre-feet)	Maximum occurs in modeled year	Minimum AWN (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	11,000	7,800	2,900	11,000	1956	150	1957
Taiban Constant	2,600	1,900	720	3,700	1971	54	1995

Alternative/ Baseline	Net depletions to the Carlsbad Project water supply without CPWA								
	60-year averages				Additional transmission loss - Sumner to Brantley				
	Total net depletions (acre-feet/ year)	Additional transmission loss (all reaches; acre-feet/ year)	Saved evaporation (all reservoirs; acre-feet per year)	Water lost to additional conservation spills (acre-feet per year)	Average annual additional transmission loss (acre-feet per year)	Maximum additional transmission loss (acre-feet)	Maximum occurs in modeled year	Minimum additional transmission loss (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	0	0	---	0	---
No Action	1,600	2,200	690	-13	2,200	5,400	1943	270	1991
Taiban Constant	1,200	990	450	660	860	1,700	1971	10	1986

Alternative/ Baseline	Net depletions to State-line flows without CPWA						
	60-year averages		Maximum and minimum total State-line flow net depletions				
	Total net depletions (acre-feet per year)	Reduction in CID return flows and ground-water inflows (acre-feet per year)	Water gained from additional conservation spills (acre-feet per year)	Maximum net depletions to State-line flow (acre-feet)	Maximum occurs in modeled year	Minimum net depletions to State-line flow (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	1,200	1,200	-13	3,000	1975	-440	1941
Taiban Constant	440	1,100	660	4,000	1964	-1,400	1999

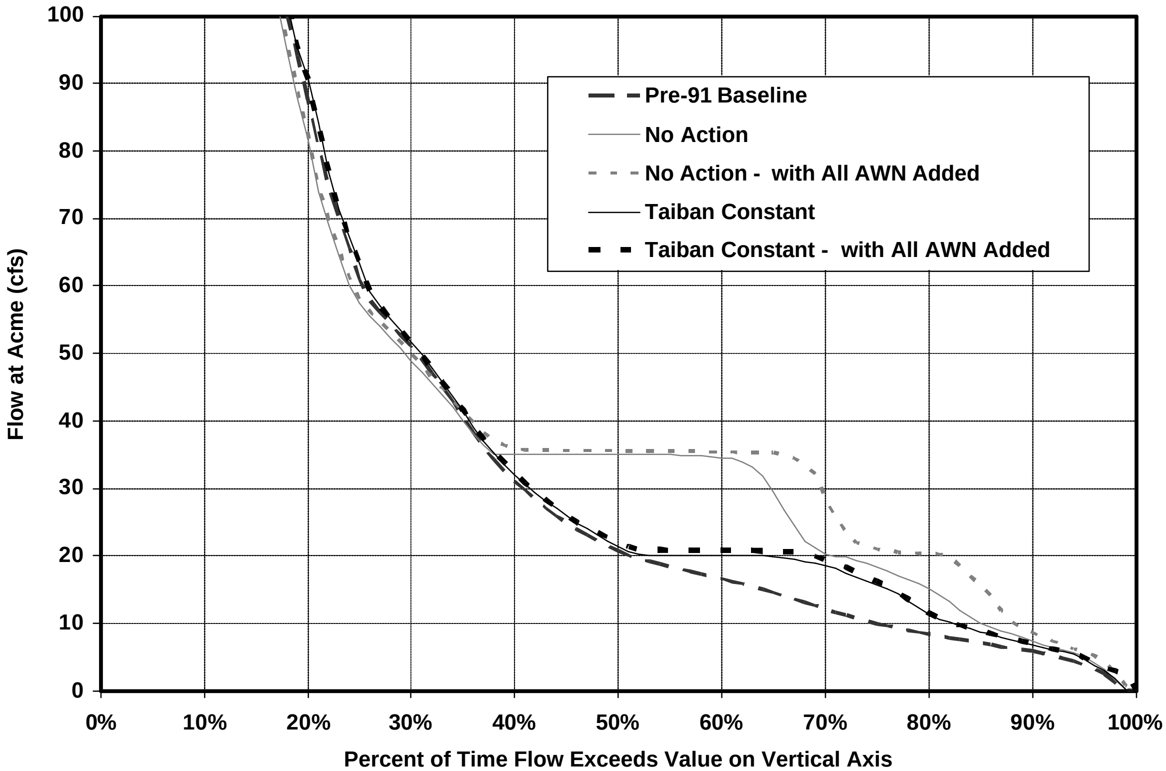

Figure 4.7 Impact of Taiban Constant Alternative on flows at the Near Acme gage.

> **Analysis of the Taiban Variable Alternative**
>
> The Taiban Variable Alternative was split into three separate analyses for the water resources impact analysis. This was done to facilitate modeling the three target flows specified at the Taiban gage during the irrigation season: 40 cfs, 45 cfs, and 55 cfs. (See table 2.2 in chapter 2.) These were respectively designated as Taiban Variable low-range summer, Taiban Variable mid-range summer, and Taiban Variable high-range summer. The reference to "summer" is a term for analysis that represents target flows throughout the irrigation season, as opposed to "winter," which correlates more closely to the nonirrigation season. Throughout the water resources impact section, impacts for this alternative are presented for all three of the irrigation season target flows that were modeled.

3.3.3 Taiban Variable Alternative

The Taiban Variable Alternative has three formulations of target flows at the Taiban gage during the irrigation season: LRS (40 cfs), MRS (45 cfs), and HRS (55 cfs). The expected average annual net depletions to the Carlsbad Project water supply are presented as a range: 1,200 to 1,700 acre-feet per year, with an annual maximum additional transmission loss of 3,700 acre-feet per year. The average additional transmission loss ranges from 1,200 to 2,500 acre-feet per year, and the annual average amount of water lost to spills ranges from 200 to 400 acre-feet per year. Likewise, model results show the average annual net depletions to flows at the State line vary from

690 to 1,600 acre-feet per year, with a maximum of 5,300 acre-feet per year. The average annual bypass volume ranges from 2,200 to 4,800 acre-feet per year. Saved evaporation ranges from 370 to 600 acre-feet per year, with 1,800 to 3,800 acre-feet less water transmitted by block release than under the pre-1991 baseline. The average annual AWN ranges from 1,400 to 4,200 acre-feet per year. See table 4.4 for the specific values that correspond with each of the irrigation season target flows.

Model results show that intermittency occurs less frequently under the Taiban Variable Alternative: 0.85 percent of the time, or 187 days over the 60-year modeling period with target flows of 55 cfs; 0.80 percent (176 days) with target flows of 45 cfs; and 0.63 percent (137 days) with target flows of 40 cfs. Table 4.4 presents values for these and other water resources indicators for the Taiban Variable and No Action Alternatives and the pre-1991 baseline. Figures 4.8 through 4.10 present flow exceedance curves. The curves are similar for all target flows, with the majority of the difference for the bypass target curves noted in the 90-100-percent frequency range.

Table 4.4 Summary of impacts on water resources indicators for the Taiban Variable Alternative

Alternative/ Baseline	Modeled Intermittency at the Near Acme Gage							
	Total intermittency		Number of occurrences over 60-years - for single or consecutive days of intermittency					
	Percent of time	Number of days (out of 60 years)	1 day	2 to 5 days	6 to 10 days	11 to 20 days	21 to 30 days	Greater than 30 days
Pre-1991	1.20 percent	263	4	8	9	3	5	0
No Action	0.94 percent	205	1	10	5	2	3	1
Taiban Variable (40 cfs)	0.85 percent	187	2	6	5	2	4	0
Taiban Variable (45 cfs)	0.80 percent	176	1	5	7	2	3	0
Taiban Variable (55 cfs)	0.63 percent	137	1	4	6	3	1	0

Alternative/ Baseline	Water needed to meet target flows						
	60-year annual averages			Maximum and minimum additional water needed			
	Total water needed (acre-feet per year)	Available water bypassed (acre-feet per year)	AWN (acre-feet per year)	Maximum AWN (acre-feet)	Maximum occurs in modeled year	Minimum AWN (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	11,000	7,800	2,900	11,000	1956	150	1957
Taiban Variable (40 cfs)	3,600	2,200	1,400	5,300	1956	82	1995
Taiban Variable (45 cfs)	5,600	3,200	2,400	6,900	1956	210	1987
Taiban Variable (55 cfs)	9,000	4,800	4,200	10,000	1956	450	1995

Table 4.4 Summary of impacts on water resources indicators for the Taiban Variable Alternative

Alternative/ Baseline	Net depletions to the Carlsbad Project water supply without CPWA								
	60-year averages				Additional transmission loss - Sumner to Brantley				
	Total net depletions (acre-feet per year)	Additional transmis-sion loss (all reaches; acre-feet per year)	Saved evapora-tion (all reservoirs; acre-feet per year)	Water lost to additional conserva-tion spills (acre-feet per year)	Average additional trans-mission loss (acre-feet/ year)	Maximum additional trans-mission loss (acre-feet)	Maximum occurs in modeled year	Minimum additional trans-mission loss (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	0	0	---	0	---
No Action	1,600	2,200	690	-13	2,200	5,400	1943	270	1991
Taiban Variable (40 cfs)	1,200	1,200	370	400	1,100	1,900	1971	27	1986
Taiban Variable (45 cfs)	1,500	1,800	600	320	1,700	2,600	1975	320	1958
Taiban Variable (55 cfs)	1,700	2,500	600	210	2,500	3,700	1943	890	1958

Alternative/ Baseline	Net depletions to State-line flows without CPWA						
	60-year averages			Maximum and minimum total State-line flow net depletions			
	Total net depletions (acre-feet per year)	Reduction in CID return flows and ground-water inflows (acre-feet per year)	Water gained from additional conservation spills (acre-feet per year)	Maximum net depletions to State-line flow (acre-feet)	Maximum occurs in modeled year	Minimum net depletions to State-line flow (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	1,200	1,200	-13	3,000	1975	-440	1941
Taiban Variable (40 cfs)	690	1,100	400	4,400	1964	-1,100	1999
Taiban Variable (45 cfs)	1,000	1,300	320	4,600	1976	-770	1999
Taiban Variable (55 cfs)	1,600	1,400	210	5,300	1964	-150	1950

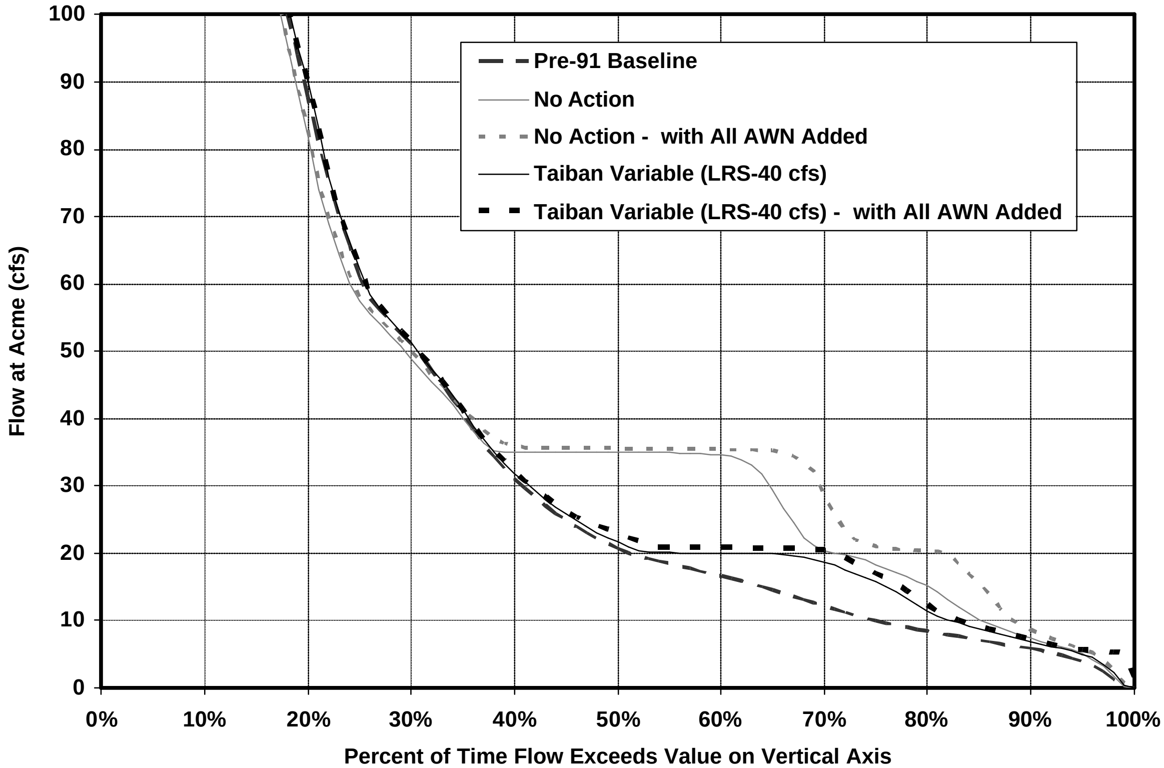

Figure 4.8 Impact of Taiban Variable Alternative (40 cfs) on flows at the Near Acme gage.

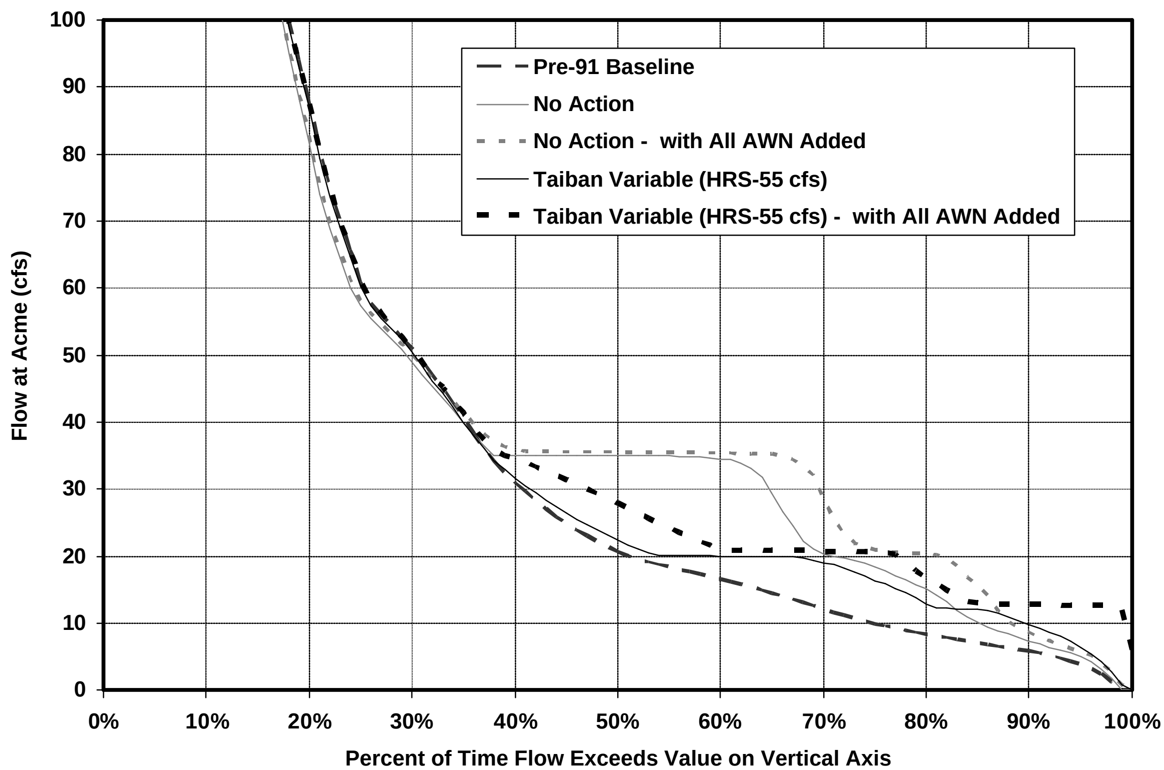

Figure 4.9 Impact of Taiban Variable Alternative (45 cfs) on flows at the Near Acme gage.

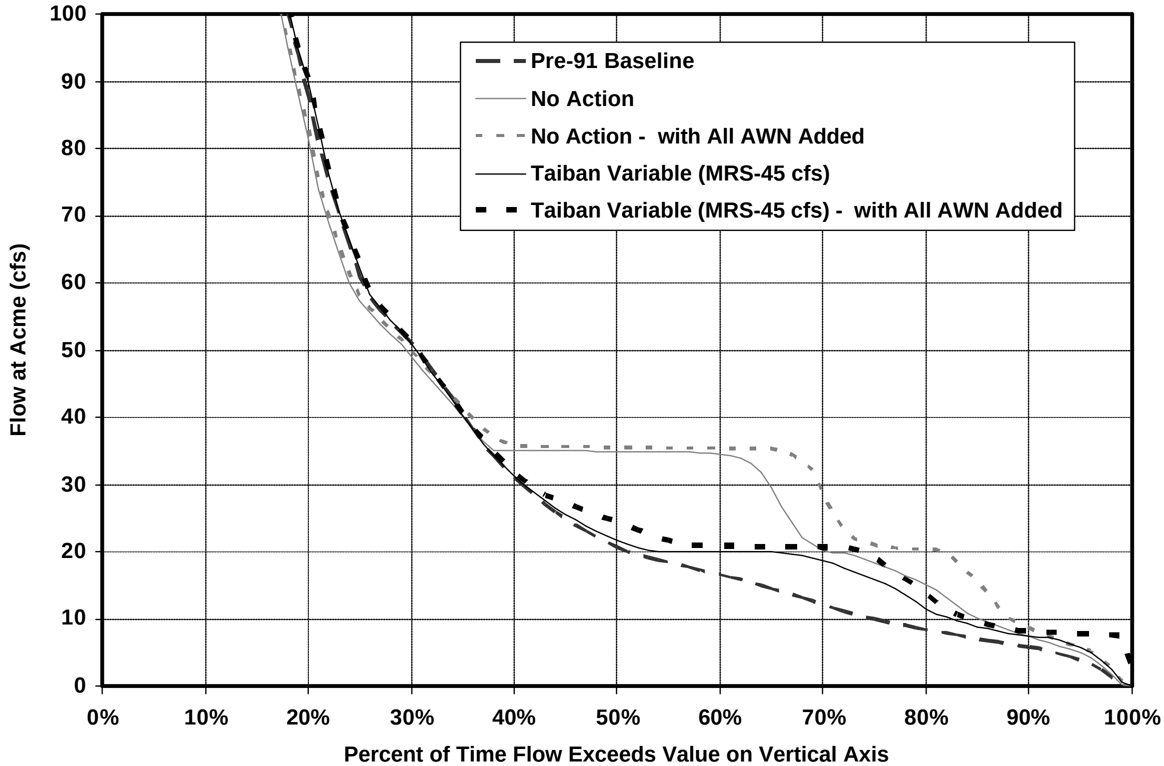

Figure 4.10 Impact of Taiban Variable Alternative (55 cfs) on flows at the Near Acme gage.

3.3.4 Acme Constant Alternative

This alternative includes the highest target for augmenting flows in critical habitat for the shiner and represents the extreme in regard to water needs. Model results show that the average annual net depletions to the Carlsbad Project (3,900 acre-feet per year) and flows at the State line (2,100 acre-feet per year) are higher than under any other alternative. Similarly, the maximum annual net depletions to the Carlsbad Project water supply (6,900 acre-feet per year) are greater than under any other alternative. The average annual transmission loss in all the reaches is 4,400 acre-feet per year, and the annual average amount of water lost to spills is 900 acre-feet per year. The average annual bypass volume is 13,000 acre-feet per year, with an average annual AWN of 9,500 acre-feet per year. The average annual volume released in block releases is approximately 11,600 acre-feet per year less than under the pre-1991 baseline, and losses to evaporation are 1,400 acre-feet per year less.

Model results show that intermittency occurs less frequently under the Acme Constant Alternative than under the pre-1991 baseline, but it is not completely eliminated. Model results still show 147 days of no flow over the 60-year modeling period (0.67 percent of the time). Table 4.5 presents values for these and other water resources indicators for the Acme Constant and No Action Alternatives and the pre-1991 baseline. Figure 4.11 presents flow exceedance curves.

Table 4.5 Summary of impacts on water resources indicators for the Acme Constant Alternative

Alternative/ Baseline	Modeled Intermittency at the Near Acme gage							
	Total intermittency		Number of occurrences over 60-years - for single or consecutive days of intermittency					
	Percent of time	Number of days (out of 60 years)	1 day	2 to 5 days	6 to 10 days	11 to 20 days	21 to 30 days	Greater than 30 days
Pre-1991	1.20 percent	263	4	8	9	3	5	0
No Action	0.94 percent	205	1	10	5	2	3	1
Acme Constant	0.67 percent	147	3	2	5	2	3	0

Alternative/ Baseline	Water needed to meet target flows						
	60-year annual averages			Maximum and minimum additional water needed			
	Total water needed (acre-feet per year)	Available water bypassed (acre-feet per year)	Additional water needed (AWN) (acre-feet per year)	Maximum AWN (acre-feet)	Maximum occurs in modeled year	Minimum AWN (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	11,000	7,800	2,900	11,000	1956	150	1957
Acme Constant	23,000	13,000	9,500	20,000	1971	1,200	1941

Alternative/ Baseline	Net depletions to the Carlsbad Project water supply without CPWA								
	60-year averages				Additional transmission loss - Sumner to Brantley				
	Total net depletions (acre-feet per year)	Additional trans-mission loss (all reaches; acre-feet per year)	Saved evapora-tion (all reservoirs; acre-feet per year)	Water lost to additional conserva-tion spills (acre-feet per year)	Average additional trans-mission loss (acre-feet per year)	Maximum additional trans-mission loss (acre-feet)	Maximum occurs in modeled year	Minimum additional trans-mission loss (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	0	0	---	0	---
No Action	1,600	2,200	690	-13	2,200	5,400	1943	270	1991
Acme Constant	3,900	4,400	1,400	900	4,200	6,900	1979	1,700	1958

Alternative/ Baseline	Net depletions to State-line flows without CPWA						
	60-year averages			Maximum and minimum total State-line flow net depletions			
	Total net depletions (acre-feet per year)	Reduction in CID return flows and ground-water inflows (acre-feet per year)	Water gained from additional conservation spills (acre-feet per year)	Maximum net depletions to State-line flow (acre-feet)	Maximum occurs in modeled year	Minimum net depletions to State-line flow (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	1,200	1,200	-13	3,000	1975	-440	1941
Acme Constant	2,100	3,000	900	5,400	1976	-1,200	1941

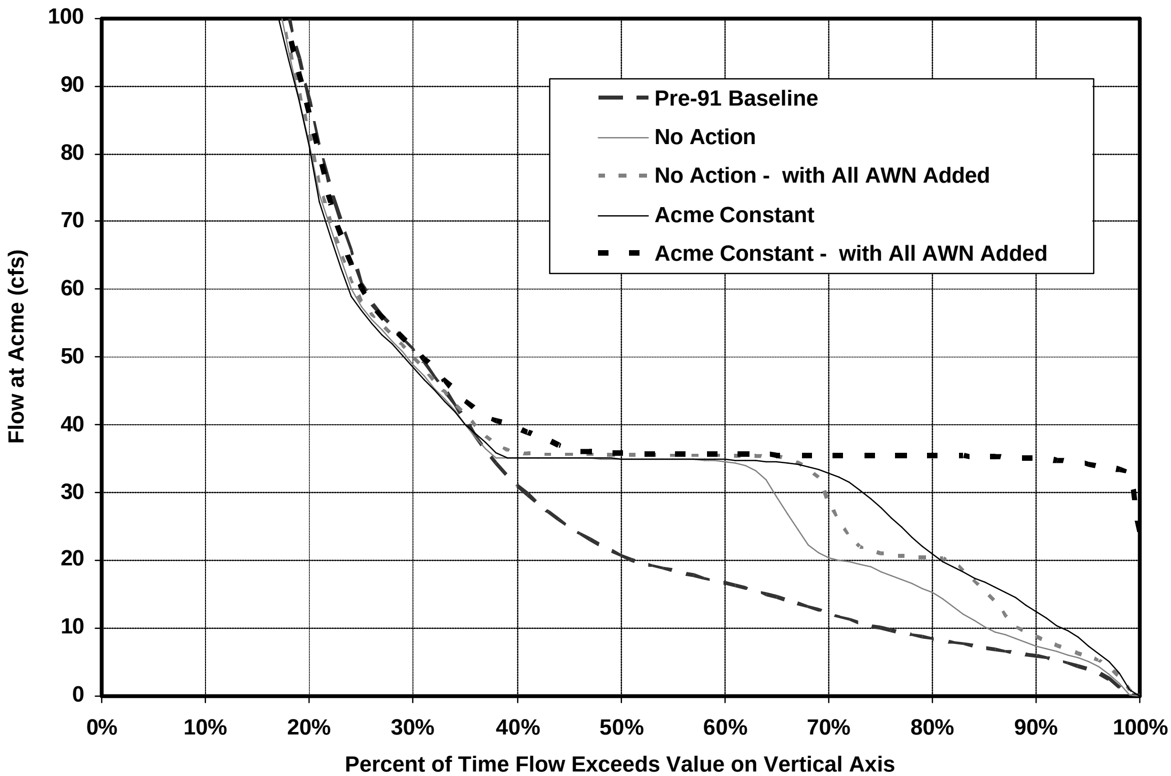

Figure 4.11 Impact of Acme Constant Alternative on flows at the Near Acme gage.

3.3.5 Acme Variable Alternative

The Acme Variable Alternative includes different target flows depending on hydrologic condition (wet, average, or dry). Water needs would be lower than under the Acme Constant Alternative but higher than under all of the other alternatives. Model results show that the average annual bypass volume is 9,700 acre-feet per year, with an average annual AWN of 5,300 acre-feet per year. The average annual net depletions to the Carlsbad Project water supply are 3,000 acre-feet per year, and net depletions to flows at the State line are 1,600 acre-feet per year. The average annual transmission loss in all the reaches is 3,300 acre-feet per year, and the annual average amount of water lost to spills is 720 acre-feet per year. The maximum annual transmission loss depletions to the Carlsbad Project water supply are 5,900 acre-feet per year, and the maximum annual depletions to State-line flows are 4,900 acre-feet per year. The average annual volume released in block releases is approximately 8,700 acre-feet per year less than under the pre-1991 baseline, and losses to evaporation are 960 acre-feet per year less.

Model results show that intermittency occurs less frequently under the Acme Variable Alternative (150 days for the 60-year modeling period, or 0.68 percent of the time), yielding approximately the same benefit as the Acme Constant Alternative in regard to reducing the occurrence of zero flow at the Near Acme gage. Table 4.6 presents values for these and other water resources indicators for the Acme Variable and No Action Alternatives and the pre-1991 baseline.

Figure 4.12 presents flow exceedance curves. The distinct "stair-steps" evident in these flow exceedance curves illustrate the effect of the different target flows.

Table 4.6 Summary of impacts on water resources Indicators for the Acme Variable Alternative

Alternative/ Baseline	Modeled Intermittency at the Near Acme gage							
	Total intermittency		Number of occurrences over 60-years - for single or consecutive days of intermittency					
	Percent of time	Number of days (out of 60 years)	1 day	2 to 5 days	6 to 10 days	11 to 20 days	21 to 30 days	Greater than 30 days
Pre-1991	1.20 percent	263	4	8	9	3	5	0
No Action	0.94 percent	205	1	10	5	2	3	1
Acme Variable	0.68 percent	150	4	3	5	3	2	0

Alternative/ Baseline	Water needed to meet target flows						
	60-year annual averages			Maximum and minimum additional water needed			
	Total water needed (acre-feet per year)	Available water bypassed (acre-feet per year)	Additional water needed (AWN) (acre-feet per year)	Maximum AWN (acre-feet)	Maximum occurs in modeled year	Minimum AWN (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	11,000	7,800	2,900	11,000	1956	150	1957
Acme Variable	15,000	9,700	5,300	15,000	1956	760	1949

Alternative/ Baseline	Net depletions to the Carlsbad Project water supply without CPWA								
	60-year averages				Additional transmission loss - Sumner to Brantley				
	Total net depletions (acre-feet per year)	Additional transmis-sion loss (all reaches--acre-feet per year)	Saved evapor-ation (all reservoirs; acre-feet per year)	Water lost to additional conservati on spills (acre-feet per year)	Average additional transmis-sion loss (acre-feet per year)	Maximum additional transmis-sion loss (acre-feet)	Max-imum occurs in modeled year	Minimum additional transmis-sion loss (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	0	0	---	0	---
No Action	1,600	2,200	690	-13	2,200	5,400	1943	270	1991
Acme Variable	3,000	3,300	960	720	3,100	5,900	1943	2,000	1946

Alternative/ Baseline	Net depletions to State-line flows without CPWA						
	60-year averages			Maximum and minimum total State-line flow net depletions			
	Total net depletions (acre-feet per year)	Reduction in CID return flows and ground-water inflows (acre-feet per year)	Water gained from additional conservation spills (acre-feet per year)	Maximum net depletions to State-line flow (acre-feet)	Maximum occurs in modeled year	Minimum net depletions to State-line flow (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	1,200	1200	-13	3,000	1975	-440	1941
Acme Variable	1,600	2300	720	4,900	1976	-1,000	1941

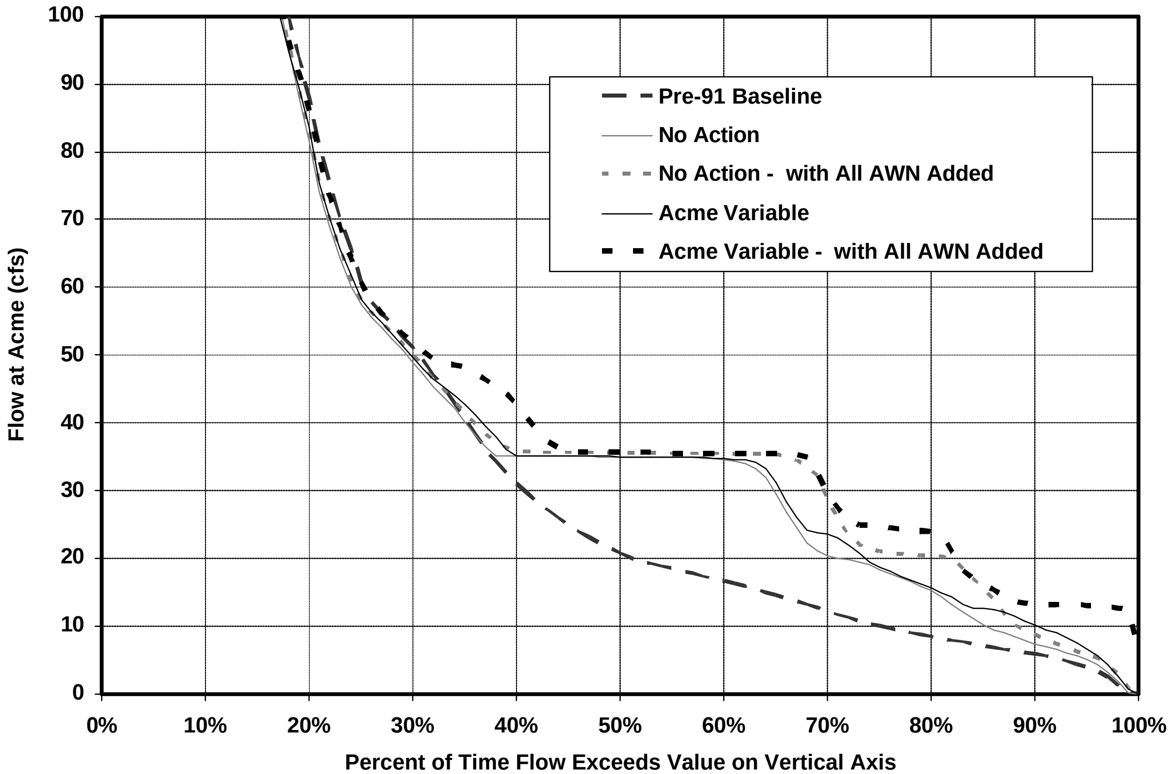

Figure 4.12 Impact of Acme Variable Alternative on flows at the Near Acme gage.

3.3.6 Critical Habitat Alternative

The Critical Habitat Alternative includes different target flows for different hydrologic conditions (wet, average, or dry), but the magnitudes of the target flows are lower than for the Acme Variable Alternative. The water needs for meeting the target flows prescribed by the Critical Habitat Alternative are close to the lowest extreme relative to the water needs of other alternatives. The Critical Habitat Alternative was designed primarily to keep the critical habitat for the shiner wet. Model results show that the associated net depletions to the Carlsbad Project water supply are 1,200 acre-feet per year, and the average annual net depletions to flows at the State line are 530 acre-feet per year. The average annual transmission loss in all the reaches is 1,100 acre-feet per year, and the annual average amount of water lost to spills is 580 acre-feet per year. The maximum annual transmission depletions and maximum annual depletions to State-line flows are 1,400 and 4,000 acre-feet per year, respectively. The average annual bypass volume is 2,100 acre-feet per year, with an average annual AWN of 620 acre-feet per year. The average annual volume released in block releases is approximately 1,700 acre-feet per year less than under the pre-1991 baseline, and losses to evaporation are 390 acre-feet per year less.

Model results show that intermittency occurs more frequently under the Critical Habitat Alternative than under any other alternative (234 days for the 60-year modeling period, or 1.00 percent of the time). The Critical Habitat Alternative showed the largest modeled intermittency of all the alternatives for two reasons:

the alternative was only designed to keep the upper critical habitat wet and not the river at the Near Acme gage (just like the No Action Alternative), and unlike the No Action Alternative, the Critical Habitat Alternative has a 6-week restriction on block releases in the middle of the summer. Block releases in dry periods when inflows are unavailable for bypass flows can help to alleviate intermittency. Table 4.7 presents values for these and other water resources indicators for the Critical Habitat and No Action Alternatives and the pre-1991 baseline. Figure 4.13 presents flow exceedance curves.

Table 4.7 Summary of impacts on water resources indicators for the Critical Habitat Alternative

Alternative/ Baseline	**Modeled Intermittency at the Near Acme gage**							
	Total intermittency		**Number of occurrences over 60-years – for single consecutive days of intermittency**					
	Percent of time	Number of days (out of 60 years)	1 day	2 to 5 days	6 to 10 days	11 to 20 days	21 to 30 days	Greater than 30 days
Pre-1991	1.20 percent	263	4	8	9	3	5	0
No Action	0.94 percent	205	1	10	5	2	3	1
Critical Habitat	1.00 percent	234	2	10	8	3	4	0

Alternative/ Baseline	**Water needed to meet target flows**						
	60-year annual averages			**Maximum and minimum additional water needed**			
	Total water needed (acre-feet per year)	Available water bypassed (acre-feet per year)	AWN (acre-feet per year)	Maximum AWN (acre-feet)	Maximum occurs in modeled year	Minimum AWN (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	11,000	7,800	2,900	11,000	1956	150	1957
Critical Habitat	2,700	2,100	620	4,000	1956	93	1957

Alternative/ Baseline	**Net depletions to the Carlsbad Project water supply without CPWA**								
	60-year averages				**Additional transmission loss - Sumner to Brantley**				
	Total net deple-tions (acre-feet per year)	Addition-al trans-mission loss (all reaches; acre-feet per year)	Saved evapora-tion (all reservoirs; acre-feet per year)	Water lost to additional conserva-tion spills (acre-feet per year)	Average additional trans-mission loss (acre-feet per year)	Maximum additional trans-mission loss (acre-feet)	Maximum occurs in modeled year	Minimum additional transmissio n loss (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	0	0	---	0	---
No Action	1,600	2,200	690	-13	2,200	5,400	1943	270	1991
Critical Habitat	1,200	1,100	390	580	980	1,400	1961	190	1959

Table 4.7 Summary of impacts on water resources indicators for the Critical Habitat Alternative

Alternative/ Baseline	Net depletions to State-line flows without CPWA						
	60-year averages			Maximum and minimum total State-line flow net depletions			
	Total net depletions (acre-feet per year)	Reduction in CID return flows and ground-water inflows (acre-feet per year)	Water gained from additional conservation spills (acre-feet per year)	Maximum net depletions to State-line flow (acre-feet)	Maximum occurs in modeled year	Minimum net depletions to State-line flow (acre-feet)	Minimum occurs in modeled year
Pre-1991	0	0	0	0	---	0	---
No Action	1,200	1,200	-13	3,000	1975	-440	1941
Critical Habitat	530	1,100	580	4,000	1964	-1,300	1999

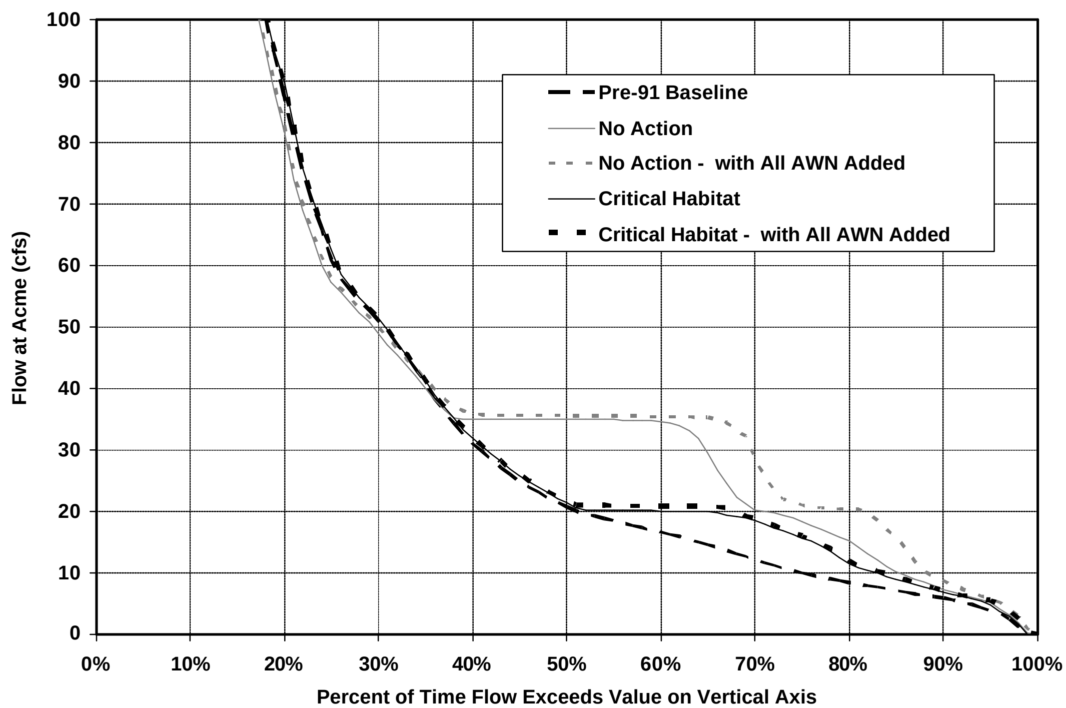

Figure 4.13 Impact of Critical Habitat Alternative on flows at the Near Acme gage.

3.4 Impacts of CPWA Options

This section presents efficiencies for CPWA options and a limited discussion concerning the results of these efficiencies. Efficiencies were calculated by dividing the amount of water that would be realized at Brantley Reservoir by the amount of water added to the Pecos River system at the source. By this definition, CPWA originating within CID was deemed to be 100-percent efficient. For CPWA options not originating within CID, the amount of water realized was limited to the consumptive use portion of the water right less any transmission loss associated with conveying the water to Brantley Reservoir (or CID). The calculated efficiencies were based on the conveyance efficiency for delivering the water to Brantley Reservoir, and it was assumed that CID would use the water as received at Brantley Reservoir. The efficiencies were used to determine the amount of water needed to reduce or eliminate net depletions to Carlsbad Project

> **CPWA Efficiencies**
>
> The effectiveness of Carlsbad Project water acquisition (CPWA) options are measured in efficiency. This efficiency reflects the amount of water that will arrive at Brantley Reservoir considering the CPWA source. If water is added to the river upstream of Brantley Reservoir, that water experiences transmission losses from the point it was added to Brantley Reservoir. The efficiency of each CPWA option denotes the percentage of water that will arrive at Brantley Reservoir from adding water at a certain offset point.

supplies. To provide a connection with the economic impacts presented in section 7 of this chapter, these amounts of water also were converted to retired acreages corresponding to each alternative and CPWA option combination (section 3.4.6).

Generally, if a water acquisition option would reduce net depletions to the Carlsbad Project water supply, it also would reduce net depletions to flows at the State line, unless the water acquisition source is directly from retirement of water rights within CID or changes to CID cropping patterns. In those cases, more spills may occur; however, the additional spills may not compensate for the reduction in CID return flows downstream from Avalon Dam. With these considerations in mind, the effects of water acquisition options on net depletions to State-line flows are discussed further for the options involving retirement of CID water rights or changes to CID cropping patterns.

Each water acquisition option had predetermined CPWA "available amounts" (chapter 2, section 7; Reclamation, 2005b). The results of the model simulations using these predetermined amounts are presented along with calculated efficiencies of each option. The required CPWA amounts to fully negate the average annual net depletions associated with each alternative were calculated. Note that these amounts may exceed the available amounts from the CPWA source, but the values are still presented for comparison.

3.4.1 Lease/Purchase of FSID Water Rights

The retirement of water rights within FSID would result in a reduction in return flows, which would immediately reduce the amount of CPWA that would be realized at Brantley Reservoir. Based on the FSID return flow method developed for the RiverWare model (Burck and Barroll, 2003), FSID only consumes 31 percent of its diversion, which reflects a corresponding total return of 69 percent.

CPWA realized at Brantley Reservoir from a lease/purchase of water rights from FSID would include the consumptive use amount minus transmission losses resulting from the conveyance of that water to Brantley Reservoir. The water that would have returned to the river as return flows (with no lease/purchase of water rights) would be conveyed more efficiently to Brantley Reservoir with a lease/purchase and subsequent release in a block release; however, model results indicate that much of this return flow from FSID already reaches CID.

The average CPWA efficiency for lease/purchase of water rights from FSID is 23 percent. Table 4.8 provides a summary of the results for this water acquisition option. Table 4.8 includes the required CPWA amounts from FSID to fully to keep CID whole under the Taiban Constant and Acme Constant Alternatives. Model results show that a lease/purchase of 5,100 acre-feet per year for the Taiban Constant Alternative and a lease/ purchase of 17,000 acre-feet per year for the Acme Constant Alternative are required to reduce the average annual net depletions. The difference in efficiency is due to the difference in the average annual amount of water moved using block releases (not bypasses); only about 1,500 acre-feet less is moved by a block release under the Taiban Constant Alternative than under the pre-1991 baseline, compared to 12,000 acre-feet less under the Acme Constant Alternative.

Table 4.8 CPWA analysis summary for lease/purchase of FSID water rights

Estimate for available CPWA at source[1]	3,000 acre-feet per year			
Volumes (acre-feet per year) for acquired water rights, the corresponding consumptive use, and associated reduced return flows along with efficiencies computed with the resulting amount that effectively eliminates net depletions to the Carlsbad Project water supply based on transmission efficiency to Brantley Reservoir				
CPWA parameter	**Taiban Constant Alternative**	**Taiban Constant Alternative**	**Acme Constant Alternative**	**Acme Constant Alternative**
Retired or leased diversion	1,500	3,000	1,500	3,000
Retired consumptive use	500	900	500	900
Reduced return flow	1,000	2,100	1,000	2,100
Transmission efficiency to Brantley Reservoir[2]	30 percent	30 percent	17 percent	16 percent
Average transmission efficiency to Brantley Reservoir from CPWA source: 23 percent				

Required average annual CPWA from FSID for each alternative[3] (acre-feet per year)					
No Action Alternative	**Taiban Constant Alternative**	**Taiban Variable Alternative**	**Acme Constant Alternative**	**Acme Variable Alternative**	**Critical Habitat Alternative**
6,800	5,100	5,200 to 7,400	17,000	13,200	5,300

[1] Aggregate amount available from both purchase and lease CPWA options. Only includes consumptive irrigation requirement (CIR) of retired or leased water right.
[2] Efficiency is computed for the forbearance amount (i.e., the purchased amount).
[3] Estimated required CPWA values were computed using the average CPWA efficiency.

3.4.2 River Pumper Retirement

The efficiency of CPWA from river pumper retirement is a function of the consumptive use portion of the retirement plus additional transmission losses associated with conveying the water to Brantley Reservoir (or CID). The consumptive irrigation requirement (CIR) associated with river pumper diversions was assumed to be 2.1 acre-feet per acre for the corresponding diversion right of 3.5 acre-feet per acre (or 60 percent); thus, the resulting return flows are 40 percent of the original diversion. The efficiency of river pumper retirement also would be affected by the difference in transmission losses associated with keeping all of the diversion right in the river, rather than just the return flows.

The water that would have returned to the river as return flows (with no river pumper retirement) would be conveyed more efficiently to Brantley Reservoir with retirement. This water would be included in the higher riverflows resulting from the retirement, and these higher flows would be conveyed to Brantley Reservoir more efficiently than just the return flows. This effect partially offsets the additional transmission losses associated with the CIR portion of river pumper retirement.

The average CPWA efficiency for river pumper retirement is 55 percent. The required river pumper retirement to eliminate the net depletions resulting from the No Action, Taiban Constant, and Acme Constant Alternatives is 2,800, 2,100, and 7,100 acre-feet per year, respectively. Table 4.9 presents results from the individual model runs plus summary information.

Table 4.9 CPWA analysis summary for river pumper retirement

Estimate for available CPWA at source[1]				**3,200 acre-feet per year**		
Volumes (acre-feet per year) for acquired water rights, the corresponding consumptive use, and associated reduced return flows along with efficiencies computed with the resulting amount that effectively eliminates net depletions to the Carlsbad Project water supply based on transmission efficiency to Brantley Reservoir						
CPWA parameter	**Taiban Constant Alternative**	**Taiban Constant Alternative**	**Taiban Constant Alternative**	**Acme Constant Alternative**	**Acme Constant Alternative**	**Acme Constant Alternative**
Retired or leased diversion	1,600	2,300	4,200	1,600	2,300	4,200
Retired consumptive use	960	1400	2,500	960	1,400	2,500
Reduced return flow	640	900	1,700	640	900	1,700
Transmission efficiency [2]	52 percent	50 percent	53 percent	59 percent	61 percent	54 percent
Average transmission efficiency to Brantley Reservoir from CPWA source for all permutations: 55 percent						
Estimated river pumper source volume of CPWA required[3] (acre-feet)						

No Action Alternative	**Taiban Constant Alternative**	**Taiban Variable Alternative**	**Acme Constant Alternative**	**Acme Variable Alternative**	**Critical Habitat Alternative**
2,800	2,100	2,200 to 3,100	7,100	5,500	2,200

[1] Aggregate amount available from both purchase and lease CPWA options. Only includes consumptive irrigation requirement (CIR) of retired or leased water right.
[2] Efficiency is computed for the forbearance amount (i.e., the purchased amount).
[3] Estimated required CPWA values were computed using the average CPWA efficiency.

3.4.3 CPWA Water from CID

Two options were analyzed for acquiring CPWA water from CID:
(1) lease/purchase of water rights and (2) changes to cropping patterns. The lease/purchase of CID water rights would be 100 percent efficient at eliminating net depletions to the Carlsbad Project water supply. Because the water would be acquired directly from CID, there would be no conveyance loss. The amount of water rights that would need to be acquired from CID under each alternative matches the net depletions determined with no CPWA. For the Taiban Constant and Acme Constant Alternatives, 1,200 and 3,900 acre-feet per year, respectively, would need to be acquired from CID. Table 4.10 summarizes these results. The

table also shows the impacts on the State-line resource indicator for the modeled retirement amounts in the CID. Note that these modeled amounts do not correspond to amounts to reduce State-line net depletions completely; these values were not calculated.

Table 4.10 CPWA analysis summary of lease/purchase of CID water rights

Estimate for available CPWA at source[1]	6,300 acre-feet per year

Volumes (acre-feet per year) for acquired water rights along with efficiencies computed with the resulting amount that effectively eliminates net depletions to the Carlsbad Project water supply based on transmission efficiency to Brantley Reservoir

CPWA parameter	Taiban Constant Alternative	Taiban Constant Alternative	Acme Constant Alternative	Acme Constant Alternative
Retired diversion[2]	5,600	11,000	5,600	11,000
Transmission efficiency[3]	100 percent	100 percent	100 percent	100 percent

Average transmission efficiency to Brantley Reservoir from source for all permutations: 100 percent

Required average annual CPWA from CID for each alternative[4] (acre-feet)

No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
1,600	1,200	1,200 to 1,700	3,900	3,000	1,200

Impacts on State-line flows with CPWA from CID retirement or lease (acre-feet per year)

Retired diversion CPWA parameter	Taiban Constant Alternative 5,600[5]	Taiban Constant Alternative 11,000	Acme Constant Alternative 5,600[5]	Acme Constant Alternative 11,000
Additional supplemental pumping	N/A	-2,100	N/A	-1,200
Gains from Avalon Dam spills	N/A	2,000	N/A	1,600
Reduction in CID returns and ground-water inflows	N/A	-200	N/A	1,500
Gains to State-line flows due to CPWA	N/A	3,500	N/A	3,000

[1]Assumes maximum CID allotment for irrigated acreage of 25,055. Only includes consumptive irrigation requirement (CIR) of retired or leased water right.
[2] Modeled average annual diversion retirement.
[3] Efficiency is computed for the purchased (diverted) amount.
[4] Estimate required CPWA values were computed using the average CPWA efficiency.
[5] Not applicable entries indicate volume permutations that were not modeled to the State line.

Changes in surface water delivery to CID would affect return flows to the river downstream from Avalon Dam and could affect the supplemental irrigation well pumping regime in CID, which, in turn, would affect ground-water conditions in the Carlsbad basin. Thus, both of these hydrologic components (i.e., surface water delivery to CID and supplemental well pumping) could affect base inflows to the Pecos River downstream from Avalon Dam and, ultimately, flows at the State line. These changes, along with changes in spills from Avalon Dam, could substantially impact the State's ability to meet its delivery obligation under the Compact. The table shows that for CID retirement, if net depletions to the Carlsbad Project were eliminated with a lease/purchase of CID water rights, the net depletions to flows at the State line would be eliminated. The contrary is true for changes to CID cropping patterns. If cropping patterns of medium (approximately 2 acre-feet/acre CIR) consumptive use crops were changed, State-line deliveries would not be made whole if CID is kept whole.

Changes to CID cropping patterns also would be 100-percent efficient at eliminating net depletions to the Carlsbad Project water supply. Because the water would be acquired directly from CID, there would be no conveyance loss. The amounts of CPWA that would need to be acquired to reduce the net depletions to the Carlsbad Project determined for each alternative with no CPWA are shown in table 4.11. Resulting impacts on State-line resource indicators for the modeled CPWA amounts are also shown in the table.

Table 4.11 CPWA analysis summary for changes to CID cropping patterns

Estimate for available CPWA at source[1]	6,000 to 10,500 acre-feet per year

Modeled alternatives, reduced diversions and transit efficiencies to Brantley from source (all alternative and forbearance volume permutations - acre-feet per year unless noted otherwise)

CPWA parameter	Taiban Constant Alternative – very low water use replacement crop	Taiban Constant Alternative - medium water use replacement crop	Acme Constant Alternative - very low water use replacement crop	Acme Constant Alternative - medium water use replacement crop
Curbed diversion compared to pre-1991 baseline[2]	14,000	5,200	14,000	5,200
Transmission efficiency	100 percent	100 percent	100 percent	100 percent

Average transmission efficiency to Brantley Reservoir from CPWA source: 100 percent

Estimated CID source volume of CPWA required[3] (acre-feet)

No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
1,600	1,200	1,200 to 1,700	3,900	3,000	1,200

Impacts on State-line flows with CPWA from CID retirement or lease (acre-feet per year)

CPWA parameter	Taiban Constant Alternative - very low water use replacement crop	Taiban Constant Alternative - medium water use replacement crop	Acme Constant Alternative - very low water use replacement crop	Acme Constant Alternative - medium water use replacement crop
Additional supplemental pumping	-2,500	-1,300	-1,400	-360
Gains from Avalon spills	5,100	2,700	4,900	2,500
Reduction in CID returns and ground-water inflows	2,700	3,900	4,400	5,600
Gains to State-line flow due to CPWA	2,600	-800	2,300	-1,100

[1] Range of possible CPWA for different replacement crops
[2] Saved water was not added back into allotment computation. For medium water use crops, this caused curbed diversion amounts to be lower than the estimated savings for consumptive use (6,000 acre-feet).
[3] Estimated required CPWA values were computed using the average CPWA efficiency.

3.4.4 Well Field Development

This water acquisition option would involve retiring ground-water pumping rights within the Roswell basin and using some of these rights on an as-needed basis to pump water to the river. Pumping scenarios were investigated for two different well field locations: near Buffalo Valley and near Seven Rivers.

The RABGW model was used to simulate modifications to pumping schedules to account for retirement and augmentation well field operations. The retirement component involved a uniformly distributed decrease in pumping, which means all of the pumping inputs in the Roswell basin were reduced proportionally to model the 10,000 acre-feet of retired consumptive use per year. Because the average annual net depletions for the Taiban Constant and Acme Constant Alternatives were much less than the indicated maximum capacity of the well field (20,000 acre-feet per year), the capacity was reduced to 10,000 acre-feet per year for modeling purposes. The augmentation pumping schedule was determined based on the bypass volume for the preceding month and corresponding decrease in conveyance efficiency relative to the efficiency of block releases (50 percent). The Pecos River RiverWare model was used to compute the initial required pumping amounts, and the RABGW model was used to model the change to Pecos River base inflows along the reach between the Near Acme and Near Artesia gages. Changes to aquifer storage also were determined. Model results show an average efficiency of 62 percent for this water acquisition option.

The calculated efficiency with the Taiban Constant Alternative is lower because the same amount of consumptive use was retired (uniformly from the entire basin), but the amount pumped to the river was lower (due to the lower bypass volume). As a result, the level of the water table rose, and a portion of the CPWA water was lost to evapotranspiration. This is an example of how acquiring too much CPWA could introduce new net depletions. Table 4.12 presents required CPWA amounts to fully make up for net depletions associated with each alternative.

Table 4.12 CPWA analysis summary for pumping from well fields

Estimate for available CPWA at source[1]	**20,000 acre-feet per year**			
Volumes (acre-feet per year) for retired consumptive use and pumped amounts along with efficiencies computed with the resulting amounts that effectively eliminates net depletions to the Carlsbad Project water supply based on transit efficiencies to Brantley Reservoir				
CPWA parameter	**Taiban Constant Alternative: Seven Rivers**	**Taiban Constant Alternative: Buffalo Valley**	**Acme Constant Alternative: Seven Rivers**	**Acme Constant Alternative: Buffalo Valley**
Well field capacity and retired consumptive use	10,000	10,000	10,000	10,000
Pumped amount	970	1,000	6,600	7,200
Base inflow gain	3,700	3,400	3,400	1,700

Table 4.12 CPWA analysis summary for pumping from well fields

Transmission efficiency [2]	42 percent	40 percent	92 percent	76 percent	
Average transmission efficiency to Brantley Reservoir from CPWA source: 62 percent					
Required average annual CPWA from well field for each alternative[3] (acre-feet)					
No Action Alternative	**Taiban Constant Alternative**	**Taiban Variable Alternative**	**Acme Constant Alternative**	**Acme Variable Alternative**	**Critical Habitat Alternative**
2,500	1,900	1,900 to 2,700	6,300	4,900	2,000

[1] Aggregate amount available from both well field options (Seven Rivers and Buffalo Valley).
[2] Efficiency is computed for the capacity of the well field. Efficiency accounts for pumped amounts and increased base inflows due to retirement.
[3] Estimated required CPWA values were computed using the average CPWA efficiency.

3.4.5 FSID Gravel Pit Pumping

Estimated ground-water inflow to the FSID gravel pit is 300 acre-feet per year (Duke Engineering and Services, 2000). As a water acquisition option, this water would be pumped to the river when flows exceed 350 cfs. This option was simulated for two pumping rates: 10 and 20 acre-feet per day. Because the water would be added only when riverflows are higher, the transmission efficiency for conveying this water to Brantley Reservoir (or CID) corresponds to the efficiency of these higher flows. This efficiency matches the model results for this option with the Taiban Constant and Acme Constant Alternatives. The CPWA efficiency is 74 percent. Table 4.13 summarizes the impacts. Even though the supply is limited, the amounts of CPWA that would need to be pumped from the FSID gravel pit to eliminate the net depletions associated with each alternative are presented for comparison.

Table 4.13 CPWA analysis summary for FSID gravel pit pumping

Estimate for available CPWA at source [1]	**300 acre-feet per year**			
Volumes (acre-feet per year) for pumped amounts along with efficiencies computed with the resulting amounts that effectively eliminates net depletions to the Carlsbad Project water supply based on transit efficiencies to Brantley Reservoir				
Parameter	**Taiban Constant Alternative 10 acre-feet/day**	**Taiban Constant Alternative 20 acre-feet/day**	**Acme Constant Alternative 10 acre-feet/day**	**Acme Constant Alternative 20 acre-feet/day**
Gravel pit annual inflow	300	300	300	300
Average annual pumping	249	296	222	288
Transmission efficiency[2]	72 percent	83 percent	71 percent	69 percent
Average transmission efficiency to Brantley Reservoir from CPWA source: 74 percent				
Required average annual CPWA from pumping gravel pit for each alternative [3] (acre-feet)				

No Action Alternative	**Taiban Constant Alternative**	**Taiban Variable Alternative**	**Acme Constant Alternative**	**Acme Variable Alternative**	**Critical Habitat Alternative**
2,100	1,600	1,600 to 2,300	5,300	4,100	1,700

[1] Estimate is dependent on inflow to gravel pit; gravel pit inflows are known to interact with FSID returns.
[2] Efficiency was computed using the pumped amount.
[3] Estimated required CPWA values were computed using the average CPWA efficiency.

3.4.6 CPWA Water Converted to Acreages

The estimates for necessary CPWA water to keep the Carlsbad Project water supply whole were converted to acreages for the applicable CPWA options and alternatives. The resulting estimated acreages are shown in table 4.14.

Table 4.14 CPWA water requirements converted to acreages

Alternative	Acreage retirement required for CPWA[1]					
	FSID lease or purchase	FSID gravel pit pumping	River pumper lease or purchase	CID lease or purchase	Change CID cropping pattern	PVACD lease or purchase for well field
No Action	3,300	N/A	1,400	800	1,600	1,200
Taiban Constant	2,500	N/A	1,000	600	1,200	900
Taiban Variable (40 cfs)	2,500	N/A	1,000	600	1,200	900
Taiban Variable (45 cfs)	3,100	N/A	1,300	700	1,500	1,200
Taiban Variable (55 cfs)	3,500	N/A	1,500	800	1,700	1,300
Acme Constant	8,100	N/A	3,400	1,900	3,900	3,000
Acme Variable	6,200	N/A	2,600	1,400	3,000	2,300
Critical Habitat	2,500	N/A	1,000	600	1,200	900

[1] FSID gravel pit pumping does not translate to acreages; cropping pattern acreage represents amount of acreage that must be converted (using average range of consumptive use for all replacement crops).

3.5 Impacts of AWA Options

Impacts for obtaining water from four separate AWA sources were analyzed. These four different sources included:

- AWA from FSID. While FSID is located downstream from Sumner Dam, the water originates upstream of the dam
- AWA from acequia districts upstream of Sumner Dam
- Pumping from the Fort Sumner well field
- FSID gravel pit pumping

Although the main focus of the analyses was to determine the effect of AWA on the occurrence of intermittency at the Near Acme gage, changes to the amount of time that target flows are met were also reviewed. While the primary purpose of AWA is to augment flows in critical habitat for the shiner beyond that achieved with bypass flows, the effects of AWA options on net depletions to the Carlsbad Project water supply also were analyzed.

3.5.1 AWA from FSID

If AWA were obtained from FSID to increase riverflows, only the consumptive use portion of FSID's water right would be available because return flows already return to the river, subsequently supplementing flows in the river. Much of the acquired water (69 percent on average) would be in the river as return flows without AWA (Burck and Barroll, 2003). This effect, combined with the expected conveyance losses to seepage and evapotranspiration, would yield a negligible benefit. In fact, AWA from FSID would not reduce the frequency of intermittency at the Near Acme gage. Model results indicate that zero flows actually occur more often because the lower return flows from FSID corresponding to AWA would increase the demand for bypass flows. For the Taiban Constant Alternative, these effects would also affect the amount of time that target flows are met. Tables 4.15 and 4.16 summarize the impacts for the Taiban Constant and Acme Constant Alternatives, respectively.

Table 4.15 Impact of AWA from FSID with the Taiban Constant Alternative

AWA with Taiban Constant	Average days per year of modeled intermittency (no flow) at the Near Acme gage		Average days per year that the modeled flow at the Taiban gage was increased
	Alternative	Alternative with AWA	Alternative with AWA
FSID (1,500 acre-feet per year)	3.3	5.8	-8.4
FSID (3,000 acre-feet per year)	3.3	7.3	-10.7
FSID (9,040 acre-feet per year)	3.3	5.6	-8.8

Table 4.16 Impact of AWA from FSID with the Acme Constant Alternative

AWA with Acme Constant Alternative	Average days per year of modeled intermittency (no flow) at the Near Acme gage		Average days per year that the modeled flow at the Near Acme gage was increased
	Alternative	Alternative with AWA	Alternative with AWA
FSID (1,500 acre-feet per year)	2.5	3.4	6.0
FSID (3,000 acre-feet per year)	2.5	3.6	21.7
FSID (9,040 acre-feet per year)	2.5	4.9	46.3

Some AWA could reach Brantley Reservoir and become part of the Carlsbad Project water supply, or the change in operations associated with AWA could cause *additional* depletions to the Carlsbad Project water supply. The impacts are not only a function of how much AWA reaches Brantley Reservoir but also a function of how AWA affects the demand for bypass flows to meet target flows associated with an alternative. As FSID irrigation return flows decrease, the demand for bypass flows increases. These two factors combined yield variability in the impacts of AWA between alternatives. Another issue affecting net depletions relates to the timing of AWA. If a block release is being made, AWA would be more efficiently conveyed to Brantley Reservoir as part of the block release. This effect, along with differences in the number of block releases between alternatives, is another reason why additional depletions to the Carlsbad Project water supply differ among alternatives. Table 4.17 summarizes the impacts on the Carlsbad Project water supply under the Taiban Constant and Acme Constant Alternatives.

Table 4.17 Impact of AWA from FSID on net depletions to the Carlsbad Project water supply

Source for AWA	Average annual net depletions (acre-feet)			
	Acme Constant Alternative	Additional depletions from AWA with Acme Constant Alternative	Taiban Constant Alternative	Additional depletions from AWA with Taiban Constant
No AWA	3,900	---	1,200	---
FSID (1,500 acre-feet per year)	4,300	400	1,200	0
FSID (3,000 acre-feet per year)	3,900	0	700	-500
FSID (9,040 acre-feet per year)	4,000	100	900	-300

3.5.2 AWA from Upstream Acequias

AWA agreements may be reached with various upstream acequias along the reach from Santa Rosa Dam to the Near Puerto de Luna gage. The conveyance losses associated with this option would substantially reduce the additional flows realized at the Near Acme gage. In fact, model results indicate intermittency at the Near Acme gage occurs as frequently with AWA from upstream acequia districts. Also, depending on the alternative, AWA from upstream acequia districts may reduce the amount of time that target flows are met. Tables 4.18 and 4.19 summarize the AWA flow frequency and intermittency impacts for the Taiban Constant and Acme Constant Alternatives, respectively.

Table 4.18 Impact of AWA from acequia districts with the Taiban Constant Alternative

AWA with Taiban Constant Alternative	Average days per year of modeled intermittency (no flow) at the Near Acme gage		Average days per year that the modeled flow at the Taiban gage was increased
	Alternative	Alternative with AWA	Alternative with AWA
Near Puerto de Luna gage (900 acre-feet per year)	3.3	4.4	-2.4
Near Puerto de Luna gage (3,000 acre-feet per year)	3.3	4.0	-1.2
Near Puerto de Luna gage (4,300 acre-feet per year)	3.3	3.6	-0.5

Table 4.19 Impact of AWA from acequia districts with the Acme Constant Alternative

AWA with Acme Constant Alternative	Average days per year of modeled intermittency (no flow) at the Near Acme gage		Average days per year that the modeled flow at the Near Acme gage was increased
	Alternative	Alternative with AWA	Alternative with AWA
Near Puerto de Luna gage (900 acre-feet per year)	2.5	2.5	2.4
Near Puerto de Luna gage (3,000 acre-feet per year)	2.5	2.6	6.5
Near Puerto de Luna gage (4,300 acre-feet per year)	2.5	2.3	10.7

AWA from upstream acequia districts would augment the Carlsbad Project water supply. Because all AWA from this source would be an effective gain to the river at the location of the source (i.e., the amount of water would not be effectively reduced because there would be no return flows without AWA), incidental benefits to the Carlsbad Project water supply are always evident. Model results indicate that 1,300 acre-feet more AWA water (from 3,000 to 4,300 acre-feet) showed slight improvement (to the nearest 100 acre-feet) under the Acme Constant Alternative and no improvement under the Taiban Constant Alternative. These results (slight to no improvement for 1,300 acre-foot increase in AWA) are consistent because the volumes are so small and the water is not being transmitted most efficiently (by block release). Table 4.20 summarizes the impacts for the Taiban Constant and Acme Constant Alternatives on net depletions to the Carlsbad Project water supply.

Table 4.20 Impact of AWA from acequia districts on net depletions to the Carlsbad Project water supply

AWA	Average annual net depletions (acre-feet)			
	Acme Constant Alternative	Additional depletions from AWA with Acme Constant Alternative	Taiban Constant Alternative	Additional depletions from AWA with Taiban Constant Alternative
No AWA	3,900	---	1,200	---
Near Puerto de Luna gage (900 acre-feet per year)	3,700	-200	600	-600
Near Puerto de Luna gage (3,000 acre-feet per year)	3,300	-600	500	-700
Near Puerto de Luna gage (4,300 acre-feet per year)	3,200	-700	500	-700

3.5.3 AWA from Fort Sumner Well Field

Model runs were conducted to evaluate whether flows in critical habitat for the shiner could be augmented further by pumping from the Fort Sumner well field. This source, located downstream from Sumner Dam, is in a good location for augmenting flows in the upper critical habitat for the shiner, but the available amount of water is too small to yield a significant change to flows. Tables 4.21 and 4.22 summarize the impacts of the AWA option to flow frequency and intermittency. The impacts on net depletions to the Carlsbad Project water supply (table 4.23) are also small.

Table 4.21 Impact of AWA from Fort Sumner well field with the Taiban Constant Alternative

AWA with Taiban Constant Alternative	Average days per year of modeled intermittency (no flow) at the Near Acme gage		Average days per year that the modeled flow at the Taiban gage was increased
	Alternative	Alternative with AWA	Alternative with AWA
Fort Sumner well field (1,800 acre-feet per year)	3.3	3.3	0.0

Table 4.22 Impact of AWA from Fort Sumner well field with the Acme Constant Alternative

AWA with Acme Constant Alternative	Average days per year of modeled intermittency (no flow) at the Near Acme gage		Average days per year that the modeled flow at the Near Acme gage was increased
	Alternative	Alternative with AWA	Alternative with AWA
Fort Sumner well field (1,800 acre-feet per year)	2.5	2.2	1.7

Table 4.23 Impact of AWA from Fort Sumner well field on net depletions to the Carlsbad Project water supply

AWA	Average annual net depletions (acre-feet)			
	Acme Constant Alternative	Additional depletions from AWA with Acme Constant Alternative	Taiban Constant Alternative	Additional depletions from AWA with Taiban Constant Alternative
No AWA	3,900	---	1,200	---
Fort Sumner well field (1,800 acre-feet per year)	4,000	100	1,000	-200

3.5.4 AWA from FSID Gravel Pit Pumping

The FSID gravel pit could be pumped to augment riverflows, but this source would yield little water to the river. Model results indicate that the available amount of water is too small to yield a substantial change to flows at the Near Acme gage. In other words, 300 acre-feet per year is insignificant compared to the additional water needs of the Taiban Constant and Acme Constant Alternatives. This is reflected in the results, which show no improvement for the Taiban Constant alternative with FSID gravel pit pumping or the slight improvement shown for the Acme Constant Alternative with FSID gravel pit pumping. Tables 4.24 and 4.25 summarize the impacts of the AWA option on flow frequency and intermittency. Table 4.26 presents the slight change to net depletions to the Carlsbad Project water supply.

Table 4.24 Impact of AWA from FSID gravel pit pumping with the Taiban Constant Alternative

AWA with Taiban Constant Alternative	Average days per year of modeled intermittency (no flow) at the Near Acme gage		Average days per year that the modeled flow at the Taiban gage was increased
	Alternative	Alternative with AWA	Alternative with AWA
FSID gravel pit pumping (10 acre-feet per day)	3.3	3.3	0.0
FSID gravel pit pumping (20 acre-feet per day)	3.3	3.3	0.0

Table 4.25 Impact of AWA from FSID gravel pit pumping with the Acme Constant Alternative

AWA with Acme Constant Alternative	Average days per year of modeled intermittency (no flow) at the Near Acme gage		Average days per year that the modeled flow at the Near Acme gage was increased
	Alternative	Alternative with AWA	Alternative with AWA
FSID gravel pit pumping (10 acre-feet per day)	2.5	2.2	0.2
FSID gravel pit pumping (20 acre-feet per day)	2.5	2.2	0.2

Table 4.26 Impact of AWA from FSID gravel pit pumping on net depletions to the Carlsbad Project water supply

AWA	Average annual net depletions (acre-feet)			
	Acme Constant Alternative	Additional depletions from AWA with Acme Constant Alternative	Taiban Constant Alternative	Additional depletions from AWA with Taiban Constant Alternative
No AWA	3,900	---	1,200	---
FSID gravel pit pumping (10 acre-feet per year)	4,100	200	1,100	-100
FSID gravel pit pumping (20 acre-feet per year)	3,900	0	1,100	-100

3.6 Impacts of Modifications to Block Releases

Block release constraints would affect net depletions to the Carlsbad Project water supply, but the magnitude of the impacts would be less than that caused by bypass flows. The limit on the duration of block releases would affect conveyance losses and trends in conservation spills. Because shorter duration block releases are slightly less efficient than the block releases made under the pre-1991 baseline, this restriction would cause slightly greater transmission losses; the difference in trends for conservation spills are explained below.

Model simulations were conducted with separate comparisons of the No Action Alternative (and pre-1991 baseline) to isolate the effects of the proposed constraints to block releases on net depletions to the Carlsbad Project water supply. The comparisons were completed to specifically evaluate how each proposed restriction would affect net depletions, while keeping other policies the same.

Changes to block release patterns would affect spills from Brantley Dam (and Avalon Dam), thus affecting the Carlsbad Project water supply. Bypass flows cause water levels at Brantley Reservoir to be higher, on average; these higher water levels, in turn, cause more spills when conservation storage limits are exceeded (Tetra Tech, Inc., 2003e). As shown on figure 4.14, the limit on the duration of block releases would prevent spills. With the 15-day limit on the duration of block releases, Brantley Reservoir would not be filled as high as with individual block releases. As a result, spills from Brantley Dam (and Avalon Dam) would be lower, on average, as conservation storage limits would not be exceeded as much. This is also shown by the water saved from conservation spills in figure 4.15; however, this effect is more pronounced under the alternatives (700 acre-feet saved under the pre-1991 baseline compared to 1,700 acre-feet under the No Action Alternative).

With the 6-week, no-block-release constraint around August 1, which was modeled as a rigid restriction during the irrigation season, Brantley Reservoir would be kept higher early in the irrigation season to meet irrigation demand through the 6-week, no-block-release period. Therefore, the 6-week, no-block-release constraint would have the opposite effect of the duration constraint, as evidenced by the results shown in figure 4.16. The higher reservoir levels during the early irrigation season would cause more spills, as fewer inflows from monsoon season rainfall events could be stored in the conservation storage pool at Brantley Reservoir.

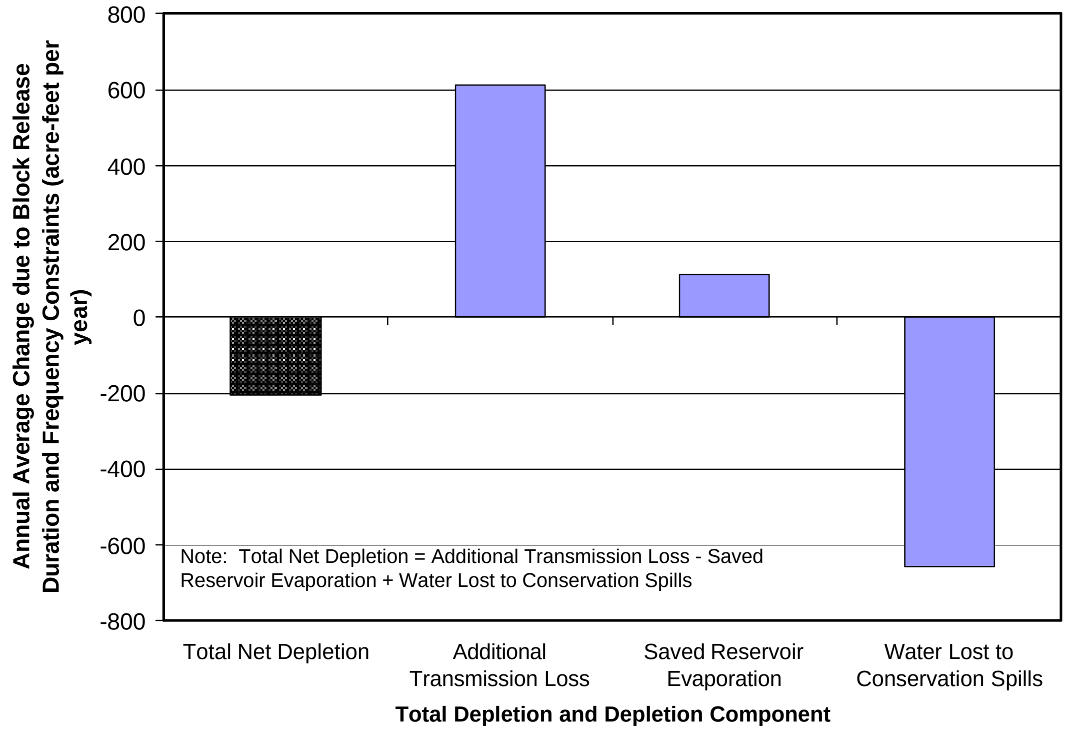

Figure 4.14 Effect of block release constraints (15-day duration limit on block releases, 14-days in between block releases) on Carlsbad Project water supply with pre-1991 baseline no bypass target operations (total net depletions and net depletion components).

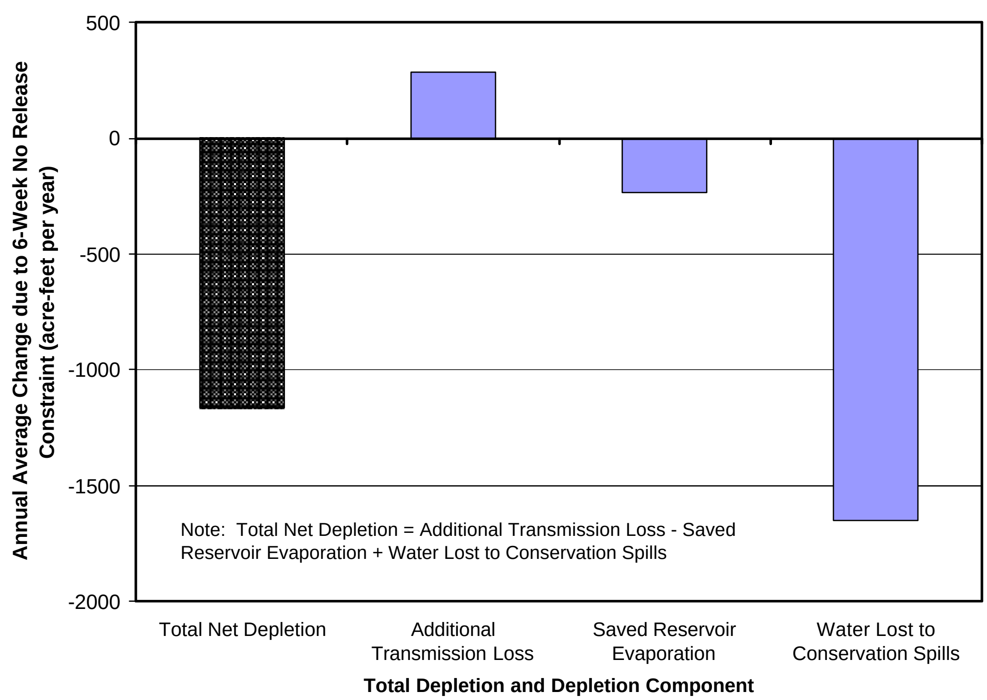

Figure 4.15 Effect of block release constraints (15-day duration limit on block releases, 14-days in between block releases) on Carlsbad Project water supply with No Action Alternative bypass target operations (total net depletions and net depletion components).

In addition to the impacts on Carlsbad Project water supply, impacts of block release modifications were also looked at in terms of their impacts on geomorphology. (See the Geomorphology Memorandum in Appendix 3, "Hydrologic and Water Resources Appendix.") These impacts were investigated in response to concerns that diminishing block release frequencies and volumes (from bypassing) would result in channel narrowing. These impacts were investigated for the original bypass volumes and also for the extreme case of taking all of the AWN from the block release flow frequency range. Both of these cases showed minimal change to modeled channel width in the vicinity of the Near Acme gage due to these reductions in block flows. Because the total volume of block flow was not reduced significantly by bypass operations or by subtracting all of the AWN from the block release frequency range, impacts on channel width under the alternatives considered in this DEIS would be insignificant.

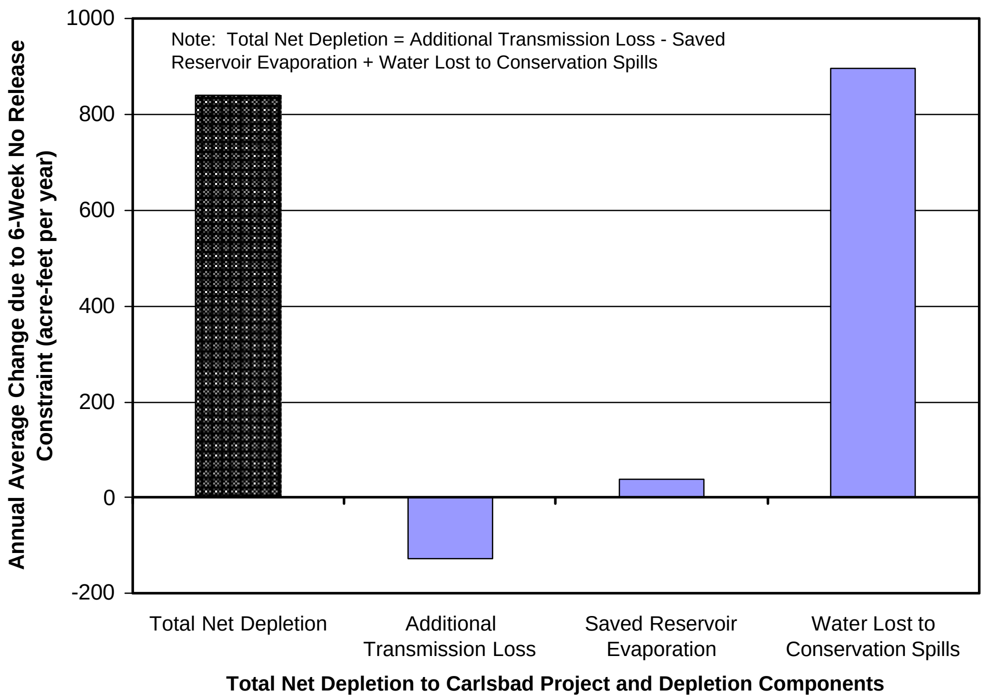

Figure 4.16 Effect of 6-week, no-release constraint centered on August 1 on Carlsbad Project water supply with alternative bypass target operations (total net depletions and net depletion components).

4. Water Quality

As discussed in chapter 3, the following indicators were selected to evaluate water quality:

- Specific electrical conductance (EC)
- Total dissolved solids (TDS), which, in most cases, needs to be computed from EC because of limited TDS data

4.1 Summary of Impacts

Table 4.27 summarizes the impacts of the alternatives on EC in Brantley Reservoir and CID, as measured at the Near Artesia and Below Brantley Dam gages. EC under each action alternative is compared to EC under the No Action Alternative for wet, normal, and dry years, and EC under the No Action Alternative is compared to EC under the pre-1991 baseline. A narrative summary discussion follows.

Table 4.27 Summary of impacts of alternatives on water quality in Brantley Reservoir and CID

Alternative	Impact summary
No Action	EC as much as 900 µS/cm higher in Brantley Reservoir and more than 300 µS/cm higher in CID; higher EC in all year types, but highest in dry year, lowest in wet year. Impacts would be moderate, localized, and long term
Taiban Constant	Slightly higher EC in wet year, but higher than under No Action in other year types. Impacts would be minor, localized, and long term.
Taiban Variable	Higher EC in dry years and lower EC in normal and wet years at high and intermediate target flows; lower EC in wet years and higher EC in normal and dry years at lowest target flows. Impacts would vary with target flows, but overall would be minor, localized, and long term.
Acme Constant	Lower EC in normal and dry years, but higher in wet years when EC is generally lower. Impacts would be moderate, localized, and long term.
Acme Variable	No change in EC in wet year, but lower EC in normal and dry years, highest EC in dry years. Impacts would be moderate, localized, and long-term.
Critical Habitat	Higher EC in all year types. Impacts would be minor, localized, and long term.

Analysis shows that the greatest difference in EC is between the No Action Alternative and the pre-1991 baseline. Thus, if the analysis is representative of conditions in the field, the greatest effects on water quality have already occurred. However, the analysis summarized in table 4.27 does not include the addition of CPWA or AWA options.

Analysis indicates that EC would be lower under the Acme Constant and Acme Variable Alternatives and higher under the Critical Habitat Alternative and Taiban Alternatives than under the No Action Alternative (table 4.27). However, model results indicate that any effects on EC resulting from bypass flows would be eliminated once the CPWA options are in place. As a result, changes in Carlsbad Project operations would have no net effect on water quality.

As shown on table 3.3, the State of New Mexico 303(d) list of impaired waters, five reaches of the Pecos River within the study area are listed as impaired for sedimentation/siltation, primarily as a result of storm runoff. Changes in Carlsbad Project operations would not affect these reaches and the reasons for their listing. The four Carlsbad Project reservoirs are listed as impaired for excessive mercury concentrations in fish tissue. Because these excessive concentrations are related to airborne sources, they also would not be affected by changes in Carlsbad Project operations.

The Pecos River from Sumner Dam to Brantley Reservoir is classified as supporting a warmwater fishery. The 303(d) list includes contaminants, which could adversely affect the ability of the river to support a warmwater fishery. This reach of the Pecos River is shown in the 305(b) report (where the evaluation of water quality is reported) to be fully supporting of all classified uses. In addition to a warmwater fishery, the river is classified for irrigation, livestock watering, wildlife habitat, and secondary contact recreation, i.e., contact that does not involve full body immersion in the water. None of these uses should be adversely affected by changes in Carlsbad Project operations.

4.2 Scope and Methods

The water quality analysis focused on the Pecos River near Brantley Reservoir. The specific electrical conductance of water is related to TDS. Specifically, alternatives were evaluated on the basis of EC at two gages near Brantley Reservoir: Near Artesia and Below Brantley Dam. EC at the Near Artesia gage reflects the EC of the inflow to Brantley Reservoir and also was used to estimate the EC of outflow from Brantley Reservoir. EC at the Near Artesia gage reflects the net effect of the alternatives in the river reach between Sumner Dam and Brantley Reservoir. EC of the outflow from Brantley Reservoir, measured at the Below Brantley Dam gage, represents EC of the water supply to CID.

4.2.1 Assessment of Dry, Normal, and Wet Years for Surface Water

Because surface water quality is intimately related to the amount of water in the system, this analysis relied on the results of the Pecos River RiverWare model. Reservoir storage results from the model were used to calculate the effective Brantley storage, as described in Section 3, “Water Resources.” Effective Brantley storage values were then used to determine whether April 1 of each year should be classified as wet, normal, or dry. Table 4.28 presents the number of wet, normal, and dry years over the 60-year modeling period for each alternative, based on effective Brantley storage.

As shown in table 4.28, the number of dry, normal, and wet years varies by alternative; for most of the action alternatives, there are more dry years than either normal or wet years (e.g., there are more dry years for each action alternative than for the No Action Alternative).

Table 4.28 Number of dry, normal, and wet years over 60-year modeling period by alternative, based on effective Brantley storage

Alternative	Dry years	Average years	Wet years
Pre-1991 baseline	19	21	20
No Action	22	24	14
Taiban Constant	24	19	17
Taiban Variable (40 cfs)	25	18	17
Taiban Variable (45 cfs)	25	17	18
Taiban Variable (55 cfs)	23	19	18
Acme Constant	25	24	11
Acme Variable	23	25	12
Critical Habitat	24	19	17

The median flow years for each grouping in table 4.28 are shown in table 4.29. As might be expected, the median flow year also varies by alternative, with one notable exception. The driest year for each alternative is 1965. The driest year is likely to be the most critical, and its use provides a consistent basis for comparison among the alternatives. In other words, 1965 should represent something of a "worst case" scenario.

Table 4.29 Year between 1940 and 1999 representative of various year types based on effective Brantley storage

Alternative	Driest year	Representative year type by alternative		
		Dry year	Normal year	Wet year
Pre-1991 baseline	1965	1952	1967	1943
No Action	1965	1952	1962	1943
Taiban Constant	1965	1981	1967	1985
Taiban Variable (40 cfs)	1965	1954	1967	1985
Taiban Variable (45 cfs)	1965	1954	1947	1959
Taiban Variable (55 cfs)	1965	1975	1997	1985
Acme Constant	1965	1990	1960	1951
Acme Variable	1965	1949	1960	1943
Critical Habitat	1965	1975	1967	1950

Each action alternative was compared to the No Action Alternative by plotting the daily projected EC at the Near Artesia gage and at the Below Brantley Dam gage for each of the four selected year types: driest, dry, normal, and wet (table 4.29).

4.2.2 Assessment of Ground-Water Quality

The ground-water quality analysis focused on changes in the quality of the recharge water in CID. The quality (EC) of the recharge under each action alternative was compared to the quality under the No Action Alternative. Most of the recharge to the CID ground water would not be affected under any alternative. The most affected sources of recharge would be the seepage from the Main Canal and the Southern Main Canal.

The effects of the water acquisition options vary greatly in their effects on water quality, and effects depend more on the source of the water than the actual amount acquired. As was shown in chapter 3, water quality differs greatly from north to south in both the river and the ground water between Fort Sumner Dam and Brantley Reservoir. The effects on ground-water quality were evaluated based on various scenarios and mixes of source water for the supply. These sources were superimposed on the quality of water at the Near Artesia gage that was estimated as described previously.

4.3 No Action Alternative

Table 4.30 compares the projected average (geometric mean) annual EC at the Near Artesia and Below Brantley Dam gages under the No Action Alternative (which represents current conditions in terms of Carlsbad Project operations) to the pre-1991 baseline for each of the four year types. The table also shows the annual difference in EC.

Table 4.30 Comparison of EC under No Action Alternative to pre-1991 baseline

Gage	Condition	Year	Year type	EC (µS/cm)	
				Average[1]	Difference
Near Artesia	Pre-1991 baseline	1943	Wet	4,707	—
		1967	Normal	5,861	—
		1952	Dry	5,592	—
		1965	Driest	6,213	—
	No Action Alternative	1943	Wet	5,018	285
		1962	Normal	6,280	390
		1952	Dry	6,166	584
		1965	Driest	7,081	937
Below Brantley Dam	Pre-1991 baseline	1943	Wet	4,253	—
		1967	Normal	4,643	—
		1952	Dry	4,527	—
		1965	Driest	4,735	—
	No Action Alternative	1943	Wet	4,361	106
		1962	Normal	4,772	125
		1952	Dry	4,750	204
		1965	Driest	5,043	323

[1] All of the averages presented here and in later tables are based on log-transformed data.

As expected, the highest average EC at each gage occurs in the driest year. However, the second highest EC does not occur in the dry year as expected but, rather, in the normal year (table 4.30). The third highest EC occurs in the dry year. More importantly, all of the comparisons show higher EC under the No

Action Alternative than under the pre-1991 baseline (i.e., all of the differences are positive and illustrative of higher EC). These results indicate that the experimental operations over the last decade would increase the EC of the water supply to CID somewhat (EC at the Below Brantley Dam gage), although that increase is not as great as the increases shown at the Near Artesia gage.

To put the difference in EC into perspective, figure 4.17 shows the effect of higher EC on the yield of alfalfa. The data to construct figure 4.17 were taken from Ayers and Westcot (1985). As shown on figure 4.17, there is a linear decrease in the percent yield of alfalfa with EC of 1,300 to 10,000 microSiemens per centimeter (µS/cm). Each 900-µS/cm increase in EC results in about a 10-percent decrease in alfalfa yield. On this basis, the effects of the higher EC at Brantley Dam would be less than 5 percent. However, under the pre-1991 baseline, annual average EC is about 4,250 to 4,700 µS/cm. With this range, some yield reduction should already be occurring. On the basis of information presented in figure 4.10, the reduction would be about 30 to 40 percent. However, note that the values plotted on figure 4.17 are considered a guide to relative tolerances; absolute tolerances vary depending on climate, soil conditions, and climate (Ayers and Westcot, 1985). In the Pecos River area, at the higher EC values, the presence of gypsum often reduces the actual yield reduction.

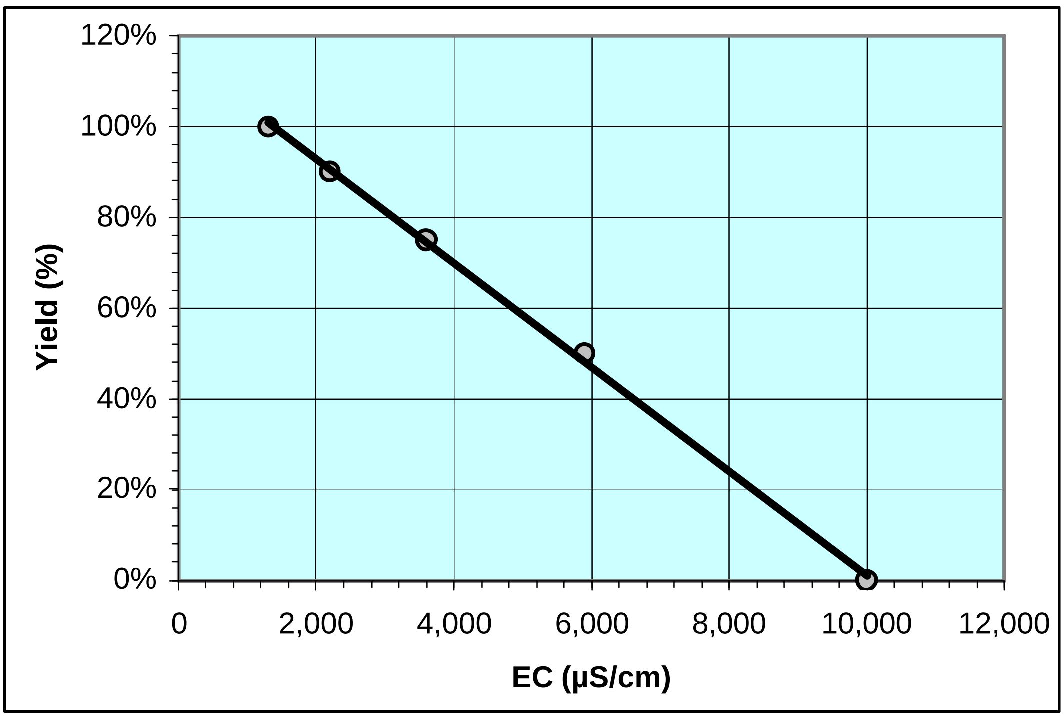

Figure 4.17 Effect of higher EC on alfalfa.

The EC data shown in table 4.30 are annual averages. Within the year, a range in EC would occur. As an example, the projected range in EC for the pre-1991 baseline and the No Action Alternative in a normal year is shown on figure 4.18.

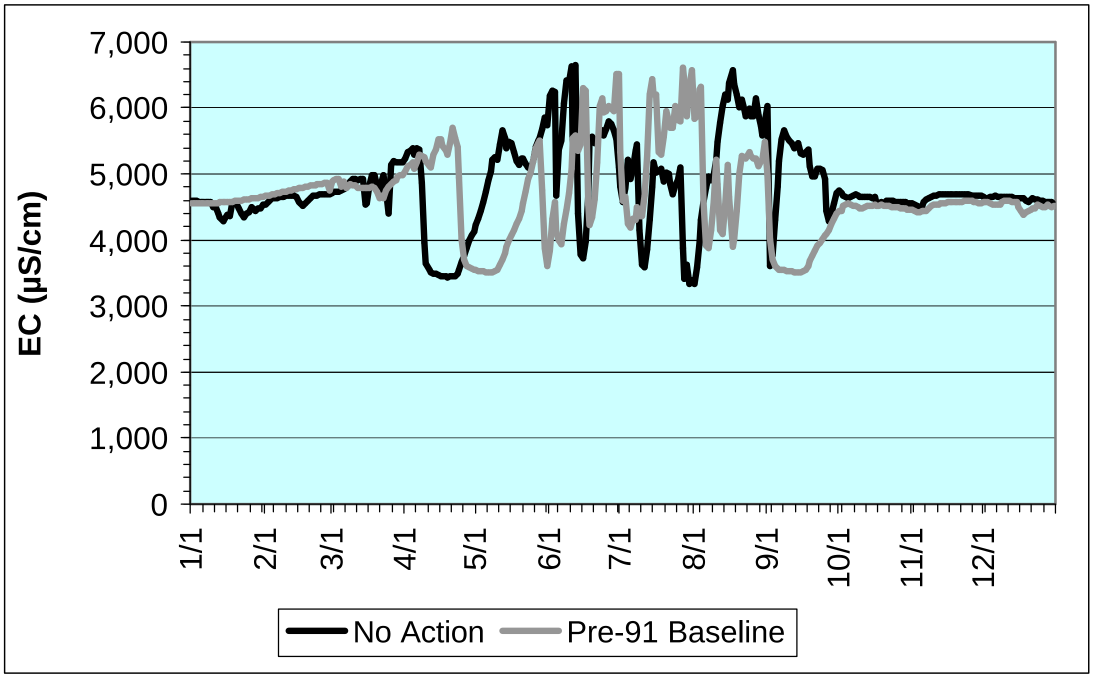

Figure 4.18 Daily EC at the Artesia gage in a normal year under the pre-1991 baseline and No Action Alternative.

As shown on figure 4.18, while EC is higher under the No Action Alternative than under the pre-1991 baseline, it is higher only for part of the year.

The major differences in EC between the No Action Alternative and the pre-1991 baseline include the following:

- Little difference in EC during the winter, although slightly lower EC than under the pre-1991 baseline
- Considerably lower EC during April than under the pre-1991 baseline
- Considerably higher EC through most of May and June than under the pre-1991 baseline
- Generally lower EC than under the pre-1991 baseline during most of the summer

As shown on figure 4.18, daily EC ranges from about 3,500 to about 6,500 µS/cm under both the pre-1991 baseline and the No Action Alternative. From this perspective, effects probably would be about the same under either operation. Depending on the duration of the high EC, the yield reduction would be more a factor of the highest EC, rather than the average.

Another important point is that the sensitivity of alfalfa to salt varies during the growing season. Alfalfa has been shown to be very sensitive to salinity during emergence (Bauder et al., 1992). For example, the results of an experiment by Bauder et al. (1992) indicate that the loss of seedlings increased at TDS concentrations somewhere between 1,150 and 1,650 milligrams per liter (approximate EC of 1,770 to 2,540 µS/cm, respectively). The 100-percent yield level of alfalfa shown on figure 4.17 is at an EC of 1,300 µS/cm, with a 10-percent reduction in yield at 2,200 µS/cm. However, there is a large difference between seedling survival and a reduction in productivity in that the latter only involves growth, not survival.

4.4 Taiban Constant Alternative

The Taiban Constant Alternative has target flows of 35 cfs at the Taiban gage. Figure 4.19 compares the projected average annual EC under the Taiban Constant Alternative and the No Action Alternative at the two sites for each of the four year types.

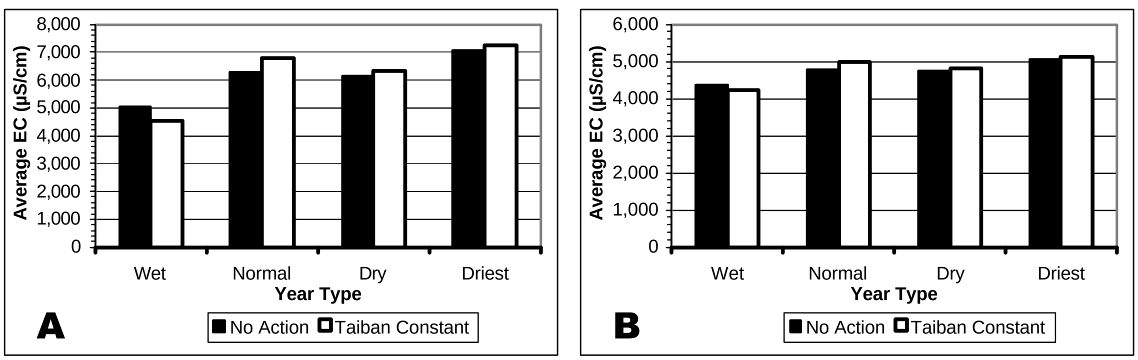

Figure 4.19 Comparison of EC under No Action Alternative and Taiban Constant Alternative: A = Near Artesia gage and B = Below Brantley Dam gage.

The major differences in EC between the Taiban Constant Alternative and the No Action Alternative include the following:

- Higher EC at the Near Artesia gage in three of the four year types
- Lower EC in the wet year
- Because the projected EC at the Below Brantley Dam gage is related to the inflow EC, same pattern of EC changes as at the Near Artesia gage
- Because of the buffering in Brantley Reservoir, lower EC than at the Near Artesia gage
- Smaller differences between each action alternative and the No Action Alternative in EC at the Below Brantley Dam gage than at the Near Artesia gage

These last two factors are true for all alternatives in comparison with the No Action Alternative and are not noted further. However, EC downstream from Brantley Dam is shown.

4.5 Taiban Variable Alternative

The Taiban Variable Alternative has the same winter target flows as the Taiban Constant Alternative, but the Taiban Variable Alternative has three different summer target flows (40, 45, and 55 cfs). Figure 4.20 compares the projected average annual EC under the Taiban Variable Alternative (with each of the three summer target flows) and the No Action Alternative at the two sites for each of the four year types.

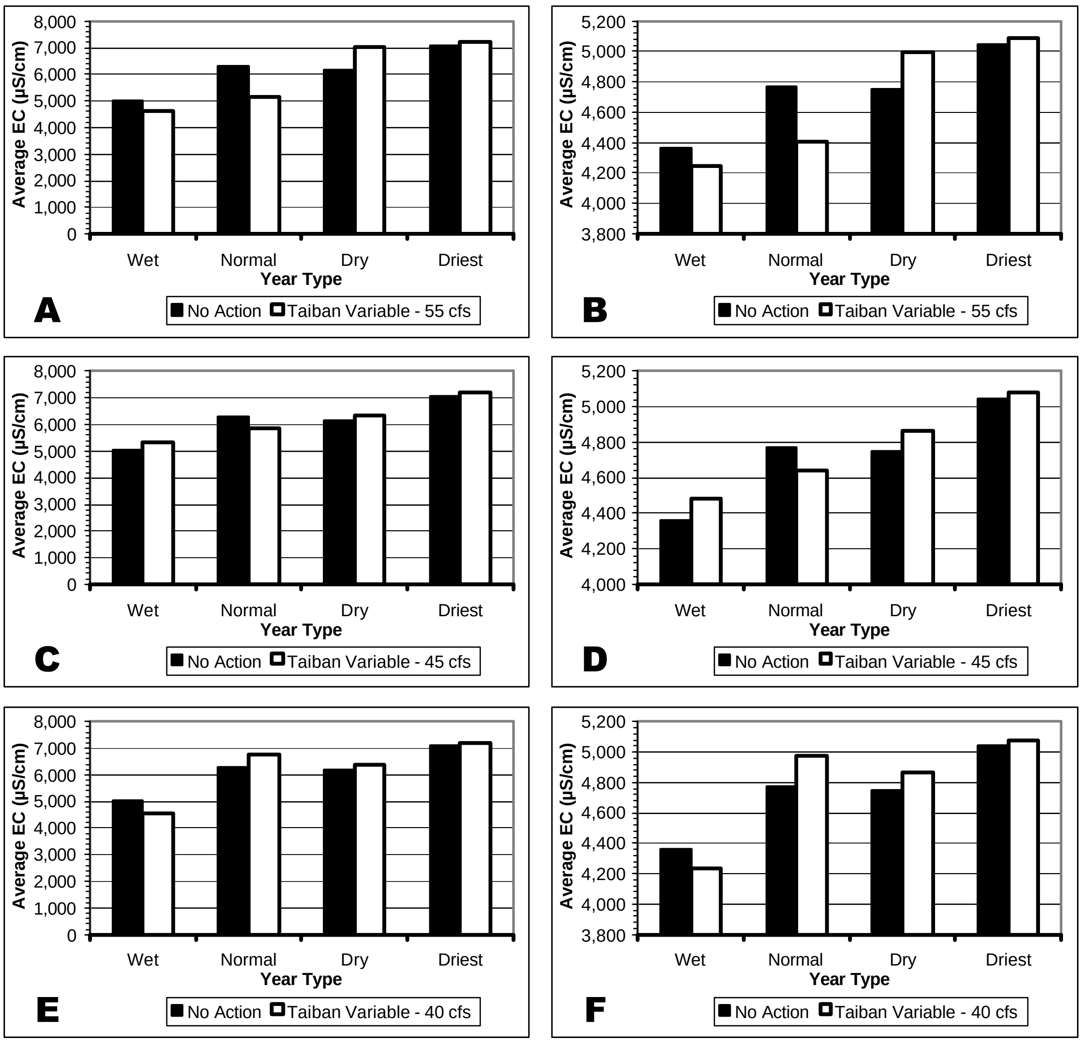

Figure 4.20 Comparison of EC under the No Action Alternative and the Taiban Variable Alternative: A, C, E = Near Artesia gage and B, D, F = Below Brantley Dam gage.

The major differences in EC between the Taiban Variable Alternative and the No Action Alternative include the following:

- At the highest target flows (55 cfs), higher EC in the wet and normal years and lower EC in the dry years
- At the intermediate target flows (45 cfs), lower EC in the normal year and higher EC in the other year types
- At the lowest target flows (40 cfs), lower EC in the wet year and higher EC in other year types

4.6 Acme Constant Alternative

Figure 4.21 compares the projected annual average EC under the Acme Constant Alternative and the No Action Alternative at the two sites for each of the four year types.

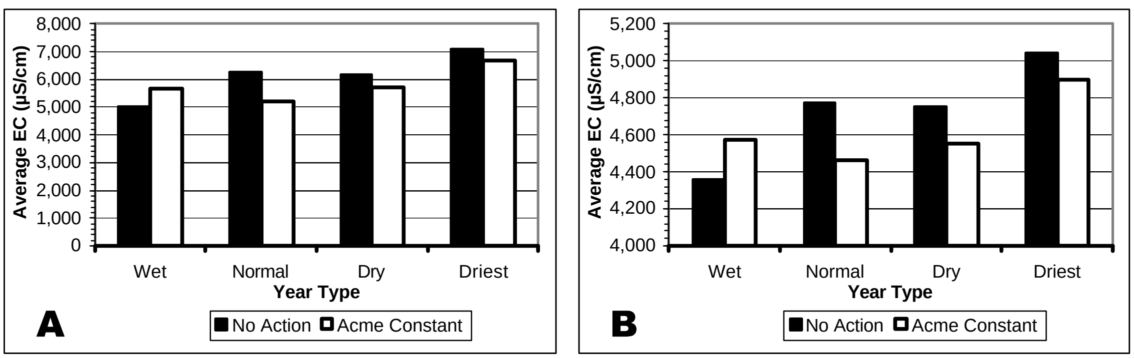

Figure 4.21 Comparison of EC under the Acme Constant Alternative and No Action Alternative: A = Near Artesia gage and B = Below Brantley Dam gage.

The major differences in EC between the Acme Constant Alternative and the No Action Alternative include the following:

- Lowest EC at the Near Artesia gage in the normal year
- Approximately the same EC in the wet and dry years, or about 500 µS/cm higher than in the normal year
- EC about 1,000 µS/cm higher in the driest year than in the wet and dry years

4.7 Acme Variable Alternative

Figure 4.22 compares the projected annual average EC under the Acme Variable Alternative and the No Action Alternative at the two sites for each of the four year types.

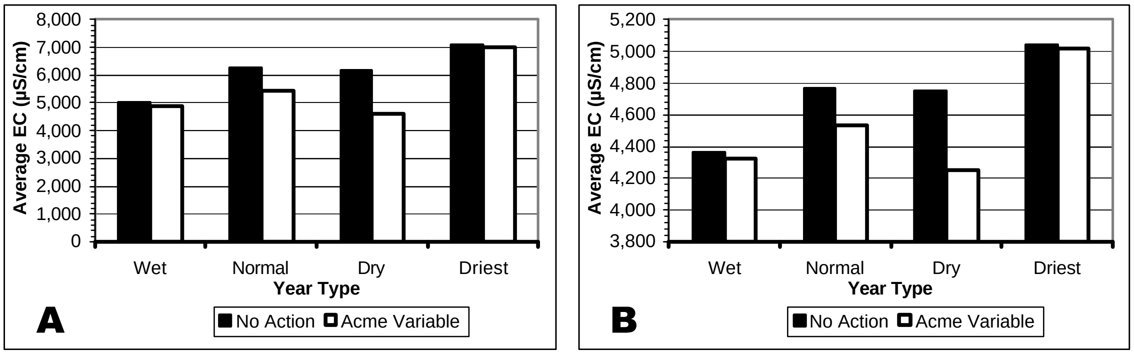

Figure 4.22 Comparison of EC under the Acme Variable Alternative and No Action Alternative:
A = Near Artesia gage and B = Below Brantley Dam gage.

The major differences in EC between the Acme Variable Alternative and the No Action Alternative include the following:

- Highest EC in the driest year
- Lowest EC in the dry year
- Average ECs in the wet and normal years intermediate between those of the preceding year types

4.8 Critical Habitat Alternative

Figure 4.23 compares the projected annual average EC under the Critical Habitat Alternative and No Action Alternative at the two sites for the four year types.

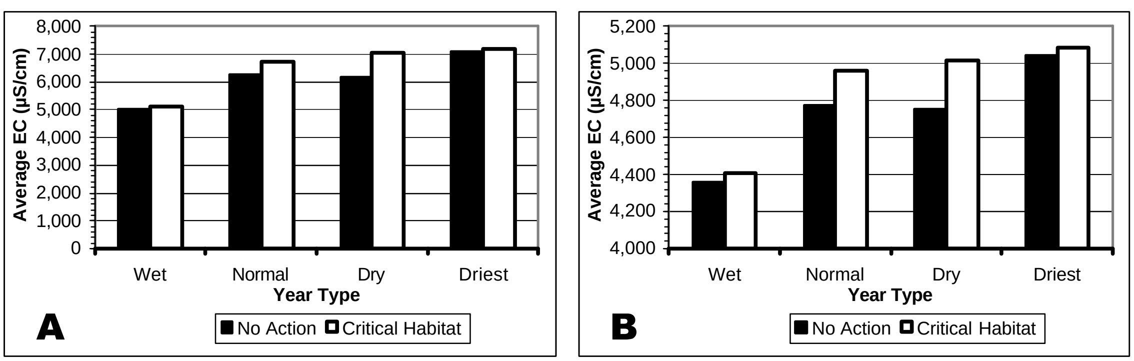

Figure 4.23 Comparison of EC under Critical Habitat Alternative with No Action Alternative:
A = Near Artesia gage and B = Below Brantley Dam gage.

The major differences in EC between the Critical Habitat Alternative and the No Action Alternative include the following:

- Lowest EC in the wet year
- As water supply decreases, EC increases

- Smallest difference in EC from No Action Alternative in the driest year
- The sequence of increasing differences with decreasing water supply follows for the other 3 years

4.9 Impacts of CPWA and AWA Options

Table 4.31 summarizes the impacts of the CPWA options on water quality. The first set of CPWA options relates to water right acquisition, either by purchase or lease. From a practical perspective, the only difference between purchase and lease is that one is permanent and one is temporary. In terms of the effect on water quality, there is no difference, other than duration.

Table 4.31 Impacts of CPWA options on water quality

Option category	Impact intensity (negligible, minor, moderate, or major)	Impact location (localized, or general)	Impact duration (short-term, long-term)	Impact summary
Water right purchases	Depends on source of water: FSID or CID: negligible; PVACD: moderate benefit	Sumner Dam to Roswell: negligible; PVACD: moderate between Roswell and Brantley Reservoir	Permanent.	Water from FSID would be essentially the same quality as water from Sumner Lake. In general, savings on CID would be used on CID and not enter the river. Water from PVACD, assumed from the artesian aquifer, would be slightly lower in EC (~4000 µS/cm) than the river near Artesia (~7000 µS/cm) and would have a moderate benefit to the river.
Water right leases	Essentially the same as water right purchases	Depends on the location of the leases	Duration of the lease	See water right purchases option.
Well field development: Seven River or Buffalo Valley	Minor to moderate	Localized	For the duration of the activity	Seven Rivers: moderate decrease in EC when pumped water discharged to river. Buffalo Valley: minor decrease to moderate increase depending on source of water
Changes to cropping patterns	Negligible	Localized	Short-term	The analysis focused on CID. There may be no change or there may be reduced deliveries to Brantley Reservoir. In either case, there should be no measurable change in EC in the Pecos River.

Table 4.31 Impacts of CPWA options on water quality

Option category	Impact intensity (negligible, minor, moderate, or major)	Impact location (localized, or general)	Impact duration (short-term, long-term)	Impact summary
FSID gravel pit pumping	Negligible	Localized	Short-term	Ground water, which feeds the gravel pit, in the vicinity of the FSID is similar in EC to the river; adding ground water to the river in the area of the pit would have no noticeable effect.

The relationship between EC and riverflows is inverse. In other words, greater riverflows provide greater dilution of diffuse saline inflows, resulting in lower EC. The water acquisition options would leave water in the river rather than diverting it for irrigation. The EC values presented in figures 4.19 through 4.23 for the alternatives can be adjusted to illustrate the effects of the addition of water acquisition options. In the four year types shown in the figures, the total CPWA could be supplied by a set of water acquisition options if the total amount of water that can be purchased or leased were available. On the possibly unwarranted assumption that this is true, resulting adjusted EC computed based on the correlation between flow rate and EC at the Near Artesia gage is presented in table 4.32. The problem is that in dry years, water may be short everywhere and acquired water rights may not yield the amount of water needed. The data presented in table 4.32 are based on the assumption that CPWA water needed up to the limit would be available.

Table 4.32 Difference in EC at the Near Artesia gage with bypass flows only from addition of CPWA water to the bypass flows shown in the tables related to the individual alternatives

Alternative	Wet year	Normal year	Dry year	Driest year (1965)
No Action	-57	-420	-301	0
Taiban Constant	-42	-840	-88	-29
Taiban Variable (40 cfs)	-42	-840	-1,235	-441
Taiban Variable (45 cfs)	0	-81	-1,113	-447
Taiban Variable (55 cfs)	-54	-31	-1,257	-631
Acme Constant	-335	-136	-372	-230
Acme Variable	-40	-165	-452	-29
Critical Habitat	0	-23	-1,290	0

The only instance in which a value in table 4.32 is not negative is when no CPWA water is needed (i.e., in the wet year under the Critical Habitat Alternative and under the Taiban Variable Alternative with target flows of 45 cfs). Interestingly, no CPWA water is needed in the driest year under the No Action Alternative or under the Critical Habitat Alternative. In these cases, there would be no change relative to what was earlier shown for the individual alternatives.

In general, the largest projected decreases in EC shown in table 4.32 occur during the dry year under the action alternatives. Under the No Action Alternative, the largest projected decrease occurs in the normal year. The decrease at the Near Artesia gage shown in table 4.32 under the No Action Alternative is slightly greater than the increase shown in table 4.30 (390 µS/cm). The net effect would be essentially no change in EC in the normal year. In the wet and dry years, EC would be greater under the No Action Alternative than under the pre-1991 baseline; the CPWA option decreases would not be sufficient to completely eliminate the previously shown increases.

Note that the EC data on which the relationships are based are rounded to the nearest 10 µS/cm. Furthermore, the regressions on which the EC projections are based have an even greater error. Consequently, differences of less than 100 µS/cm (or, in some cases, more than that) should be considered no change at all.

To put the effect of the CPWA options on EC into better perspective, the EC for the normal and dry year types under each alternative are shown in table 4.33, along with EC after the CPWA options are included. The apparent inconsistencies related to the selection of years in comparison with the No Action Alternative that were discussed earlier are still shown in the adjusted EC data, but the decreases relative to the bypass flows alone are apparent. In all cases, the EC with CPWA options is lower than without the CPWA options, indicating that the options, in addition to ameliorating the effects of depletions, ameliorate the effects on EC as well.

Table 4.33 Comparison of adjusted and unadjusted (previously shown) EC (µS/cm) at the Near Artesia gage

Alternative	Adjusted		Unadjusted	
	Normal year	Dry year	Normal year	Dry year
No Action	6,101	6,032	6,280	6,160
Taiban Constant	6,479	6,345	6,771	6,349
Taiban Variable (40 cfs)	6,479	5,823	6,770	6,376
Taiban Variable (45 cfs)	5,823	5,865	5,861	6,363
Taiban Variable (55 cfs)	5,112	6,404	5,126	7,004
Acme Constant	5,135	5,499	5,199	5,703
Acme Variable	5,368	4,383	5,445	4,591
Critical Habitat	6,708	6,445	6,723	7,060

Table 4.34 shows a sample of AWA options that could be used to provide additional flows for the shiner. AWA options are a subset of the CPWA options shown in table 4.31, with all of the impacts on water quality restricted to the critical habitat reach. The effects would be relatively minor and would result in some water quality improvement.

Table 4.34 Impacts of AWA options on water quality

Option category	Impact intensity (negligible, minor, moderate, or major)	Impact location (localized or general)	Impact duration (short-term, long-term)	Impact summary
Water right purchase	Depends on the source of the water: FSID or CID: negligible; PVACD: moderate benefit	Localized. Sumner Dam to Roswell: negligible; PVACD: moderate between Roswell and Brantley Reservoir	Long-term	See table 4.32.
Water right lease	Same as water right purchase	Same as water right purchase	Short-term, i.e., for the duration of the lease	See table 4.32
Changes to cropping patterns	Same as water right purchase	Same as water right purchase	Short-term, i.e., for the duration of the practices	See table 4.32; another form of conservation
FSID gravel pit pumping	Negligible	Localized	Short-term	See table 4.32

4.10 Ground-Water Recharge

Figure 4.24 presents the minimum, median, and maximum EC of ground-water recharge under the pre-1991 baseline and the alternatives. The median EC is the focus of the analysis. For the most part, the median EC appears to rest on the 9,000 µS/cm gridline, except for the pre-1991 baseline, which is 8,700 µS/cm. The higher EC under all the alternatives compared to the pre-1991 baseline is consistent with the results of the analysis of surface water quality presented previously.

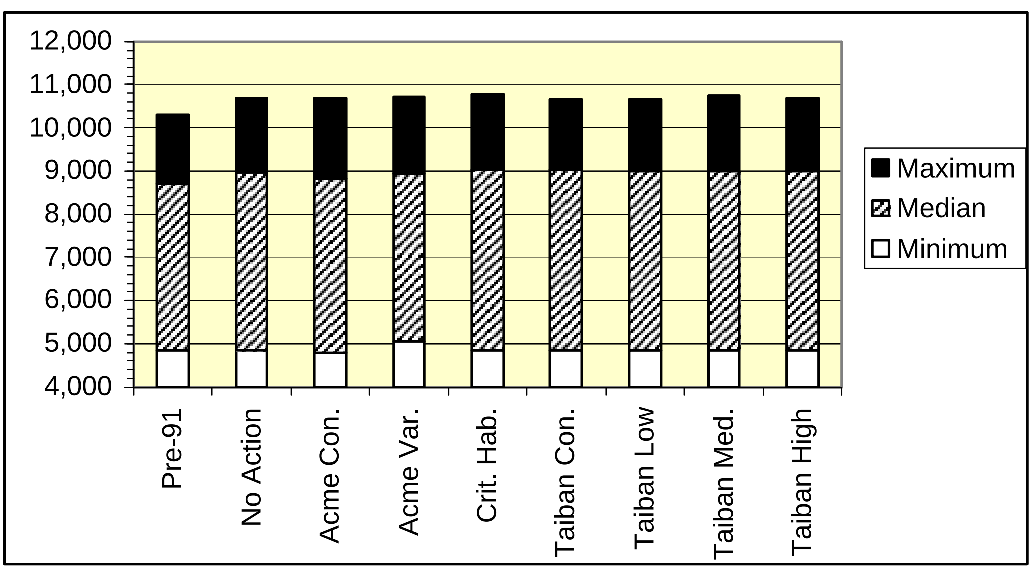

Figure 4.24 Minimum, median, and maximum ground water EC (µS/cm) under the pre-1991 baseline and alternatives.

Projected median EC is somewhat lower under the Acme Constant and Acme Variable Alternatives than under the No Action Alternative. The actual increases in the EC of the ground water relative to that of the recharge are assumed to be proportional to what has occurred historically.

4.11 Mitigation Measures

Once the AWA options are applied, no mitigation appears to be needed. The CPWA options also would mitigate adverse effects on water quality.

4.12 Residual Impacts

No residual impacts are anticipated.

5. Agricultural Soil and Land Resources

As discussed in chapter 3, the following indicators were selected to evaluate agricultural soil and land resources:

Soil Resources

- Erosion potential (mainly wind erosion)
- Quality (mainly soil salinity)

Land Resources

- Quality, as measured by the acres of lands meeting criteria for national prime farmland (PF) and the acres of lands meeting criteria for farmlands of Statewide importance (FSI)
- Acres of land infested with noxious weeds and plants (mainly salt cedar)

Any alternative or action that results in any of the following changes would adversely affect agricultural soil and land resources:

- Increases the salinity, relative sodium percentage, or potentially toxic trace element content of the irrigation water. These increases would, in turn, increase soil salinity, sodicity, and, possibly, toxicity to biota.
- Retires land from irrigation. Land retirements would reduce soil quality and increase soil erosion potential unless remedial measures were taken to preserve the soil resource.
- Reduces the volume of irrigation water. These changes would increase soil salinity, reduce crop yields, and force changes to cropping patterns.
- Retires, long-term fallows, or increases the flood or erosion hazards of important farmlands.
- Reduces water deliveries per acre or increases the salinity of the irrigation water, especially during the critical spring crop emergence period. These changes would reduce crop yields and water use efficiency.
- Reduces flood conservation storage, reduces Pecos River channel capacity, or permits higher block releases. These changes would increase flooding, water erosion, and spread of noxious weeds.
- Reduces the acreage of important farmlands, including PF.

5.1 Summary of Impacts

Table 4.35 summarizes the impacts of the alternatives on agricultural soil and land resources. A narrative summary discussion follows.

Table 4.35 Summary of impacts of alternatives on agricultural soil and land resources

No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Minor localized adverse impacts on agricultural soil and land resources compared to pre-1991 baseline	Minor adverse impacts compared to No Action	Minor adverse impacts compared to No Action	Minor adverse impacts compared to No Action, mainly because of increased land retirement	Minor adverse impacts compared to No Action	Minor, mitigatable impacts compared to No Action

Greater evaporative transmission losses associated with the No Action Alternative and all the action alternatives would tend to lead to a smaller water supply and a higher salinity of the irrigation water at the CID diversion structure compared to conditions since the construction of Brantley Reservoir.

In the absence of water acquisition options, the result would be substantial adverse impacts (e.g., greater soil salinity, reduced crop yields) to CID soil and land resources. Many CID lands barely meet the criteria for national PF, and any decrease in the quantity or increase in the salinity of the irrigation water would raise soil salinity above the threshold of 4 deciSiemens per meter (dS/m) EC of the saturation extract (ECe) for PF in many areas (Brummer, 2001). Higher soil salinity also would lead to smaller crop yields and encourage abandonment of some marginal lands. In dry and average hydrologic conditions, water quality (salinity) also would deteriorate during the critical early spring crop establishment period, a major adverse impact on CID.

This analysis of the alternatives is based on full water acquisition options to make up for any depletions to the Carlsbad Project water supply and provide for an early spring block release to reduce the salinity in Brantley Reservoir for crop establishment. These water acquisition options have the effect of “spreading” the impacts on the land and resources over the entire Pecos River Valley downstream from the Guadalupe County northern boundary line. The principal adverse impact would be the loss of PF due to water right purchase and retirement of lands from irrigation. Impacts on soil quality should be minimal as long as the retired lands are reseeded to perennial grasses. The impacts also could be minimized by targeting marginal and unproductive lands for retirement rather than prime farmlands.

5.2 Scope and Methods

The general scope of this analysis is the Pecos River Valley in Eddy, Chaves, De Baca, and Guadalupe Counties in eastern New Mexico. This analysis focuses on irrigated lands, but impacts on dry lands are also evaluated for some water acquisition options.

This analysis was conducted using recent onsite evaluations of soil and land resources and interviews with local experts, including Natural Resources Conservation Service (NRCS) personnel, county extension agents, and irrigation and flood control district officials. Data analysis is based on well-established soil salinity equations and computer models (Watsuit) (ARS, 1992), relatively simple and straightforward cause-and-effect relationships, and professional judgment. Existing Reclamation land and soil data, as well as NRCS soil surveys and internet websites (NRCS, 2005), also were used.

5.3 No Action Alternative

As discussed for water resources, transmission losses would be greater under the No Action Alternative than under the pre-1991 baseline. These losses would be in the form of direct evaporation as well as seepage. Seepage losses would be consumed by salt cedar along the river, which would tend to increase the acreage and vigor of these plants and result in minor deterioration of soil quality in localized areas of new salt cedar infestations. Reclamation would attempt to lease, rather than purchase, water rights to make up for any depletions to the Carlsbad Project water supply. This analysis assumes that short-term leases of water rights would not necessarily be for the same lands year after year; therefore, these lands would remain in the PF and FSI inventory. Leased lands would be dryfarmed or fallowed. Fallowing could greatly increase wind erosion impacts. Leased lands would need to be seeded to small grain, grasses, or other desirable vegetation to prevent excessive wind erosion of topsoil and infestation with noxious weeds. This alternative would result in minor localized adverse impacts on agricultural soil and land resources when compared to the 1991–2002 period.

5.4 Taiban Constant Alternative

Average annual net depletions (water needed for habitat maintenance and to make up for any depletions to the Carlsbad Project water supply) would be less than under the No Action Alternative. These depletions would increase the acreage and vigor of some salt cedar stands along the river, with a decline in soil quality in these areas. Reclamation would retire important farmlands from irrigation under water acquisitions options. The potential for increased wind and, in some areas, water erosion is greater on these lands. These lands would no longer meet the criteria for important farmlands. Fewer acres of land would meet the criteria for PF and FSI. This alternative would result in minor adverse impacts compared to the No Action Alternative. Some of the impacts would be mitigatable. (See section 5.10.)

5.5 Taiban Variable Alternative

Average annual net depletions would be slightly greater than under the Taiban Constant Alternative, but the impacts on agricultural soils and lands would be about the same.

5.6 Acme Constant Alternative

Average annual net depletions would be greater than under the No Action Alternative. Most of these depletions could be eliminated by the purchase of water rights. However, other water acquisitions options, including water right leases, onfarm water conservation, and changes to cropping patterns, may be needed because of high depletions in some years. These additional options would tend to have some beneficial impacts on land resources relative to water right purchase and land retirement and would compensate somewhat for some adverse impacts associated with land retirement. This alternative would result in minor adverse impacts compared to the No Action Alternative, mainly because of greater land retirement. Some of the impacts would be mitigatable**.** (See section 5.10.)

5.7 Acme Variable Alternative

Average annual net depletions would be similar to those under the Acme Constant Alternative, with water right purchase and land retirement as the principal water acquisitions options. Some other water acquisitions options also could be implemented to eliminate some of the high depletions in some years. These options would tend to have more beneficial impacts and would compensate somewhat for adverse impacts associated with land retirement. This alternative would result in minor adverse impacts on land and soil resources.

5.8 Critical Habitat Alternative

Average annual net depletions would be less than under the No Action alternative. Water right purchase and land retirement would be used to eliminate these net depletions. These options would result in minor impacts that could be partially mitigated, compared to the No Action Alternative.

5.9 Impacts of CPWA and AWA Options

Following is discussion of the impacts of CPWA and AWA options on agricultural soil and land resources

5.9.1 Water Right Purchase

This water acquisition option would purchase water rights and retire the land from irrigation. Retirement from irrigation could potentially leave the lands susceptible to wind and water erosion, as well as infestation with noxious weeds. To prevent or minimize these adverse effects, the landowner could reseed the parcel to perennial grasses such as alkali sacaton, wheat grasses, or wild rye. These grasses are very salt- and drought-tolerant once established. Lands retired from irrigation would no longer qualify for listing as PF or FSI and would reduce the Nation's inventory of important farmlands. Loss of the Nation's prime farmlands is considered a widespread cumulative adverse impact.

5.9.2 Water Right Lease

Short-term water right leasing, such as under the No Action Alternative, would temporarily fallow lands in return for the annual water supply. These lands could be dry-farmed or planted with annual or perennial grasses. Wind erosion could increase on lands that are left unprotected during the fallow period. In some cases, noxious annual and perennial weeds would overgrow the lands during the fallow period. These lands would remain in the PF and FSI inventory, because it is assumed the same tracts of lands would not be leased year after year. This option would generally result in minor mitigatable adverse impacts on lands and soil resources.

Lands under long-term leasing agreements (leases of more than 5 years) would no longer qualify for PF or FSI status and would contribute to long-term adverse impacts relating to important farmland losses.

5.9.3 Changes to Cropping Patterns

This option would tend to reduce the acreage of alfalfa in irrigated areas. Although alfalfa is generally considered a desirable soil-building crop, it is currently grown so extensively in some areas that crop diseases are increasing. Slightly reducing alfalfa acreage would increase the crop rotation with other crops and reduce disease and insect potential. This is considered a minor beneficial impact for land and soil resources.

5.9.4 Well Field Development

These options generally would provide less saline water to Brantley Reservoir, which would tend to improve CID soil salinity conditions slightly. For maximum benefit, use of these wells could be timed to provide the less saline water during periods when it is most needed. This CPWA option would require the purchase of water rights and the retirement of lands with associated adverse impacts. These impacts, providing less saline water and retirement of lands, would tend to offset each other, and the net impact would be minor and adverse.

5.9.5 FSID Gravel Pit Pumping

This option would pump a small amount of water from an existing gravel pit during periods when critical habitat flows are needed. Pumping this water would provide some drainage benefits to the surrounding lands and reduce soil and salinity in localized areas. This option is considered a long-term, moderate, localized, beneficial impact to land and soil resources in the area near the gravel pit.

5.9.6 Summary of Impacts

Table 4.36 presents a brief summary of the impacts of CPWA options on agricultural soil and land resources, and table 4.37 presents a brief summary of the impacts of AWA options.

Table 4.36 Impacts of CPWA options on agricultural soil and land resources

Option category	Impact intensity (negligible, minor, moderate, or major)	Impact location (localized or general)	Impact duration (short-term, long-term)	Impact summary
Water right purchases	Moderate, adverse	General	Long-term	See narrative.
Water right leases	Minor, adverse	General	Short-term	See narrative.
Changes to cropping patterns	Minor, beneficial	General	Short-term	See narrative.
Well field development	Minor, beneficial	General	Long-term	Same as ground-water recharge/conjunctive use.
FSID gravel pit pumping	Moderate, beneficial	Localized	Long-term	Periodic pumping during dry periods would improve drainage conditions in localized areas surrounding the gravel pit.

Table 4.37 Impacts of AWA options on agricultural soil and land resources

Option category	Impact intensity (negligible, minor, moderate, or major)	Impact location (localized or general)	Impact duration (short-term, long-term)	Impact summary
Water right purchases	Moderate, adverse	General	Long-term	See narrative.
Water right leases	Minor, adverse	General	Long-term	See narrative.
Changes to cropping patterns	Minor, beneficial	General	Long-term	See narrative.
FSID gravel pit pumping	Moderate, beneficial	Localized	Short-term	Would reduce soil wetness, decrease soil salinity, and improve crop yields in a few nearby areas when gravel pit is pumped.
Well field development	Moderate, adverse	Localized	Long-term	Would reduce the acreage of PF and FSI due to land retirement. Potential for soil erosion would increase. Possible construction-related soil impacts.

5.10 Mitigation Measures

Mitigation measures for land retirement and fallowing would be reseeding with perennial grasses for all retired and long-term fallowed lands. Targeting marginal and unproductive lands for retirement also would reduce adverse impacts related to lands qualifying for important farmland inventories.

NRCS would need to perform a farmland conversion impact rating under the Federal Farmland Protection Policy Act to determine if the potential adverse impacts on the farmland exceed the recommended allowable level.

5.11 Residual Impacts

Most of the impacts from water acquisition options would be beneficial; however, the continuing loss of the Nation's prime farmlands is of concern. Large private and public sector investments in development and improvement of irrigated lands have created many prime farmlands in the arid West. Upon retirement, irrigation structures, drainage features, and carefully graded fields and terraces quickly deteriorate. In many cases, noxious weeds increase on these lands and increase the cost of farming nearby lands still in production.

6. Biological Resources

As discussed in chapter 3, the following indicators were selected to evaluate biological resources:

Terrestrial and flood plain ecosystem components (including wetlands, riparian vegetation, and wildlife)

- Increased potential for overbank flows and erosion of riverbanks containing riparian, wetland, and terrestrial habitats

- Increased potential for inundation of habitats used by nesting shorebirds, including interior least tern; terrestrial wildlife species; and wetland aquatic species

Riverine aquatic ecosystem components

- Changes in frequency, extent, and duration of intermittency (flows of 0 cfs) at the Near Acme gage that would cause direct mortality of aquatic organisms and loss of aquatic habitat

- Changes in frequency of extreme low flows (less than 3 to 5 cfs) at the Near Acme gage that could result in rapid development of channel intermittency and loss of aquatic habitat

- Change in frequency, magnitude, or duration of managed or natural peak flows at the Near Acme gage that could impact aquatic habitat or spawning activities

Reservoir aquatic ecosystem components

- Changes in availability of sport fish spawning habitat and adult habitat in response to reservoir elevation changes

Special status species that occur within the study area

- For each species, see the indicators listed previously for the ecosystem that contains its habitat (e.g., riverine aquatic for Pecos bluntnose shiner and terrestrial for interior least tern)

Critical habitat within the study area

- For each designated critical habitat, refer to the indicators listed for appropriate ecosystem type (i.e., riverine aquatic ecosystem for Pecos bluntnose shiner critical habitat)

6.1 Summary of Impacts

Table 4.38 summarizes the impacts of the alternatives on biological resources. A narrative summary discussion of the impacts on each ecosystem component follows.

6.1.1 Terrestrial and Flood Plain Ecosystem Components

No additional impacts on terrestrial, flood plain, and wetland ecosystem components, including special status species inhabiting terrestrial ecosystems, are expected under any alternative because no changes in overbank flooding or bank erosion are expected under any alternative. Carlsbad Project water acquisition options may occur on upland habitats and would have direct impacts to terrestrial vegetation.

6.1.2 Riverine Aquatic Ecosystem Components

6.1.2.1 Santa Rosa Reservoir to Sumner Lake

No change in riverine aquatic ecosystem components is expected in this reach of the Pecos River under any alternative because of stable base inflow conditions. No changes are expected in the schedule, magnitude, or duration of managed irrigation releases. Temporary impacts could occur to riverine habitats under all alternatives because of scouring and/or high water velocities during irrigation

6.1.2.2 Sumner Lake to Brantley Reservoir

Why is Intermittency at the Near Acme Gage an Important Indicator for Riverine Species?

Intermittency at the Near Acme gage is defined as riverflow of 0 cfs (equivalent to a completely dry channel). Changes in the frequency, extent, or duration of intermittency at the Near Acme gage are important to identify for several reasons:

- An increase in the period of intermittency would result in mortality of aquatic organisms and impact the health and sustainability of their populations.
- Increased mortality of Pecos bluntnose shiners caused by intermittency would be considered take under the Endangered Species Act of 1973, as amended.

Model results show that intermittency occurs under all alternatives with bypass flows, with little difference among the alternatives (table 4.38). Model results show the greatest occurrence of drying events during 1956, 1971-72, 1974, and 1981, regardless of the alternative. (See figure 4.25, which is representative of conditions for all alternatives.) These results indicate that the operational and adaptive management flexibilities provided by the action alternatives would be most critical in these dry years when impacts on riverine aquatic ecosystem components and the Pecos bluntnose shiner would be greatest. The results also indicate that, in some years, regardless of the alternative, intermittency is likely to occur without implementation of the AWA options and adaptive management guidance available under each of the action alternatives.

Table 4.38 Summary of impacts of alternatives on biological resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Terrestrial and flood plain ecosystem components	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Riverine aquatic ecosystem components: Santa Rosa Reservoir to Sumner Lake	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	No change The lack of AWA options and adaptive management guidelines would not provide the management flexibility necessary to offset these potential impacts.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under the No Action Alternative. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under the No Action Alternative. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under the No Action Alternative. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under the No Action Alternative. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency for the benefit of the shiner.	With bypass flows only: Total amount of intermittency likely would not be significantly different from No Action. Flows greater than 3 to 5 cfs likely would not be significantly different from No Action. Same as No Action. AWA/AWN options would not reduce or eliminate intermittency as under other action alternatives.
Riverine aquatic ecosystem components: Brantley Dam to New Mexico-Texas State line	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Reservoir aquatic ecosystem components	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Pecos bluntnose shiner	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir	Same as for riverine aquatic ecosystem components: Sumner Lake to Brantley Reservoir
Interior least tern	No change	No significant change from No Action.	No significant change from No Action	No significant change from No Action	No significant change from No Action	No significant change from No Action

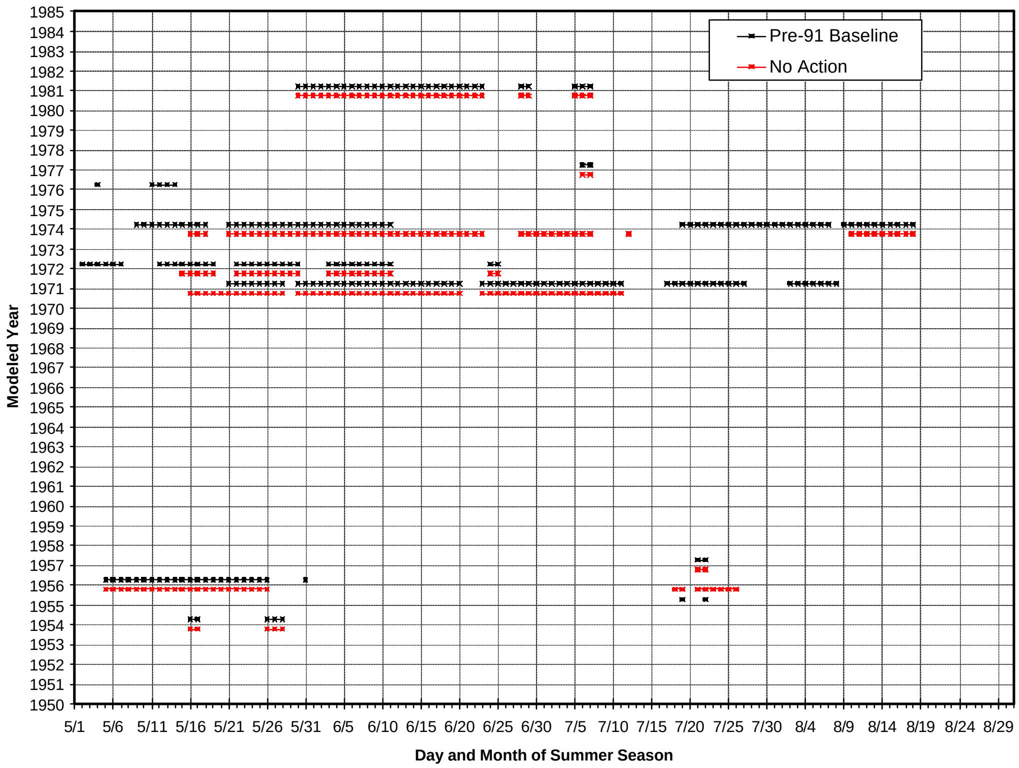

Figure 4.25 Comparison of intermittency under the No Action Alternative and pre-1991 baseline. Two extended period of intermittency during the nonirrigation season (2/10/1940-3/5/1940 and 2/27/1979-3/4/1979) were not plotted in this figure. Years with intermittency are consistent under all alternatives.

Because intermittency does not occur during the nonirrigation season with bypass flows (table 4.39) or during the irrigation season in wet hydrologic conditions under any alternative (table 4.40), riverine aquatic ecosystem components and aquatic habitats would be protected during these periods. Intermittency would have the greatest impact on these components and aquatic organisms during the irrigation season in dry and average hydrologic conditions under all alternatives.

Table 4.39 Percent of time intermittency occurs at the Near Acme gage with bypass flows only and with all AWN added

Alternative	Bypass flows only	Bypass flows with all AWN added
No Action	0.9	NA
Taiban Constant	0.9	0.0
Taiban Variable (40 cfs)	0.9	0.0
Taiban Variable (45 cfs)	0.8	0.0
Taiban Variable (55 cfs)	0.6	0.0
Acme Constant	0.7	0.0
Acme Variable	0.7	0.0
Critical Habitat	1.1	0.9

Table 4.40 Percent of time that channel intermittency occurs at the Near Acme gage under each alternative in dry, average, and wet hydrologic conditions during irrigation (3/1 – 10/31) and nonirrigation (11/1 – 2/28) seasons (values for bypass flows only)

Alternative	Hydrologic condition						
	Dry nonirrigation (%)	Dry irrigation (%)	Average nonirrigation (%)	Average irrigation (%)	Wet nonirrigation (%)	Wet irrigation (%)	Total (%)
No Action	0.0	2.4	0.0	0.8	0.0	0.0	0.9
Taiban Constant	0.0	2.1	0.0	1.0	0.0	0.0	0.9
Taiban Variable (40 cfs)	0.0	2.0	0.0	1.0	0.0	0.0	0.9
Taiban Variable (45 cfs)	0.0	1.9	0.0	1.0	0.0	0.0	0.8
Taiban Variable (55 cfs)	0.0	1.6	0.0	0.5	0.0	0.0	0.6
Acme Constant	0.0	1.4	0.0	0.8	0.0	0.0	0.7
Acme Variable	0.0	1.5	0.0	0.8	0.0	0.0	0.7
Critical Habitat	0.0	2.7	0.0	1.0	0.0	0.0	1.1

With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under the No Action Alternative for each action alternative, except for the Critical Habitat Alternative. Riverine aquatic ecosystem components would be the least protected under the Critical Habitat Alternative; under all the other action alternatives, these components would be slightly better protected than under the No Action Alternative.

Model results show that flows of less than 3 to 5 cfs at the Near Acme gage (table 4.41) occur about as frequently under all the alternatives, especially during the irrigation season in wet and average hydrologic conditions. During the irrigation season in dry hydrologic conditions, small differences would be expected among the alternatives in the percent of time that flows are less than 3 to 5 cfs. Flows in the range of 3 to 5 cfs would be best protected under the Taiban Variable, Acme Constant, and Acme Variable Alternatives; these flows would be slightly less protected during the irrigation season in dry hydrologic conditions under the Critical Habitat, Taiban Constant, and No Action Alternatives. Flows of less than 3 to 5 cfs are not expected to occur during the nonirrigation season under any alternative, and no change to riverine aquatic ecosystem components is anticipated.

No additional impacts resulting from irrigation releases are expected under any alternative. Any difference in the impacts of irrigation releases among the alternatives would be related to the timing of the events, not the frequency, duration, or magnitude. Limiting block releases during the 6-week period around August 1 might increase the likelihood of large, lengthy channel drying events during the irrigation season in dry hydrologic conditions when compared to the No Action Alternative.

Table 4.41 Percent of time under each alternative that flows at the Near Acme gage are expected to be greater than or equal to 5 cfs and 3 cfs, respectively (values are for bypass flows only)

Hydrologic condition	No Action Alternative		Taiban Constant Alternative		Taiban Variable Alternative (40 cfs)		Taiban Variable Alternative (45 cfs)		Taiban Variable Alternative (55 cfs)		Acme Constant Alternative		Acme Variable Alternative		Critical Habitat Alternative	
	5 cfs (%)	3 cfs (%)	5 cfs (%)	3 cfs (%)	5 cfs (%)	3 cfs (%)	5 cfs (%)	3 cfs (%)	5 cfs (%)	3 cfs (%)	5 cfs (%)	3 cfs (%)	5 cfs (%)	3 cfs (%)	5 cfs (%)	3 cfs (%)
Dry irrigation	88.2	93.4	87.6	93.2	89.7	94.2	91.2	95.0	92.7	95.4	94.1	96.4	93.1	95.7	87.7	92.9
Average irrigation	96.2	97.4	94.4	96.4	94.7	96.7	95.5	97.1	95.3	97.1	96.3	97.7	95.7	96.9	94.3	96.4
Wet irrigation	99.0	99.6	99.0	99.6	99.0	99.6	99.0	99.6	99.0	99.6	98.8	99.5	98.9	99.5	99.0	99.6

6.1.2.3 Brantley Dam to New Mexico-Texas State Line

No changes in riverine aquatic ecosystem components are expected in this reach under any alternative. Base inflow conditions downstream from Brantley Dam are largely controlled by ground water, tributary inflows, and irrigation return flows. None of the alternatives would change these controlling factors; therefore, no changes in riverine aquatic ecosystem components, including aquatic biota and habitat, are anticipated.

6.1.3 Reservoir Aquatic Ecosystem Components

Model results show that the minimum, average, and maximum pool elevations at each Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoirs are very similar under all the alternatives. Additionally, measures of variation in pool elevations are very similar and indicate that little difference would be expected in elevations over time. Because of the similarities, impacts on reservoir aquatic ecosystem components, including the habitats of reservoir fishes or their spawning areas, would be comparable under all alternatives.

6.1.4 Selected Special Status Species

The Pecos bluntnose shiner and interior least tern are the species that would be most likely impacted under any alternative. Generally, impacts on other species would be minimal, and discussions of these impacts are included in the resource sections in which they inhabit (e.g., terrestrial ecosystem for upland plant special status species).

6.1.4.1 Pecos Bluntnose Shiner

Impacts on the Pecos bluntnose shiner would be identical to those described under Section 6.1.2, “Riverine Aquatic Ecosystem Components, Sumner Lake to Brantley Reservoir.” With bypass flows only, there is little difference among the alternatives; model results show that intermittency occurs about as frequently under the action alternatives as under the No Action Alternative. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under the No Action Alternative for each action alternative, except for the Critical Habitat Alternative. These flexibilities would provide managers with the ability to augment base inflows, limit intermittency, and provide suitable spawning, rearing, and adult habitat to conserve the Pecos bluntnose shiner. These flexibilities would be extremely important for protecting Pecos bluntnose shiner populations during the irrigation season in dry and average hydrologic conditions.

6.1.4.2 Interior Least Tern

Nesting pairs of interior least tern have been observed within the conservation storage space of Brantley Reservoir between the 3240- and 3245- foot elevation contours. (See chapter 3, section 6.5.2.) On the basis of this best available scientific data, suitable tern nesting conditions at Brantley Reservoir were modeled over a 60-year period. Changes in the nesting elevations may occur, depending on reservoir elevations. This analysis is meant only as a comparative tool and might not reflect the only available suitable habitat. Regardless of the analysis, impacts under all action alternatives would be expected to be very similar to those under the No Action Alternative.

Table 4.42 summarizes the occurrences of suitable tern nesting conditions for the 60-year modeling period. Scenario A represents the number of years with suitable nesting and fledging conditions (reservoir elevation below 3240 feet on May 15 with no potential inundation of nests before August 1). Scenario B represents the number of years with suitable nesting conditions (elevation less than 3240 feet) in which nests would be inundated before the selected July 1 hatching or fledging date. Scenario B would represent possible take under the Endangered Species Act of 1973, as amended (ESA) of unhatched eggs and unfledged chicks unable to move above the reservoir water line. Scenario C represents the number of years with suitable nesting conditions (elevation less than 3240 feet) in which nests would be inundated before the selected August 1 fledging date. Scenario C would represent possible take under ESA of unfledged chicks unable to move above the reservoir water line. Scenario D represents the number of years in which reservoir elevations would be greater than the 3245-foot elevation contour during the May 15-June 15 nest establishment period. Scenario D represents periods with no suitable nesting conditions.

Model results show that previously occupied habitat for nesting is inundated during the nesting season in the majority of years under all alternatives. However, even when the pool elevation is within this range, suitable habitat may not be available because of vegetation growth, unsuitable substrate, or some other environmental variable. Years with conditions suitable for establishing nests (pool elevation below 3245 feet on May 15) occur under all alternatives, but, in nearly all years, the reservoir would fill and nests would be inundated before hatching of eggs or fledging of chicks. The greatest number of years with suitable nesting conditions (26 of 60) occurs under the Acme Constant Alternative. However, in 24 of those years, the reservoir would fill to a level above elevation 3245 feet, creating potential take of unhatched eggs or newly hatched chicks.

Model results show that suitable nesting, incubation, and hatching conditions throughout the entire season occur only under the No Action Alternative; however, these conditions occur in only 1 of 60 years. Overall, the highest level of tern habitat with the least frequent periods of habitat inundation would occur under the No Action Alternative.

Table 4.42 Occurrences of suitable conditions in documented tern nesting habitats within the storage space of Brantley Reservoir (between 3245-foot and 3240-foot elevation contours) over 60-year modeling period

Alternative	Scenario A (suitable habitat throughout the interior least tern nesting season)	Scenario B (suitable habitat for nesting, but inundated before July 1)	Scenario C[1] (suitable habitat for nesting, but inundated before August 1)	Scenario D (unsuitable habitat for nesting)
	Number of years (out of 60)			
No Action	1	8	11	40
Taiban Constant	0	15	2	43
Taiban Variable (40 cfs)	0	16	2	42
Taiban Variable (45 cfs)	0	13	2	45
Taiban Variable (55 cfs)	0	17	2	41
Acme Constant	0	24	2	34
Acme Variable	0	16	2	42
Critical Habitat	0	16	2	42

[1] Estimates for Scenario C are conservative and may not reflect a potential impact to terns. It is likely that many colonies may have completely fledged before increased reservoir elevations, causing no impact to nesting or fledgling terns.

6.2 Scope and Methods

Evaluation of biological resources was based on five distinct analysis components: terrestrial and flood plain ecosystem, riverine aquatic ecosystem, reservoir aquatic ecosystem, special status species that occur within the study area, and critical habitat that occurs within the study area. Each of these components was described in detail in chapter 3. Resource indicators were selected as a measurement tool to evaluate the level of potential effect of alternatives on each resource component.

6.3 Impact Analysis Overview

The following sections describe impacts on resources common to all alternatives, including the No Action Alternative.

6.3.1 Terrestrial and Flood Plain Ecosystem Components

Continued Carlsbad Project operations under all alternatives are not expected to have any additional impacts on terrestrial and flood plain ecosystem components. Because of physical limitations of various dam outlet works and limitations on the duration of irrigation releases, impacts of peak flows resulting from reservoir operations are not expected to change from current conditions, and no changes are expected in overbank flooding or bank erosion.

6.3.2 Riverine Aquatic Ecosystem Components

6.3.2.1 Santa Rosa Dam to Sumner Lake

No change in riverine aquatic ecosystem components is expected in this reach under any alternative. Releases from Santa Rosa Dam largely control streamflow conditions immediately downstream from the reservoir. Continued operation of the dam likely will not change flows the aquatic ecosystem. Ground-water inflows generally control base inflow conditions downstream from the city of Santa Rosa. The alternatives would not change this controlling factor; therefore, no change is expected in the riverine aquatic ecosystem components, including aquatic biota and habitat. Releases of irrigation water from Santa Rosa Dam may cause temporary impacts on riverine habitat caused by scouring or high water velocities.

6.3.2.2 Brantley Dam to New Mexico-Texas State Line

No change in riverine aquatic ecosystem components is expected in this reach under any alternative. Ground-water and tributary inflows and dam releases largely control base inflow conditions downstream from Brantley Dam. The alternatives would not change these controlling factors; therefore, no change is expected in the riverine aquatic ecosystem components, including aquatic biota and habitat.

6.3.3 Reservoir Aquatic Ecosystem Components

No changes are anticipated in reservoir aquatic ecosystem components, including sport fish habitat availability or spawning habitat availability, under any alternative.

6.3.4 Special Status Species

6.3.4.1 Pecos Bluntnose Shiner

Potential impacts on the Pecos bluntnose shiner are described in table 4.43.

6.3.4.2 Interior Least Tern

Potential impacts on the interior least tern are described in table 4.44.

6.3.4.3 Other Special Status Species

Potential impacts on other special status species are described in table 4.45.

Table 4.43 Summary of potential impacts on Pecos bluntnose shiner

Alternative	Potential impacts
No Action	With bypass flows, the frequency of intermittency under the No Action Alternative potentially would affect Pecos bluntnose shiner populations and habitat. These impacts are anticipated to be greatest during the irrigation season in dry and average hydrologic conditions, when lengthy periods of intermittency are possible. The lack of AWA options and adaptive management guidelines would not provide the management flexibility necessary to offset these potential impacts.
Taiban Constant	With bypass flows only, intermittency would occur about as frequently under the Taiban Constant Alternative as under the No Action Alternative. Flows greater than 3 to 5 cfs at the Near Acme gage also would be similar to those under No Action (table 4.41). Flows greater than this range provide the conditions necessary to provide shiner habitat. With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under the No Action Alternative. These flexibilities would provide managers with the ability to augment base inflows and limit intermittency (table 4.40) for the benefit of the shiner.
Taiban Variable	With bypass flows only, intermittency under the Taiban Variable Alternative with target flows of 40 and 45 would occur about as frequently as under the No Action Alternative. However, with target flows of 55 cfs, intermittency would occur less frequently than under any other action alternative. With target flows of 40 cfs, flows greater than 3 to 5 cfs at the Near Acme gage would be similar to those under the No Action. With target flows of 45 and 55 cfs, fewer periods with flows of less than 3 to 5 cfs at the Near Acme gage would occur than under the No Action Alternative. As under the Taiban Constant Alternative, impacts on the shiner would be further reduced through the flexibilities provided through AWA options and adaptive management guidance.
Acme Constant	With bypass flows only, intermittency would occur slightly less frequently under the Acme Constant Alternative than under the No Action Alternative. Flows greater than 3 to 5 cfs at the Near Acme gage would occur more frequently than under No Action (table 4.41). Impacts on the shiner would be further reduced through the flexibilities provided through AWA options and adaptive management guidance.
Acme Variable	Same as Acme Constant Alternative.
Critical Habitat	Same as No Action Alternative. AWA options would not reduce or eliminate intermittency as under other action alternatives.

6.3.4.4 Critical Habitat Occurring within the Study Area

Without considering AWA or adaptive management flexibilities, because of limited bypass supplies, intermittency within the critical habitat is anticipated under every alternative. The frequency and magnitude of high flows associated with block releases are the same under all alternatives and are not anticipated to adversely affect critical habitat.

Table 4.44 Summary of potential impacts on interior least tern

Alternative	Potential impacts
No Action	Model results show that documented nesting areas are inundated and not available for nest establishment in 40 of 60 years (table 4.42). Potentially suitable conditions in documented nesting areas for the entire period between May and August occur in 1 year. Potentially suitable nesting habitats that would be inundated before July 1 occur in 8 years. Potentially suitable conditions in documented nesting areas with inundation of nesting sites before August 1 occur in 11 years. Generally, of all alternatives, most suitable conditions for interior least tern nesting in the flood space of Brantley Reservoir would occur under the No Action Alternative.
Taiban Constant	Model results show that documented nesting areas are inundated and not available for nest establishment in 43 of 60 years (table 4.42). Potentially suitable conditions in documented nesting areas for the entire period between May and August do not occur in any year. Potentially suitable conditions in documented nesting habitat with inundation of nesting sites before July 1 occur in 15 years. Potentially suitable conditions in documented nesting areas with inundation of known nesting sites before August 1 occur in 2 years. Impacts under this alternative likely would be similar to those under other alternatives, including the No Action.
Taiban Variable	Depending on the target flows for this alternative, model results show that documented nesting areas are inundated and not available for nest establishment that in 42-45 of 60 years (table 4.42). Potentially suitable conditions in known nesting areas for the entire period between May and August do not occur in any year. Potentially suitable conditions in known nesting habitat with inundation of nesting sites before July 1 occur in 13 to 17 years. For all target flows, potentially suitable conditions in known nesting habitats with inundation of nesting sites before August 1 occur in 2 years. Impacts under this alternative likely would be similar to those under the other alternatives, including the No Action.
Acme Constant	Model results show that documented nesting areas are inundated and not available for nest establishment in 34 of 60 years (table 4.42). Potentially suitable conditions in documented nesting habitats for the entire period between May and August do not occur in any year. Potentially suitable nesting conditions in documented occupied habitat with inundation of nesting sites before July 1 occur in 24 years, the highest of all alternatives, and 67 percent higher than under the No Action Alternative. Potentially suitable conditions in documented nesting habitats with inundation of nesting sites before August 1 occur in 2 years. The greatest impacts on the tern likely would occur under this alternative because of the relatively high frequency of occurrence of potential suitable nesting habitat and the high frequency of potential nest inundation.
Acme Variable	Model results show that documented nesting areas are inundated and not available for nest establishment in 42 of 60 years (table 4.42). Potentially suitable conditions in documented nesting areas for the entire period between May and August do not occur in any year. Potentially suitable nesting conditions in documented occupied habitat with inundation of nesting sites before July 1 occur in 16 years. Potentially suitable conditions in known nesting areas with inundation of nesting sites before August 1 occur in 2 years. This alternative likely would have impacts on the tern similar to those under other alternatives, including the No Action.
Critical Habitat	Same as Acme Variable Alternative.

Table 4.45 Summary of potential impacts on special status species

Species	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Gypsum wild-buckwheat	No impacts on the upland habitat of this species are anticipated.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Pecos sunflower	High flows associated with irrigation releases do not create overbank conditions that would impact this species, and no impacts are anticipated.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Pecos assiminea snail	No impacts on this species' off -channel habitats are anticipated.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Noel's amphipod	Same as Pecos assiminea snail.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Roswell pyrg [spring-snail]	Same as Pecos assiminea snail.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Koster's tryonia	Same as Pecos assiminea snail.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Pecos gambusia	No impacts on Pecos gambusia or their off-channel spring/seep habitats are anticipated.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Piping plover	No impacts are anticipated because of the rarity of the species in the study area.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Northern aplomado falcon	No impacts on the species or its upland habitats are anticipated.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Bald eagle	No impacts are anticipated because no changes in winter reservoir levels, roosting habitats, or river water levels are anticipated.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Black-footed ferret	No impacts are anticipated because the species is likely eradicated from the study area and would occur in upland areas unaffected by project alternatives.	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action

6.4 No Action Alternative

6.4.1 Riverine Aquatic Ecosystem Components

6.4.1.1 Sumner Dam to Brantley Reservoir

Model results show that with bypass flows only, 22 separate events of intermittency of varying lengths occur over the 60-year modeling period (total of 205 days; see figures 4.25 and 4.26). When compared to the pre-1991 baseline, the No Action Alternative provides greater protection from intermittency.

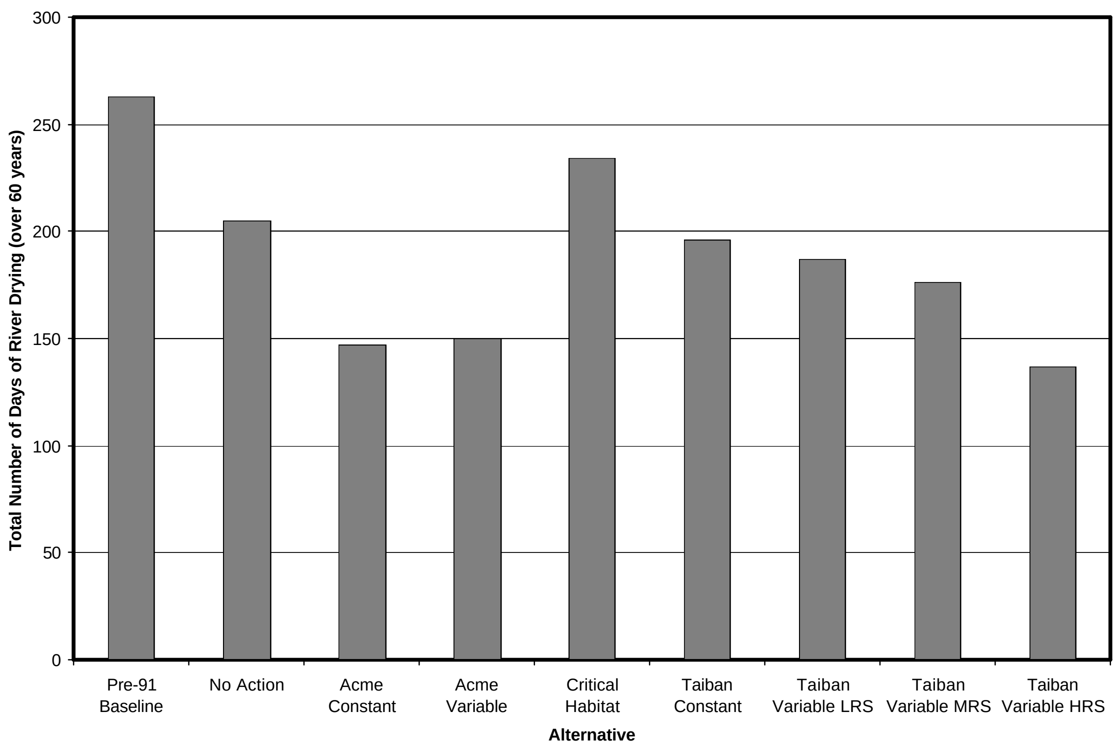

Figure 4.26 Number of days with intermittency at the Near Acme gage under the pre-1991 baseline and the alternatives.

When flows are intermittent at the Near Acme gage, flow exceedance values at the Near Dunlap gage vary little among the alternatives (figure 4.27), indicating that little difference would be expected in the length of river that goes dry under each alternative. However, model results indicate that more water could be provided at the Near Dunlap gage between the 90-percent and 100-percent exceedance values under the No Action Alternative. This range likely characterizes extremely dry hydrologic conditions, when severe channel drying may occur. Data suggest that the 90-percent to 100-percent exceedance values for the No Action Alternative would be higher because of irrigation releases that would be allowed during the 6-week period centered on August 1. These results could indicate that during extremely dry hydrologic conditions, the 6-week limit on block releases may increase the extent or duration of intermittency in the system. However, this minor change would be unlikely to result in significant impacts on riverine aquatic ecosystem components.

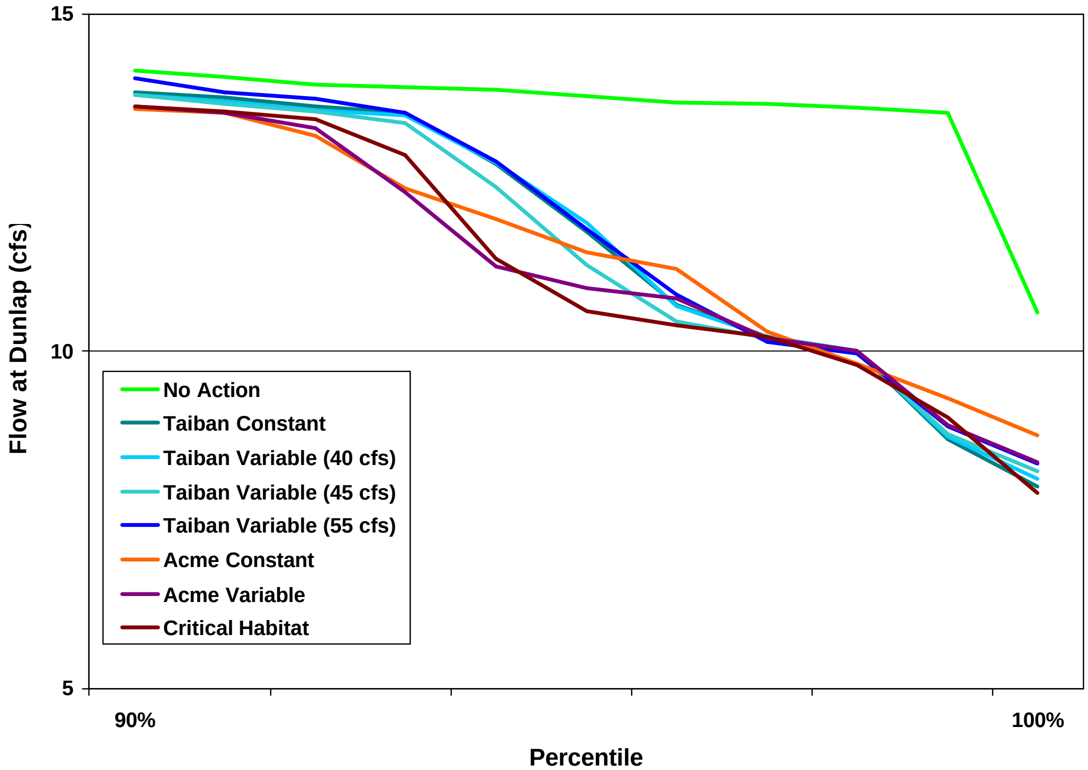

Figure 4.27 90%-100% exceedence plot of riverflow at the Near Dunlap gage when intermittency occurs at the Near Acme gage.

6.4.1.1.1 Nonirrigation Season

During the nonirrigation season, when target flows are 35 cfs at the Near Acme gage, riverine aquatic ecosystem components would be protected under the No Action Alternative in most circumstances; model results show that target flows are met 93 percent of the time during dry hydrologic conditions, 94 percent of the time during average hydrologic conditions, and 97 percent of the time during wet hydrologic conditions. During average and wet hydrologic conditions, model results show that flows at the Near Acme gage are never less than about 33 cfs, indicating that available aquatic habitats would be protective of aquatic communities. Model results show that flows at the Near Acme gage during the nonirrigation season in dry hydrologic conditions are greater than 10 cfs more than 99.9 percent of the time.

6.4.1.1.2 Wet Irrigation Periods

With bypass flows only, impacts on riverine aquatic ecosystem components would vary by irrigation season and hydrologic condition. During the irrigation season in wet hydrologic conditions, riverine aquatic ecosystem components would be protected under the No Action Alternative because intermittency is avoided at all times (table 4.40), with flows at the Near Acme gage greater than 3 to 5 cfs most of the time (table 4.41). These flows would still provide river connectivity and aquatic habitat and movement corridors necessary for aquatic organisms.

6.4.1.1.3 Average Irrigation Periods

Model results show that with bypass flows only, during the irrigation season in average hydrologic conditions, intermittency occurs with the second least frequency under the No Action Alternative (table 4.40). During these periods, river connectivity and habitat for aquatic organisms would be available under most circumstances, with flows at the Near Acme gage greater than 3 to 5 cfs most of the time (table 4.41). Unlike the action alternatives, the No Action Alternative would not provide the flexibility to avoid intermittency and flows of less than 3 to 5 cfs.

6.4.1.1.4 Dry Irrigation Periods

Model results show that with bypass flows only, during the irrigation season in dry hydrologic conditions, intermittency occurs with the second greatest frequency under the No Action Alternative (table 4.40). During these periods, river connectivity and habitat for aquatic organisms would be limited for much of the time, with flows of less than 3 to 5 cfs at the Near Acme gage occurring 7 to 12 percent of the time (table 4.41). Unlike the action alternatives, the No Action Alternative would not provide the flexibility to avoid intermittency and flows of less than 3 to 5 cfs.

6.5 Taiban Constant Alternative

6.5.1 Riverine Aquatic Ecosystem Components

6.5.1.1 Sumner Dam to Brantley Reservoir

Model results show that with bypass flows only, intermittency occurs as frequently under the Taiban Constant Alternative as under the No Action Alternative (table 4.39), although the timing and duration of these events varies (figure 4.28) and fewer dry days occur (figure 4.26). Because of the similar frequency of intermittency and channel drying, with bypass flows only, riverine aquatic ecosystem components would be no better protected under the Taiban Constant Alternative than under the No Action Alternative.

With AWA options and adaptive management guidance, impacts could be eliminated or mitigated to levels that would be better than under the No Action Alternative. The relatively small volume of AWN to meet the Taiban Constant Alternative target flows when compared to the other alternatives would provide additional flexibilities that could be used to avoid intermittency and augment low flows. If these flexibilities were applied to the alternative, it is likely that riverine aquatic ecosystem components would be better protected under the Taiban Constant Alternative than under the No Action Alternative.

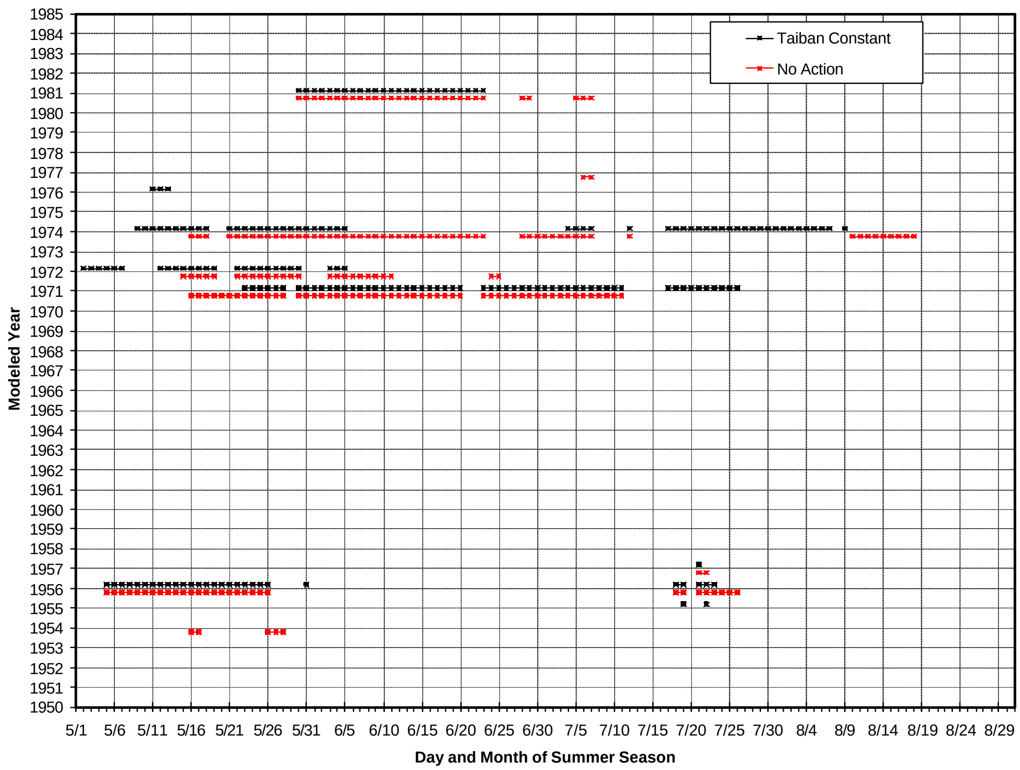

Figure 4.28 Comparison of intermittency under the No Action and Taiban Constant Alternatives.

About the same length of river would go dry during intermittency under the Taiban Constant Alternative as under the No Action Alternative, except for the events between the 90- to 100-percent exceedance values at the Near Dunlap gage (figure 4.27).

6.5.1.1.1 Nonirrigation Season

During the nonirrigation season, when target flows are 35 cfs at the Taiban gage, riverine aquatic ecosystem components would be protected in most circumstances under the Taiban Constant Alternative. During average and wet hydrologic conditions, model results show that flows at the Near Acme gage are never less than 19 cfs, indicating that available aquatic habitats would be protective of aquatic communities. During dry hydrologic conditions, model results show that conditions at the Near Acme gage are very similar to those under the No Action Alternative

6.5.1.1.2 Wet Irrigation Periods

During the irrigation season in wet hydrologic conditions, riverine aquatic ecosystem components would be protected under the Taiban Constant Alternative because intermittency would be avoided at all times (table 4.40). Model results indicate that during the irrigation season in wet hydrologic conditions, flows at the Near Acme gage are greater than 3 to 5 cfs for the same amount of time as under the No Action Alternative (table 4.41) and would provide the same level of protection as under the No Action Alternative. However, the application of AWA options and adaptive management guidance would increase the flexibility of the Taiban Constant Alternative and provide operational flexibility that could be used to benefit riverine aquatic ecosystem components.

6.5.1.1.3 Average Irrigation Periods

With bypass flows only, during the irrigation season in average hydrologic conditions, river connectivity and habitat for aquatic organisms would be available under most circumstances, with flows at the Near Acme gage 3 to 5 cfs or greater most of the time (table 4.41). In addition, according to model results, the application of AWA options would decrease the amount of time that flows are less than 3 to 5 cfs at the Near Acme gage.

6.5.1.1.4 Dry Irrigation Periods

Model results show that with bypass flows only, during the irrigation season in dry hydrologic conditions, intermittency occurs with the third greatest frequency under the Taiban Constant Alternative (table 4.40). During these periods, river connectivity and habitat for aquatic organisms would be limited for much of the time when flows are less than 3 to 5 cfs at the Near Acme gage (table 4.41).

6.6 Taiban Variable Alternative

6.6.1 Riverine Aquatic Ecosystem Components

6.6.1.1 Sumner Dam to Brantley Reservoir

As under the No Action Alternative, intermittency most likely would occur under the Taiban Variable Alternative during the irrigation season in dry hydrologic conditions, with the remainder of channel drying events occurring during the irrigation season in average hydrologic conditions (table 4.40). Model results show that intermittency occurs less frequently with target flows of 55 cfs at the Taiban gage than with target flows of 40 or 45 cfs (figures 4.29, 4.30, and 4.31). With target flows of 40 cfs or 45 cfs, model results show that intermittency occurs as frequently as under the No Action Alternative. However, with target flows of 55 cfs, intermittency occurs less frequently (table 4.39). While the percentage of time with intermittency differs by only 0.3 percent, over the 60–year modeling period, more than 60 days of intermittency would be avoided with target flows of 55 cfs when compared to the No Action Alternative. Under all three target flows, fewer total days of intermittency occur than under the No Action Alternative (figure 4.26).

About the same length of river would go dry during intermittency under the Taiban Variable Alternative as under the No Action Alternative, except for the events between the 90- to 100-percent exceedance values at the Near Dunlap gage (figure 4.27).

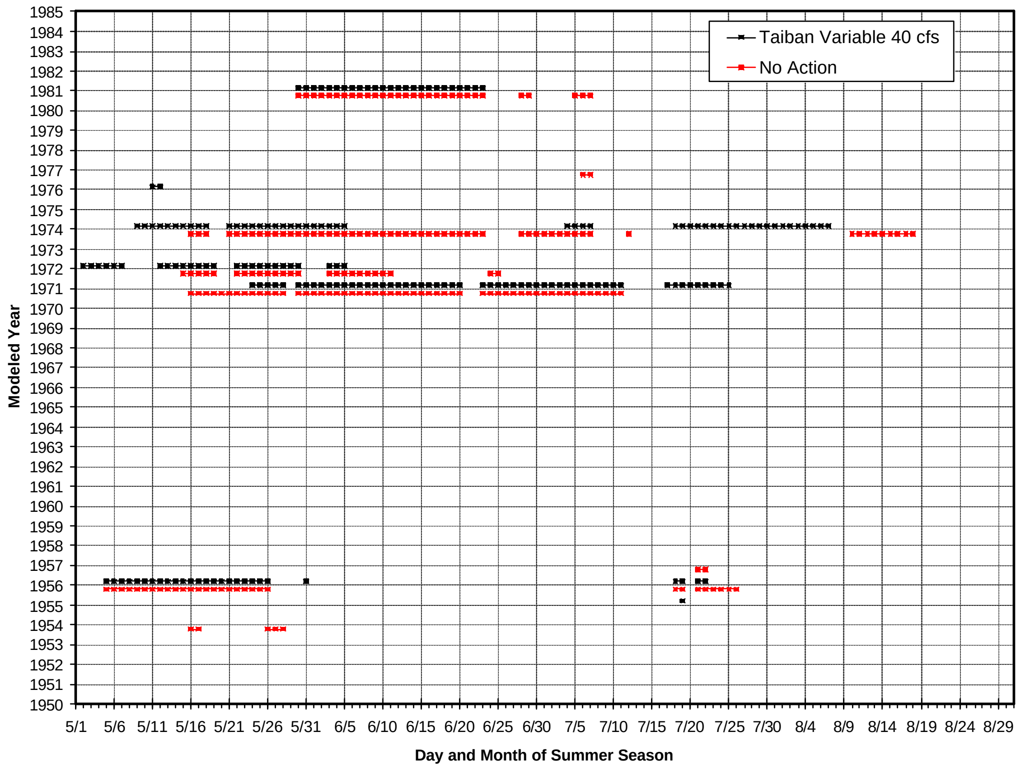

Figure 4.29 Comparison of intermittency under the No Action and the Taiban Variable Alternatives with target flows of 40 cfs at the Taiban gage.

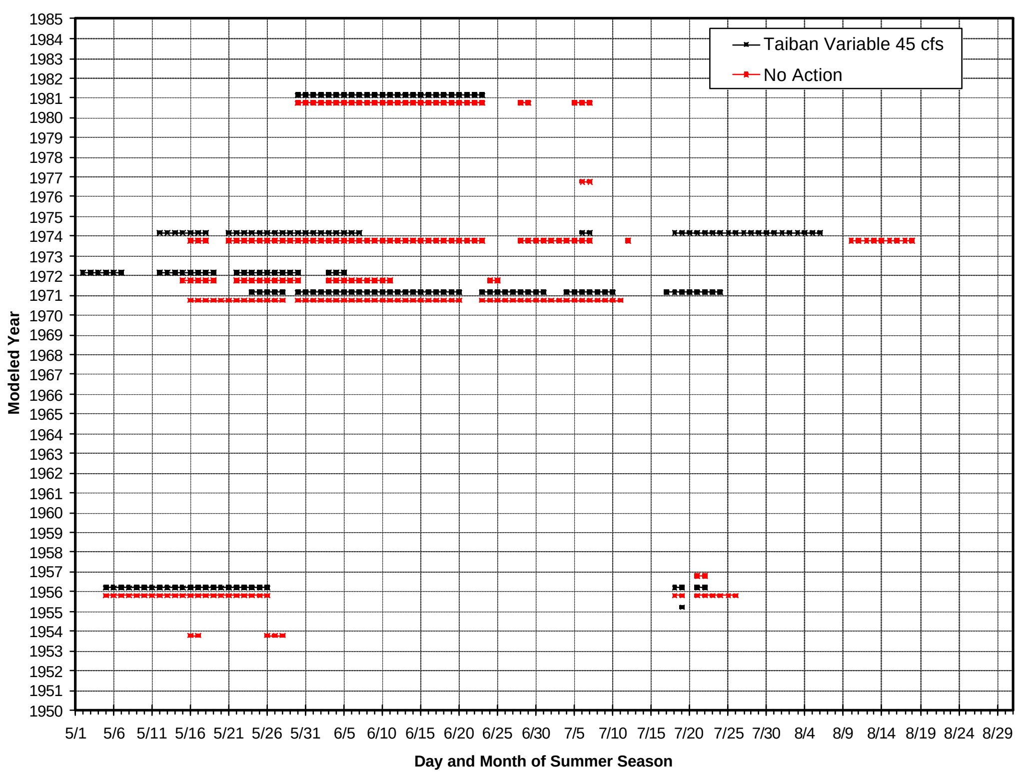

Figure 4.30 Comparison of intermittency under the No Action and Taiban Variable Alternatives with target flows of 45 cfs at the Taiban gage.

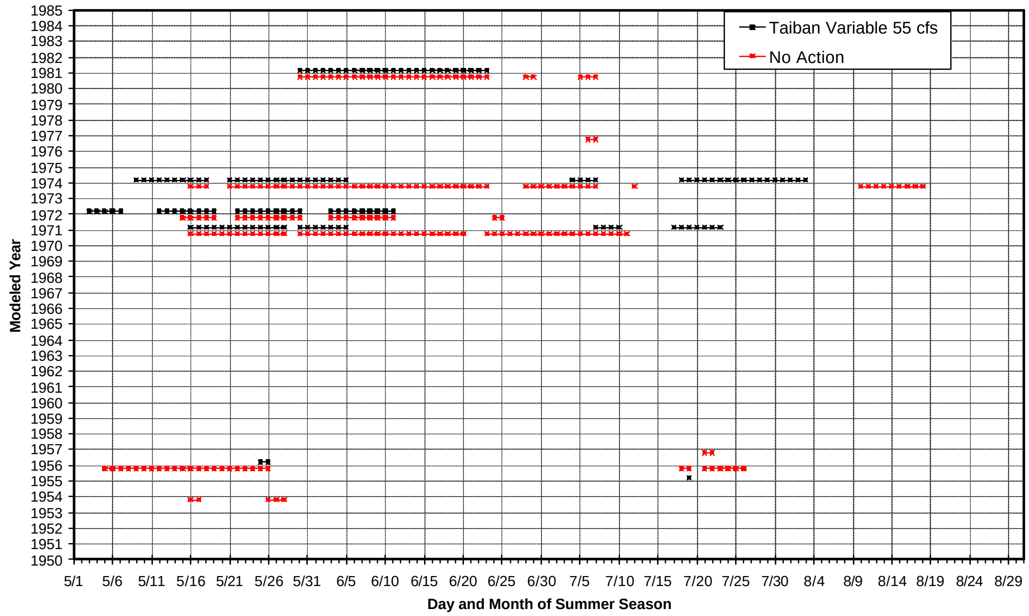

Figure 4.31. Comparison of intermittency under the No Action and the Taiban Variable Alternatives with target flows of 55 cfs at the Taiban gage.

Because intermittency generally would occur less frequently and for shorter periods, especially at target flows of 55 cfs, riverine aquatic ecosystem components would be better protected under the Taiban Variable Alternative than under the No Action Alternative. This protection could be enhanced with the flexibilities provided through AWA options and adaptive management guidance. If these flexibilities were applied to the Taiban Variable Alternative, model results indicate that intermittency could be reduced and riverine aquatic ecosystem components likely would benefit.

6.6.1.1.1 Nonirrigation Season

Because nonirrigation season target flows are the same as under the Taiban Constant Alternative, impacts on riverine aquatic ecosystem components also would be the same.

6.6.1.1.2 Wet Irrigation Periods

Impacts on riverine aquatic ecosystem components would be the same as under the Taiban Constant Alternative.

6.6.1.1.3 Average Irrigation Periods

Impacts on riverine aquatic ecosystem components would be the same as under the Taiban Constant Alternative.

6.6.1.1.4 Dry Irrigation Periods

Model results show moderate levels of intermittency under the Taiban Variable Alternative compared to other alternatives (table 4.40). During the irrigation season in dry hydrologic periods, river connectivity and habitat for aquatic organisms would be available for much of the time, with flows greater than 3 to 5 cfs at the Near Acme gage 90 to 95 percent of the time (table 4.41). If AWA options were applied, intermittency would be reduced and flexibilities would be available to increase the frequency of flows greater than 3 to 5 cfs. Because of the varying target flows of this alternative, more flexibility would be available to augment base inflows to benefit aquatic ecosystem components.

6.7 Acme Constant Alternative

6.7.1 Riverine Aquatic Ecosystem Components

6.7.1.1 Sumner Dam to Brantley Reservoir

Model results show that with bypass flows only, intermittency occurs less frequently under the Acme Constant Alternative than under the No Action Alternative (table 4.39, figure 4.32). Additionally, 50 fewer days with channel drying occur than under the No Action Alternative (figure 4.26). As a result, riverine aquatic ecosystem components likely would be better protected under the Acme Constant Alternative than under the No Action Alternative. In addition, these protections would be enhanced if AWA options and adaptive management guidance were applied. The large amount of AWN to meet the Acme Constant Alternative target flows would decrease the operational flexibilities that could be used with this option to further enhance riverine aquatic ecosystem components. However, if AWA and adaptive management flexibilities were added to the alternative, these components would be better protected than under the No Action Alternative.

About the same length of river would go dry during intermittency under the Acme Constant Alternative as under the No Action Alternative, except for the events between the 90- to 100-percent exceedance values at the Near Dunlap gage (figure 4.27). However, this minor change would be unlikely to result in significant impacts on riverine aquatic ecosystem components.

6.7.1.1.1 Nonirrigation Season

During the nonirrigation season, impacts would be the same as under the No Action Alternative.

6.7.1.1.2 Wet Irrigation Periods

With bypass flows only, conditions would be identical to those under the No Action Alternative. However, the operational flexibilities provided by AWA options and adaptive management guidance would be beneficial when compared with the No Action Alternative.

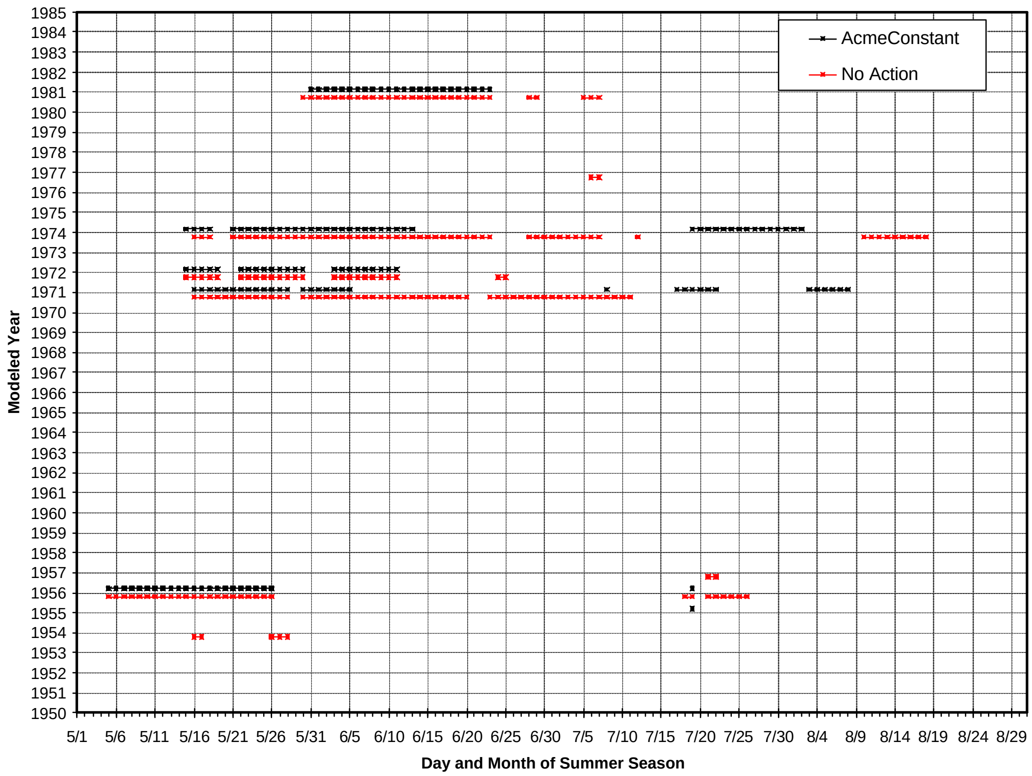

Figure 4.32 Comparison of intermittency under the No Action and Acme Constant Alternatives.

6.7.1.1.3 Average Irrigation Periods

With bypass flows only, conditions under the Acme Constant Alternative would be about the same as under the No Action Alternative. Conditions could be enhanced with the application of AWA options and adaptive management guidance to avoid intermittency. If these flexibilities were applied, riverine aquatic ecosystem components would be better protected under the Acme Constant Alternative than under the No Action Alternative.

6.7.1.1.4 Dry Irrigation Periods

During the irrigation season in dry hydrologic conditions, river connectivity and habitat for aquatic organisms would be available at greater levels than under the No Action Alternative. Model results show that intermittency occurs less frequently under the Acme Constant Alternative than under the other alternatives (table 4.40) and that flows at the Near Acme gage are higher than 3 to 5 cfs most of the time (table 4.41). With less frequent intermittency and fewer flows of less than 3 to 5 cfs, aquatic resources would be better protected from channel drying and related impacts on riverine aquatic ecosystem components. If the flexibilities provided with the AWA options and adaptive management guidelines were applied, riverine aquatic ecosystem components would be even better protected.

6.8 Acme Variable Alternative

6.8.1 Riverine Aquatic Ecosystem Components

6.8.1.1 Sumner Dam to Brantley Reservoir

Model results show that with bypass flows only, intermittency occurs less frequently under the Acme Variable Alternative than under the No Action Alternative (table 4.39, figure 4.33) with fewer total days of intermittency over the 60-year modeling period (figure 4.26). As a result, riverine aquatic ecosystem components would be better protected under the Acme Variable Alternative than under the No Action Alternative. As under the other alternatives, if AWA options and adaptive management guidance were applied, riverine aquatic ecosystem components would be even better protected. The high volume of AWN to meet the Acme Variable Alternative target flows would decrease the operational flexibilities that could be used to further enhance aquatic ecosystem components. The addition of AWA to the alternative, however, would provide greater conservation potential than under the No Action Alternative.

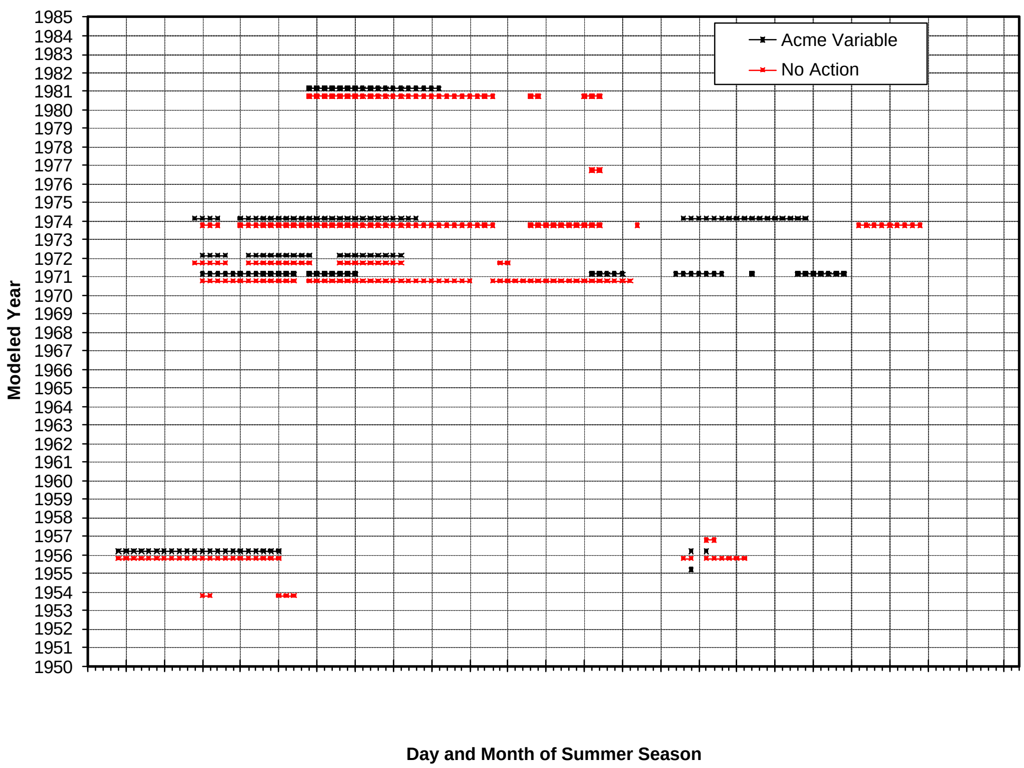

Figure 4.33 Comparison of intermittency under the No Action and the Acme Variable Alternatives.

About the same length of river would go dry during intermittency under the Acme Variable Alternative as under the No Action Alternative, except for the events between the 90- to 100-percent exceedance values at the Near Dunlap gage. However, this minor change would be unlikely to result in significant impacts on riverine aquatic ecosystem components.

6.8.1.1.1 Nonirrigation Season
During the nonirrigation season, impacts would be the same as under the No Action Alternative.

6.8.1.1.2 Wet Irrigation Periods
During the irrigation season in wet hydrologic conditions, impacts would be nearly the same as under the Acme Constant Alternative, but with slightly higher average flows associated with the higher target flows.

6.8.1.1.3 Average Irrigation Periods
During the irrigation season in average hydrologic conditions, impacts would be nearly the same as under the Acme Constant Alternative, but with slightly lower average flows associated with the lower target flows.

6.8.1.1.4 Dry Irrigation Periods
During the irrigation season in dry hydrologic conditions, impacts would be nearly the same as under the Acme Constant Alternative, but with slightly lower average flows. Average flows likely would be similar to the higher target flows of the Taiban Variable Alternative.

6.9 Critical Habitat Alternative

6.9.1 Riverine Aquatic Ecosystem Components

6.9.1.1 Sumner Dam to Brantley Reservoir
Model results show that with bypass flows only, intermittency occurs more frequently under the Critical Habitat Alternative than under all other alternatives, including the No Action Alternative (table 4.39, figure 4.34). Therefore, the Critical Habitat Alternative would provide the least protection for riverine aquatic ecosystem components of all alternatives. Even if AWA options and adaptive management guidance were applied, intermittency would occur only slightly less frequently than under the No Action Alternative. Because the alternative does not provide the flexibilities necessary to eliminate threats associated with channel drying, it is the least desirable alternative and likely would not provide any additional protection when compared with the No Action Alternative.

6.9.1.1.1 Nonirrigation Season
During the nonirrigation season, impacts would be the same as under the Taiban Constant Alternative.

6.9.1.1.2 Wet Irrigation Periods
During the irrigation season in wet hydrologic conditions, impacts would be the same as under the Acme Variable Alternative with target flows of 12 cfs at the Near Acme gage.

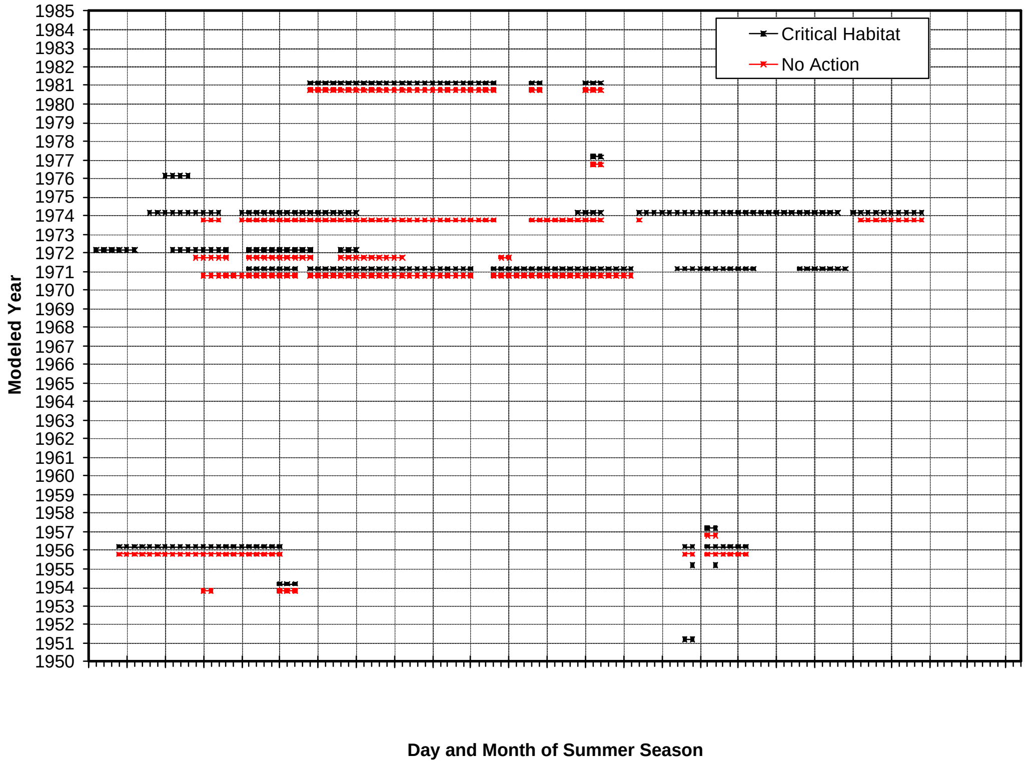

Figure 4.34 Comparison of intermittency under the No Action and the Critical Habitat Alternatives.

6.9.1.1.3 Average Irrigation Periods

During the irrigation season in average hydrologic conditions, impacts would be the same as under the Taiban Constant and No Action Alternatives.

6.9.1.1.4 Dry Irrigation Periods

During the irrigation season in dry hydrologic conditions, impacts would be the same as under the No Action Alternative.

6.10 Impacts of CPWA and AWA Options

Some impacts might be expected from the CPWA and AWA options to augment riverflows. Impacts on biological resources may occur in the form of short-term impacts, such as the disturbances of terrestrial or aquatic organisms, or long-term impacts, such as decreased or improved habitat conditions caused by changes in riverflows. Table 4.46 presents a brief summary of impacts of CPWA options on biological resources, and table 4.47 presents a brief summary of the impacts of AWA options.

Table 4.46 Impacts of CPWA options on biological resources

Option category	Impact intensity (negligible, minor, moderate, or major)	Impact location (localized or general)	Impact duration (short-term, long-term)	Impact summary
Water right purchases	Moderate	General	Long-term and short-term	Bypasses from storage or addition of the purchased water to the FCP could benefit aquatic ecosystems. Release of the retired water during block release would likely have no benefit to aquatic ecosystems.
Water right leases	Moderate	General	Short-term	Impacts resulting from water right leases likely would be identical to those from purchasing surface water and ground-water rights. However, the long-term benefits of increased base inflows resulting from ground-water retirement likely would not apply to leases because of their uncertain duration.
Changes to cropping patterns	Negligible	Localized	Short-term	Changes to cropping patterns would have negligible impacts on biological resources. Some impacts on terrestrial ecosystem components might be possible because of potential changes in available food sources that are provided by various crops.
Well field develop-ment	Moderate	General and localized	Short-term and long-term	Some impacts could be expected from individual organisms being disturbed during any construction or maintenance activities associated with this option. However, the use of a well field to augment flows would likely increase water management flexibilities that could be used to benefit aquatic ecosystem components. For new construction, an appropriate level of inventory would be conducted. If biological resources are present, potential impacts include direct disturbance of habitat through ground-disturbing activities at facility footprints, distribution infrastructure, construction support areas, access roads, and utility corridors.
FSID gravel pit pumping	Minor	Localized	Short-term	Some impacts could be expected from individual organisms being disturbed during any construction or maintenance activities associated with this option. However, the use of a pump to augment flows would likely increase water management flexibilities that could be used to benefit aquatic ecosystem components. Complete desiccation of the gravel pit could impact migratory waterfowl or aquatic organisms dependent on the water source. For new construction an appropriate level of inventory would be conducted. If biological resources are present, potential impacts include direct disturbance of habitat through ground-disturbing activities at facility footprints, distribution infrastructure, construction support areas, access roads, and utility corridors.

Table 4.47 Impacts of AWA options on biological resources

Option category	Impact intensity (negligible, minor, moderate, or major)	Impact location (localized or general)	Impact duration (short-term, long-term)	Impact summary
Water right purchase	Moderate	General	Long-term and short-term	Retiring surface water rights could have a greater, immediate, short-term benefit to aquatic ecosystem components than retiring ground-water rights. However, any benefits to aquatic ecosystems would depend on how the retired water was released from storage. Gradual release from storage or addition of the purchased water to FCP could benefit aquatic ecosystems. Release of the retired water during block release would likely have no benefit to aquatic ecosystems.
Water right lease	Moderate	General	Short-term	Impacts resulting from water right leases would likely be identical to those from purchasing surface water and ground-water rights. However, the long-term benefits of increased base inflows resulting from ground-water retirement likely would not apply to leases due to their uncertain duration.
Changes to cropping patterns	Negligible	Localized	Short-term	Changes to cropping patterns would have negligible impacts on biological resources. Some impacts on terrestrial ecosystem components might be possible because of potential changes in available food sources that are provided by various crops.
FSID gravel pit pumping	Minor	Localized	Short-term	Some impacts could be expected from individual organisms being disturbed during any construction or maintenance activities associated with this option. However, the use of a pump to augment flows likely would increase water management flexibilities that could be used to benefit aquatic ecosystem components. For new construction, an appropriate level of inventory would be conducted. If biological resources are present, potential impacts include direct disturbance of habitat through ground-disturbing activities at facility footprints, distribution infrastructure, construction support areas, access roads, and utility corridors.
Fort Sumner well field develop-ment	Moderate	General	Long-term and short-term	Some impacts could be expected from individual organisms being disturbed during any construction or maintenance activities associated with this option. However, the use of a well field to augment flows would likely increase water management flexibilities that could be used to benefit aquatic ecosystem components. Complete desiccation of the gravel pit could impact migratory waterfowl or aquatic organisms

Table 4.47 Impacts of AWA options on biological resources

Option category	Impact intensity (negligible, minor, moderate, or major)	Impact location (localized or general)	Impact duration (short-term, long-term)	Impact summary
				dependent on the water source. For new construction, an appropriate level of inventory would be conducted. If biological resources are present, potential impacts include direct disturbance of habitat through ground-disturbing activities at facility footprints, distribution infrastructure, construction support areas, access roads, and utility corridors.

6.11 Mitigation Measures

Multiple events of intermittency in a single year are likely to be more damaging to riverine aquatic ecosystem components than a single lengthy event because of the repeated drying of aquatic habitats (Kehmeier et al., 2004). After flows are restored to a reach that has dried, aquatic organisms can quickly repopulate the reach to exploit the available and unpopulated habitats and resources. With repeated channel drying within a single season, the organisms that move into these areas are subject to multiple mortality events that would not have occurred had the channel remained dry and they were unable to access those areas. Therefore, releases to minimize the impacts of intermittency by reconnecting channel flows should only be made if there is reasonable certainty that water will be available to maintain those flows for the remainder of the irrigation season.

During extremely dry hydrologic conditions, when intermittency occurs at the Near Acme gage, model results show that flows are slightly lower under the action alternatives than under the No Action Alternative between the 90- and 100-percent exceedance values at the Near Dunlap gage. These lower flows are partially caused by the inability of river managers to make irrigation block releases for a 6-week period around August 1 under the Taiban Constant Alternative. Flexibilities to make these releases during extremely dry hydrologic conditions for the purpose of preventing intermittency should be evaluated through adaptive management guidance.

6.12 Residual Impacts

Implementation of the mitigation measures would provide additional benefits to the aquatic species that are subject to impacts resulting from channel drying.

7. Regional Economy

As discussed in chapter 3, the following indicators were selected to evaluate impacts on the regional economy:

- Change in value of regional output produced in the study area
- Change in regional income
- Change in regional employment
- Change in farm acreage

7.1 Summary of Impacts

Table 4.48 summarizes the annual impacts of the alternatives on the regional economy compared to the pre-1991 baseline. Ranges of impacts are shown as a result of different acreages and locations where land retirement or changes to cropping patterns could occur. Table 4.49 summarizes the impacts of the action alternatives compared to the No Action Alternative. A narrative summary discussion follows.

Regional economic impacts associated with changes in Carlsbad Project operations could occur as a result of water right purchases/leases (and associated land retirement or fallowing) and changes to cropping patterns. These impacts are the result of changes in net farm revenues and input expenditures associated with changes in agricultural production. Most of these changes in agricultural production would lead to negative regional economic impacts. Some positive one-time impacts also could occur as a result of land or lease payments made to farmers adversely affected by land use changes. Impacts are based on a comparison of each alternative, including the No Action Alternative, to the pre-1991 baseline and a comparison of impacts from action alternatives to the No Action Alternative.

To mitigate for water depletions and additional water needs associated with each alternative, land may be retired or cropping patterns may change. The agricultural impacts of each alternative were evaluated by translating needed land retirement and changes to cropping patterns into changes in agricultural production. The acreages required to meet water needs were obtained from the water resources analysis. These acreages are presented in table 4.50. A range of impacts are estimated based on the equivalent acreage requirements shown in table 4.50.

Table 4.48 Summary of annual impacts of alternatives on the regional economy compared to pre-1991 baseline

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative (45 cfs)	Taiban Variable Alternative (50 cfs)	Taiban Variable Alternative (55 cfs)	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Change in value of regional output ($) compared to pre-1991 baseline	-350,000 to -2,165,000	-263,000 to -1,640,000	-263,000 to -1,640,000	-329,000 to -2,034,000	-372,000 to -2,296,000	-854,000 to -5,314,000	-657,000 to -4,067,000	-263,000 to -1,640,000
Change in regional income ($) compared to pre-1991 baseline	-27,000 to -871,000	- 20,000 to - 660,000	- 20,000 to - 660,000	- 26,000 to - 818,000	-29,000 to -924,000	-66,000 to -2,138,000	-51,000 to -1,637,000	-20,000 to -660,000
Change in regional employment compared to pre-1991 baseline (jobs)	-0.3 to -28.1	-0.2 to -21.3	-0.2 to -21.3	-0.3 to -26.4	-0.3 to -29.8	-0.8 to -68.9	-0.6 to -52.7	-0.2 to -21.3

Table 4.49 Summary of annual impacts of action alternatives on the regional economy compared to No Action Alternative

Indicator	Taiban Constant Alternative	Taiban Variable Alternative (45 cfs)	Taiban Variable Alternative (50 cfs)	Taiban Variable Alternative (55 cfs)	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Change in the value of regional output ($) compared to No Action Alternative	+ 88,000 to +525,000	+ 88,000 to +525,000	+ 22,000 to +131,000	- 22,000 to -131,000	- 504,000 to - 3,149,000	- 307,000 to - 1,902,000	+88,000 to +525,000
Change in regional income ($) compared to No Action Alternative	+ 7,000 to + 211,000	+ 7,000 to + 211,000	+ 2,000 to + 53,000	- 2,000 to + 53,000	- 39,000 to - 1,267,000	- 24,000 to - 766,000	+ 7,000 to - 211,000
Change in regional employment compared to No Action Alternative	+0.1 to +6.8	+0.1 to +6.8	0.0 to +1.7	0.0 to -1.7	-0.5 to -40.8	-0.3 to -24.7	+0.1 to +6.8

Lost agricultural production represented by the retired/fallowed acreage and changes to cropping patterns lead to lower net farm revenues and input purchases on an annual basis. The analysis indicates that the greatest negative regional economic impacts resulting from lost production and input purchases would occur under the Acme Constant Alternative (up to $5.3 million in total value of output lost compared to pre-1991 conditions and $3.1 million in total value of output lost compared to the No Action Alternative). The Acme Constant Alternative could lead losses of up to 69 jobs each year compared to the pre-1991 baseline and losses of 41 jobs compared to the No Action Alternative. The second greatest impact would occur under the Acme Variable Alternative, with up to $4.1 million in total value of output lost and losses of 53 jobs per year compared to the pre-1991 conditions.

Table 4.50 Equivalent acreage retirement and changes to cropping patterns for Carlsbad Project water acquisition options

Alternative	FSID lease or purchase	River pumper lease or purchase	CID lease or purchase	CID cropping pattern	PVACD lease or purchase for well field
No Action	3,300	1,400	800	1,600	1,200
Taiban Constant	2,500	1,000	600	1,200	900
Taiban Variable (45 cfs)	2,500	1,000	600	1,200	900
Taiban Variable (50 cfs)	3,100	1,300	700	1,500	1,200
Taiban Variable (55 cfs)	3,500	1,500	800	1,700	1,300
Acme Constant	8,100	3,400	1,900	3,900	3,000
Acme Variable	6,200	2,600	1,400	3,000	2,300
Critical Habitat	2,500	1,000	600	1,200	900

Regional economic impacts are estimated to be less under the Taiban Constant Alternative, the Taiban Variable Alternative (45 cfs), and the Critical Habitat Alternative than under the No Action Alternative. The estimated upper range of regional economic impacts under these three alternatives are $1.6 million in total value of output lost and losses of about 21 jobs per year compared to the pre-1991 baseline. The high range of impacts is $0.5 million in additional value of output and creation of 7 jobs each year compared to the No Action Alternative.

Some positive impacts are associated with each action alternative as a result of lump-sum land retirement or lease payments and compensation for lost farm revenues as a result of changes to cropping patterns. These are **one-time impacts,** not recurring negative annual impacts discussed previously. The greatest one-time positive impacts would occur under the Acme Constant Alternative. The second greatest one-time positive impacts would occur under the Acme Variable Alternative. Moderate one-time positive impacts would occur under the Taiban Variable Alternative, and the smallest one-time positive impacts are associated with the Taiban Constant and Critical Habitat Alternatives. Table 4.51 summarizes these one-time impacts.

Table 4.51 Estimated total one-time impacts from a lump sum land retirement payment, compared to No Action Alternative

Alternative	Output	Income	Employment
Taiban Constant	-$246,000 to -$985,000	-$44,000 to -$178,000	-2.2 to -8.6
Taiban Variable (45 cfs)	-$246,000 to -$985,000	-$44,000 to -$178,000	-2.2 to -8.6
Taiban Variable (50 cfs)	$0 to -$246,000	$0 to -$44,000	0 to -2.2
Taiban Variable (55 cfs)	$0 to +$246,000	$0 to +$44,000	0 to +2.2
Acme Constant	+$1,354,000 to +$5,909,000	+$244,000 to +$1,066,000	+11.9 to +51.8
Acme Variable	+$739,000 to +$3,570,000	+$133,000 to +$644,000	+6.5 to +31.3
Critical Habitat	-$246,000 to -$985,000	-$44,000 to -$178,000	-2.2 to -8.6

7.2 Scope and Methods

As discussed in chapter 3, the impact area for this analysis includes Guadalupe, De Baca, Curry, Chaves, Eddy, and Roosevelt Counties (map 3.2 in chapter 3). The major cities in the study area include Santa Rosa (Guadalupe), Fort Sumner (De Baca), Clovis (Curry), Portales (Roosevelt), Roswell (Chaves), and Carlsbad (Eddy). The economic impact area extends beyond the area of physical impacts to account for the economic ties between the larger urban areas in eastern New Mexico. These ties are the result of consumer and producer buying and supply patterns outside the immediate impact area.

The regional economic impacts from retiring, leasing, or fallowing agricultural land or changing cropping patterns can be separated into five categories:

1. Impacts from changes in agricultural production inputs

2. Impacts from changes in farm income

3. Impacts from income received from land payments when applicable

4. Impacts from any annual maintenance expenditures associated with the new use of retired land

5. Fiscal impacts resulting from changes in property tax revenues

The first two categories of impacts represent losses in regional economic activity in the case of land retirement or fallowing as a result of reduced agricultural production. The impacts from reduced agricultural production are annual impacts because production would have occurred each year if the land had not been taken out of irrigated production. Category 3 and 4 impacts would have regional economic positive impacts when land or lease payments are made to landowners and the new land use requires some level of development or maintenance. The land and lease payments are one-time impacts because the payment is assumed to be made in one lump sum, from which there would be a one-time injection of money into the local economy. The fiscal impacts would be negative if a change in land use and/or ownership were to lead to reduced property valuations and reduced property tax revenues. The negative impacts associated with land retirement and fallowing generally would be greater than the positive impacts. However, it needs to be recognized that there are positive effects that partially mitigate the regional economic losses associated with retiring or fallowing irrigated land.

7.2.1 Changes in Agricultural Production Inputs

Irrigated agricultural land generates regional impacts through the demand and payments for crop production inputs such as labor, fertilizer, pesticides, fuel and oil, machinery, and custom work. Retiring irrigated agricultural land and converting it to dryland production or some type of wildlife habitat generally will result in a reduction in the amount of input expenditures associated with that land, or will at least change the types of inputs required, as will fallowing land. Estimating the change in input expenditures requires knowledge of both the level and type of expenditures under current conditions and expenditures that would be required for the land use after the land is retired.

For example, suppose land that is currently used to grow alfalfa hay is slated for retirement and the water currently used for irrigation on the land will be used for instream flows. Also, suppose the land that was farmed will now be native grass. The native grassland will require some general maintenance. The change in input expenditures that needs to be evaluated for regional impacts is represented by the impact of total input expenditures for irrigated agriculture minus the estimated impacts of input expenditures for native grassland.

Input expenditures represent demands for goods and services provided by both local and nonlocal retailers and wholesalers. To the extent that these goods and services are purchased from within the region, these expenditures generate positive economic impacts in the form of income and employment. The level of expenditures required for retired land that may be returned to native grass or some other dryland cover crop generally will be much lower than for irrigated production. Therefore, land retirement will generally result in net negative regional impacts with respect to the level of input expenditures.

7.2.2 Changes in Farm Income

Similar to the impacts from reduced input expenditures, a shift from irrigated agriculture to dryland use generally will result in lower levels of household income associated with net farm revenues. The one exception is when the irrigated operation is actually operating at a loss and, therefore, retiring the land will reduce the loss. Net farm revenues represent funds that are available for purchasing goods and services. For a family farm operation, these expenditures are typically for household goods and services. Net revenues from larger operations may be reflected through reinvestment in the farm operation or investment outside the farm, in addition to household goods and services. If the farm is leased, then a representative lease payment needs to be subtracted (along with any other payments to the owner) from net farm income to represent local household expenditures (unless the owner receiving the lease payment lives in the study area). In any case, a reduction in irrigated acreage is likely to result in lower regional income.

7.2.3 Income Received from Land Payments

Payments made to landowners willing to sell, lease, or fallow their land may generate positive regional impacts. The extent of these impacts depends on where the landowner spends the payment received. If the landowner lives in the study area, but plans on taking the sale/lease payments and retiring outside of the study area, the payments will not generate regional economic impacts. However, if the landowner lives in the study area and plans to remain in the area after the land retirement payment is made, then some or all of the payment will create regional economic impacts. The magnitude of these impacts depends on how the landowner uses the payments. Payments used to purchase goods and services sold in the region will generate regional economic impacts. Payments that are put in savings or used to pay off debt to financial institutions outside of the study area will not generate regional impacts.

For example, suppose that 1,000 acres of land are to be retired and the average land retirement payment is $200 per acre. Also, assume that the retired acreage is owned by four individuals, each owning 250 acres. If one of the owners is an absentee owner living outside of the impact area, then $50,000 in land payments will not generate regional economic impacts. If another owner plans on retiring out of the State after he sells the land, then that represents another $50,000 in land payments that will not create regional impacts. If a third landowner plans on investing one-half of the land payment outside of the region, then $25,000 of payments will not create regional impacts. Assuming the fourth landowner is remaining in the region and will spend all of the land payment in the region, a maximum of only $75,000 of the total $200,000 in retirement payments for land in the study area will actually generate positive regional economic impacts.
For purposes of this analysis, it was assumed that all individuals participating in any program that includes payments for land retirement, land fallowing, or changes to cropping patterns would remain in the study area and would generate regional economic positive impacts.

7.2.4 Annual Maintenance Expenditures Associated with the New Use of Retired Land

Expenditures related to supporting new use of the land after it is retired generate positive regional economic impacts. These expenditures could be the result of re-establishing native grass for erosion control, establishing dryland production, or some other goal. The expenditures also could be for some type of ongoing annual expenditures, such as weed control. Expenditures for the new land use is a mitigating factor to the negative impacts associated with lost irrigated production to the extent that these expenditures occur within the impact region.

7.2.5 Fiscal Impacts Resulting from Changes in Property Tax Revenues

Privately held irrigated land is generally subject to local property taxes that help fund county services. Government land retirement programs can reduce the funds available for local governments in two possible ways. First, if the land is actually purchased by the government, then that land is not subject to the same taxation as privately held land. This does not appear likely to occur in this case. Second, a land retirement program also can affect property tax revenues by changing the taxable value of irrigated land. The assessed value of nonirrigated land is lower than that of irrigated land. Therefore, tax revenues from retired land will be lower than before retirement.

Federal programs exist that can partially offset some fiscal impacts. Payments in Lieu of Taxes (PILT) are Federal payments to local governments that help offset losses in property taxes due to nontaxable Federal lands within their boundaries. The law that implemented these payments is Public Law 94-565, dated

October 20, 1976. The law was amended by Public Law 97-258 on September 13, 1982, and codified in Chapter 69, Title 31 of the United States Code.

PILT payments are designed to help local governments carry out such vital services as firefighting, police protection, construction of public schools, and construction of roads. However, the program only applies to land that is actually purchased by the Federal Government. Land that is not purchased by the Federal Government but is no longer irrigated due to transferred water rights does not qualify for PILT payments. Therefore, the PILT program does not apply in this case.

7.2.6 Measuring Impacts

The regional impacts from changes in agricultural production and land payments were analyzed using the IMPLAN (IMpact analysis for PLANing) model. The IMPLAN model uses the Department of Commerce national input-output model to estimate flows of commodities used by industries and commodities produced by industries. Social accounts are included in the IMPLAN model data base for each region under consideration. Social accounts represent the flow of commodities to industry from producers and consumers, as well as consumption of the factors of production from outside the region. Social accounts are converted into input/output accounts and the multipliers for each industry within the region, which accounts for the multiple effects of changes in spending associated with land retirement. The IMPLAN model also accounts for the percentage of expenditures in each category that would remain within the region and expenditures that would flow outside the region.

Estimating the regional impacts from land retirement, fallowing, and changes to cropping patterns requires information on current agricultural production expenditures, net farm revenues from land targeted for retirement, any one-time and annual expenditures associated with the new land use, and the amount of the land payments made for retiring land.

7.3 Impact Analysis Overview

Each alternative is likely to have some impact on irrigated agricultural production as a result of water right purchases, land retirement, and changes to cropping patterns. Acreage retirement and changes to cropping patterns shown in table 4.50 were used to estimate the regional economic impacts.

Representative agricultural production costs and revenues were estimated using data from the publication Crop Cost and Return Estimates in New Mexico, 1999 (New Mexico State University, Agricultural Experiment Station, 2001). These cost and return estimates show production requirements and costs that would typically be expected for a farm operation, along with typical yields. Irrigated alfalfa is grown throughout the region and is based on an average of data for Chaves, Curry, De Baca, and Eddy Counties. The costs and returns from irrigated wheat were based on data for Curry County. Costs and returns for cotton were based on data from Chaves and Eddy Counties. Irrigated sorghum costs and returns were based on data for Curry County, and barley returns were based on data for Eddy County. Cost and return information for dryland sorghum and wheat were based on Roosevelt County data. The results are summarized in table 4.52. The results indicate alfalfa is the primary generator of agricultural income in the region.

Table 4.52 Representative costs and returns for representative irrigated land, land, and dryland with changes to cropping patterns

Revenues and expenses	CID		FSID		
	Weighted 80% hay and 20% cotton ($ per acre)	Weighted 50% hay and 50% cotton ($ per acre)	Weighted 80% hay and 20% small grains ($ per acre)	Weighted 50% hay and 50% small grains ($ per acre)	Dryland weighted 50% sorghum and 50% wheat ($ per acre)
Gross return	625.59	603.13	563.12	448.73	77.86
Expenses					
Seed	10.16	9.12	12.16	13.92	3.66
Fertilizer	35.42	27.27	42.48	45.24	-
Chemicals	54.88	62.93	43.22	33.81	6.89
Crop insurance	0.22	0.54	0.67	1.60	0.11
Other purchase inputs	18.88	11.80	18.88	11.80	-
Fuel, oil, lubricants	14.37	18.21	11.13	10.11	5.39
Irrigation energy	59.66	53.94	60.49	56.20	-
Repairs	30.06	41.27	20.50	17.37	8.01
Custom	28.82	58.82	14.33	22.78	-
Land taxes	1.38	1.45	1.30	1.25	0.13
Miscellaneous	55.28	56.50	55.01	55.44	20.54
Fixed expenses	114.40	135.66	89.79	74.31	19.82
Labor	91.81	95.43	80.12	66.31	13.29
Capital	40.90	53.04	31.96	30.75	13.14
Total expenses	556.21	625.98	482.04	440.89	90.00
Net income	69.38	-22.84	81.08	7.84	-13.13

For this analysis, alfalfa and cotton were used to represent production in the CID area, and alfalfa, wheat, sorghum, and barley were used to represent production in the FSID area. It was assumed that an irrigated cropping pattern for both areas included 80 percent alfalfa. Any changes to cropping patterns to reduce the irrigation requirement were assumed to reduce alfalfa acreage to 50 percent of the total acreage. Dryland crop acreage was assumed to be 50 percent sorghum and 50 percent wheat. Table 4.53 shows representative costs and returns for retired and fallowed land and land that experiences changes to cropping patterns.

Table 4.53 Representative crops expenses, production, and revenues in the study region ($)

Category	Alfalfa (per acre)	Cotton (per acre)	Wheat (per acre)	Sorghum (per acre)	Barley (per acre)	Dryland sorghum (per acre)	Dryland wheat (bushels per acre)
Yield	5.34 tons	765.0 pounds	61.25 bushels	85.0 bushels	30 bushels	15.0 bushels	22.0 bushels
Gross return	640.56	565.71	280.84	345.60	137.20	73.55	82.16
				Expenses			
Seed	10.85	7.38	18.30	2.65	30.80	2.82	4.50
Fertilizer	40.85	13.68	52.12	67.04	28.50	-	-
Chemicals	49.51	76.34	18.11	20.50	15.59	13.78	-
Crop insurance	-	1.09	0.81	0.29	8.82	0.12	0.09
Other purchase inputs	23.59	-	-	-	-	-	-
Fuel, oil, lubricants	11.81	24.61	6.95	9.65	8.66	6.59	4.19
Irrigation energy	63.47	44.41	50.69	57.69	37.74	-	-
Repairs	22.58	59.97	9.48	14.80	12.19	8.62	7.40
Custom	8.82	108.82	35.59	50.18	23.70	-	-
Land taxes	1.33	1.57	1.15	0.84	1.57	0.13	0.13
Miscellaneous	54.47	58.54	44.49	43.90	82.40	20.57	20.52
Fixed expenses	100.22	171.11	42.97	64.40	37.18	21.05	18.60
Labor	89.39	101.46	41.21	51.96	36.08	14.66	11.92
Capital	32.81	73.27	26.78	34.09	25.02	14.67	11.61
Total expenses	509.71	742.25	348.63	417.97	348.23	103.01	78.96
Net income	130.85	-176.54	-67.79	-72.37	-211.03	-29.46	3.20

The option of changing cropping patterns to use less irrigation water would lead to lower levels of net farm income. Any loss of farm income would need to be compensated by reimbursing the farmers for the loss in profit. It was assumed that the difference in net farm income with and without the changes to cropping patterns was distributed to the affected farmers as household income. Payments to landowners for fallowing land and land retirement were treated as household income.

The data from table 4.53 were input into the IMPLAN model, as were estimates of changes in net farm income as a result of changes to cropping patterns (to represent payment needed to compensate those farmers for lost revenues) and an estimated $1,000 per acre payment for retiring land. These data represent all of the possible cropland retirement and changes to cropping patterns for each alternative and water acquisition option, as well as nonirrigated conditions for land that is retired. Another possible dryland option would be for livestock grazing. However, there would be very little revenue and associated expenditures associated with grazing, assuming a carrying capacity of 0.3 animal unit months

(AUM) per acre and a grazing lease rate of $15 per AUM. As a result, dryland sorghum or wheat was used to represent nonirrigated land. The impacts are presented in table 4.54 on a per acre basis, except for employment, which is presented as an impact per 1,000 acres.

Table 4.54 Regional economic impacts per acre associated with various cropping patterns and retirement options

Impact area and sector	Total output per acre ($)	Income per acre ($)	Employment per 1,000 acres (number of jobs)
Current CID cropping pattern			
Farm sector	222	149	4.5
Energy suppliers	79	18	0.3
Services sector	98	20	0.9
Wholesale/retail trade	298	118	4.3
All other sectors	130	13	0.5
Total	827	318	10.5
Current FSID cropping pattern			
Farm sector	204	136	4.1
Energy suppliers	79	18	0.3
Services sector	91	18	0.6
Wholesale/retail trade	251	100	3.8
All other sectors	126	12	0.7
Total	751	284	9.5
CID after changes to cropping patterns			
Farm sector	246	165	5.0
Energy suppliers	71	16	0.3
Services sector	85	19	0.8
Wholesale/retail trade	312	123	4.2
All other sectors	84	12	0.4
TOTAL	608	335	10.7
FSID after changes to cropping patterns			
Farm sector	199	133	4.1
Energy suppliers	71	16	0.3
Services sector	68	15	0.6
Wholesale/retail trade	196	77	3.8
All other sectors	74	10	0.7
Total	608	252	9.5
Dryland acreage			
Farm sector	34	1	-
Energy suppliers	2	1	-
Services sector	9	3	0.3
Wholesale/retail trade	45	14	0.7
All other sectors	5	1	-
Total	95	20	1
Retirement payment	1,231	222	10.8
Cropping pattern subsidy CID area land	114	20	1.0
Cropping pattern subsidy FSID area land	90	16	0.8

7.4 Impacts of Alternatives

The impacts associated with each alternative are summarized in tables 4.55 through 4.60. Narrative discussions of the impacts follow.

Table 4.55 Regional impacts as measured by a change in the value of total output compared to pre-1991 baseline ($)

Alternative	FSID lease or purchase	River pumper lease or purchase	CID lease or purchase	CID cropping pattern	PVACD lease or purchase for well field
No Action	-2,165,000	-918,000	-586,000	-350,000	-787,000
Taiban Constant	-1,640,000	-656,000	-439,000	-263,000	-590,000
Taiban Variable (45 cfs)	-1,640,500	-656,000	-439,000	-263,000	-590,000
Taiban Variable (50 cfs)	-2,034,000	-853,000	-512,000	-329,000	-787,000
Taiban Variable (55 cfs)	-2,296,000	-984,000	-586,000	-372,000	-853,000
Acme Constant	-5,314,000	-2,230,000	-1,391,000	-854,000	-1,968,000
Acme Variable	-4,067,000	-1,706,000	-1,025,000	-657,000	-1,509,000
Critical Habitat	-1,640,000	-656,000	-439,000	-263,000	-590,000

Table 4.56 Regional impacts as measured by a change in regional income compared to pre-1991 baseline ($)

Alternative	FSID lease or purchase	River pumper lease or purchase	CID lease or purchase	CID cropping pattern	PVACD lease or purchase for well field
No Action	-871,000	-370,000	-238,000	-27,000	-317,000
Taiban Constant	-660,000	-264,000	-179,000	-20,000	-238,000
Taiban Variable (45 cfs)	-660,000	-264,000	-179,000	-20,000	-238,000
Taiban Variable (50 cfs)	-818,000	-343,000	-209,000	-26,000	-317,000
Taiban Variable (55 cfs)	-924,000	-396,000	-238,000	-29,000	-343,000
Acme Constant	-2,138,000	-898,000	-566,000	-66,000	-792,000
Acme Variable	-1,637,000	-686,000	-417,000	-51,000	-607,000
Critical Habitat	-660,000	-264,000	-179,000	-20,000	-238,000

Table 4.57 Regional impacts as measured by a change in employment compared to pre-1991 baseline (jobs)

Alternative	FSID lease or purchase	River pumper lease or purchase	CID lease or purchase	CID cropping pattern	PVACD lease or purchase for well field
No Action	-28.1	-11.9	-7.6	-0.3	-10.2
Taiban Constant	-21.3	-8.5	-5.7	-0.2	-7.7
Taiban Variable (45 cfs)	-21.3	-8.5	-5.7	-0.2	-7.7
Taiban Variable (50 cfs)	-26.4	-11.1	-6.7	-0.3	-10.2
Taiban Variable (55 cfs)	-29.8	-12.8	-7.6	-0.3	-11.1
Acme Constant	-68.9	-28.9	-18.1	-0.8	-25.5
Acme Variable	-52.7	-22.1	-13.3	-0.6	-19.6
Critical Habitat	-21.3	-8.5	-5.7	-0.2	-7.7

Table 4.58 Regional impacts as measured by a change in the value of total output compared to No Action Alternative ($)

Alternative	FSID lease or purchase	River pumper lease or purchase	CID lease or purchase	CID cropping pattern	PVACD lease or purchase for well field
Taiban Constant	+525,000	+262,000	+146,000	+88,000	+197,000
Taiban Variable (45 cfs)	+525,500	+262,000	+146,000	+88,000	+197,000
Taiban Variable (50 cfs)	+131,000	+66,000	+73,000	+22,000	0
Taiban Variable (55 cfs)	-131,000	-66,000	0	-22,000	-66,000
Acme Constant	-3,149,000	-1,312,000	-805,000	-504,000	-1,181,000
Acme Variable	-1,902,000	-787,000	-439,000	-307,000	-722,000
Critical Habitat	+525,000	+262,000	+146,000	+88,000	+197,000

Table 4.59 Regional impacts as measured by a change in regional income compared to No Action Alternative ($)

Alternative	FSID lease or purchase	River pumper lease or purchase	CID lease or purchase	CID cropping pattern	PVACD lease or purchase for well field
Taiban Constant	+211,000	+106,000	+60,000	+7,000	+79,000
Taiban Variable (45 cfs)	+211,000	+106,000	+60,000	+7,000	+79,000
Taiban Variable (50 cfs)	+53,000	+26,000	+30,000	+2,000	0
Taiban Variable (55 cfs)	-53,000	-26,000	0	-2,000	-26,000
Acme Constant	-1,267,000	-528,000	-328,000	-39,000	-475,000
Acme Variable	-766,000	-317,000	-179,000	-24,000	-290,000
Critical Habitat	+211,000	+106,000	+60,000	+7,000	+79,000

Table 4.60 Regional impacts as measured by a change in employment compared to No Action Alternative (jobs)

Alternative	FSID lease or purchase	River pumper lease or purchase	CID lease or purchase	CID cropping pattern	PVACD lease or purchase for well field
Taiban Constant	+6.8	+3.4	+1.9	+0.1	+2.6
Taiban Variable (45 cfs)	+6.8	+3.4	+1.9	+0.1	+2.6
Taiban Variable (50 cfs)	+1.7	+0.9	+0.9	0	0
Taiban Variable (55 cfs)	-1.7	-0.9	0.0	0	-0.9
Acme Constant	-40.8	-17.0	-10.5	-0.5	-15.3
Acme Variable	-24.7	-10.2	-5.7	-0.3	-9.4
Critical Habitat	+6.8	+3.4	+1.9	+0.1	+2.6

7.5 No Action Alternative

Impacts under the No Action Alternative are the result of short-term water right purchases/leases that would be needed to meet instream flow requirements as prescribed in the BO. Therefore, negative impacts would be expected under the No Action Alternative compared to the pre-1991 baseline. An estimated 800 to 3,300 acres of irrigated lands could be retired, and cropping patterns could change on 1,600 acres. Negative annual regional economic impacts would range from $0.35 million to $2.2 million in total value of output lost and losses of 0.3 to 28.1

jobs compared to the pre-1991 baseline. Some positive impacts would be expected as a result of payments made for short-term water right purchases/leases. These positive impacts represent one-time effects as opposed to the recurring negative annual impacts discussed previously. Therefore, the one-time positive impacts are much smaller than the recurring negative impacts over the long term.

7.6 Taiban Constant Alternative

The smallest impacts of the alternatives considered in detail are associated with the Taiban Constant Alternative. An estimated 600 to 2,500 acres of irrigated land could be retired under the Taiban Constant Alternative, or cropping patterns could change on 1,200 acres. An estimated range of annual regional economic impacts are $88,000 to $0.5 million in total value of output gained and the creation of 0.1 to 6.8 jobs compared to the No Action Alternative. One-time positive impacts under the Taiban Constant Alternative are likely to be less than under the No Action Alternative.

7.7 Taiban Variable Alternative

A range of regional economic impacts are estimated for the Taiban Variable Alternative. An estimated 600 to 3,500 acres of irrigated land could be retired, or cropping patterns could change on 1,200 to 1,700 acres. The Taiban Variable Alternatives would range from negative annual regional economic impacts of $131,000 in total value of output lost to a positive impact of $525,000 in total value of output gained and the losses of 2 jobs to the creation of 6.8 jobs compared to the No Action Alternative. One-time impacts associated with land payments under the Taiban Variable Alternative are likely to be negative compared to the No Action Alternative.

7.8 Acme Constant Alternative

The greatest negative annual regional economic impacts associated with reduced agricultural production would occur under the Acme Constant Alternative. An estimated 1,900 to 8,100 acres of irrigated land could be retired, or cropping patterns could change on 3,900 acres. The Acme Constant Alternative would result in negative annual regional economic impacts of about $0.5 million to $3.1 million in total value of output lost and losses of 0.5 to 41.0 jobs compared to the No Action Alternative. Positive one-time impacts under the Acme Constant Alternative are $1.3 to $5.9 million in total value of output gained and the creation of 12 to 52 jobs.

7.9 Acme Variable Alternative

The second greatest negative annual regional economic impacts would occur under the Acme Variable Alternative. An estimated 1,400 to 6,200 acres of irrigated lands could be retired, or cropping patterns could change on 3,000 acres. The Acme Variable Alternative would result in negative annual regional economic impacts of about $307,000 to $1.9 million in total value of output lost and losses of 0.3 to 25 jobs compared to the No Action Alternative. One-time positive impacts under the Acme Variable Alternative are estimated to range from $0.7 million to $3.6 million in total value of output gained and the creation of 6.5 to 31 jobs.

7.10 Critical Habitat Alternative

Small acreage impacts are associated with the Critical Habitat Alternative. An estimated 600 to 2,500 acres of irrigated lands could be retired, or cropping patterns could change on 1,200 acres. The Critical Habitat Alternative would result in positive annual regional economic impacts of $88,000 to $525,000 in total value of output gained and creation of an additional 0.1 to 6.8 jobs compared to the No Action Alternative. One-time impacts under the Acme Variable Alternative are negative compared to the No Action Alternative.

7.11 Impacts of CPWA and AWA Options

Many possible water acquisition options could be used to meet the water needs associated with each alternative. These options include water right purchase, water right leasing, well field development, changes to cropping patterns, and FSID gravel pit pumping. These options would have varying impacts on agricultural production and income. Clearly, any options that include components that move water away from irrigated agricultural production, such as land retirement or crop fallowing, would have an effect on farm output and revenues. The type of land impact (retirement, fallowing, changes to cropping patterns), potential acreage affected, efficiency, and location of impacts could vary greatly for the different options. The primary difficulty in estimating agricultural economic impacts is determining the mix of options that would be implemented in association with each alterative. The extent to which different options would be implemented cannot be known with certainty.

7.12 Mitigation Measures and Residual Impacts

No mitigation measures or residual impacts have been identified.

8. Recreation

As discussed in chapter 3, the following indicators were selected to evaluate recreation:

- Recreation visitation and associated expenditures at Santa Rosa Reservoir, Sumner Lake, Brantley Reservoir, and Avalon Reservoir

- Recreation along the Pecos River

8.1 Summary of Impacts

Table 4.61 summarizes the impacts of the alternatives on recreation. A narrative summary discussion follows.

Table 4.61 Summary of impacts of alternatives on recreation

Indicator	Alternative					
	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Reservoir recreation and impacts	No change	Approximately the same as No Action	Approximately the same as No Action	Approximately the same as No Action	Approximately the same as No Action	Approximately the same as No Action
River recreation and impacts	No change	Less recreation use implies less recreation related spending and lower net benefits than No Action	Less recreation use implies less recreation related spending and lower net benefits than No Action	More recreation use implies more recreation related spending and higher net benefits than No Action	More recreation use implies more recreation related spending and higher net benefits than No Action	Approximately the same recreation use implies approximately the same recreation related spending and approximately the same net benefits as No Action

The action alternatives are expected to have negligible to minor impacts on recreation. That is, recreation use of the reservoirs and the Pecos River is expected to vary from year to year, perhaps drastically, but the different operating regimes for the system would not, in and of themselves, be the cause of major changes in use from year to year.

The impacts of changes in recreation use on the socioeconomic conditions were not quantified. Modeling efforts could not identify a statistically significant relationship between changes in the different water scenarios and recreation use. Therefore, recreation use and expenditures were not quantified.

In general, however, it is expected that more water flowing in the Pecos River and stored in the reservoirs during the recreation season would mean greater opportunities for water-oriented outdoor recreation. The timing of flows in the river, as well as the amount, can affect recreation opportunities. The impacts on recreation under the alternatives are likely to be small because the differences in flow between the No Action Alternative and the action alternatives were 0 to less than 1 percent. Some differences in the amount of river recreation available under each alternative would be expected, but impacts on recreation use due to the alternatives are localized and mostly short term because water availability fluctuates annually.

Reservoir recreation is also dependent upon the amount of water held in storage, the surface area available, and elevation of the reservoirs. Recent drought conditions and low water levels at Sumner Lake and Brantley Reservoir resulted in large declines in visitor use in 2002 and 2003. Differences in reservoir elevation and storage between the No Action Alternative and any action alternative were between 0 and -5 percent. Recreation use would be expected to be somewhat less under each of the action alternatives, but only slightly.

8.2 Scope and Methods

The affected region for impact analysis includes the four counties in New Mexico through which the Pecos River flows (north to south): Guadalupe, De Baca, Chaves, and Eddy. Water-oriented recreation occurs along the Pecos River (at Bitter Lake National Wildlife Refuge and other sites where public access is available) and at the State parks at Sumner Lake, Santa Rosa Reservoir, and Brantley Reservoir. Most recreation activities are associated with some type of related expenditures. For example, swimming and boating at Sumner Lake leads to expenditures for food, beverages, gasoline, and other related items. Therefore, changes in the amount of recreation activity have an effect on the regional economy.

The regional impacts related to changes in recreation use can be converted to a common denominator (dollars) that can be compared to the dollar impacts of other resources. Ideally, changes in recreation use could be predicted for each alternative, and changes in expenditures would be based upon these changes. Changes in expenditures, used with a regional impact model, can estimate changes in output, income, and employment. However, because the changes in recreation use cannot be quantified under the alternatives, regional impacts were not estimated quantitatively. Rather, potential changes under the action alternatives were estimated qualitatively.

8.3 Impact Analysis Overview

In general, it is expected that more water flowing in the Pecos River and stored in the reservoirs would provide more opportunities for water-oriented outdoor recreation. More recreation use implies greater expenditures. The timing of flows in the river, as well as the amount, can affect the opportunities for recreation. Lake elevations and surface areas at these reservoirs also affect recreation use. The type of hydrologic condition—dry, average, or wet—as determined by the amount of precipitation and water available within the Pecos

River basin is a primary factor in the level of recreation activity. Regardless of the alternative, reservoir elevations can vary by several feet during a particular water year, depending on precipitation, water supply on hand, and water needs for irrigation and other purposes. Lowering these reservoirs during the summer recreation season to provide water for irrigated agriculture results in less water available for recreation in the reservoirs and in the river.

Table 4.62 presents the percentage differences in maximum, average, and minimum flows under the action alternatives and the No Action Alternative. At the Near Acme gage, maximum and minimum flows are the same under the No Action Alternative and the action alternatives, and average flows vary only by 1 percent (plus or minus). The same is true at the Near Artesia gage, except that the minimum flow under Acme Constant Alternative is 4.7 percent greater than under the No Action Alternative. These data do not indicate that Pecos River flows differ significantly by alternative. Thus, only minor variations in recreation use would be expected, on average, among the alternatives.

Table 4.62 Percentage difference in maximum, average, and minimum flows between action alternatives and the No Action Alternative

Alternative	Flow measure (cfs)	Near Acme gage[1]	Near Artesia gage[1]
No Action	Maximum Average Minimum	20,606.0 142.0 0.0	41,219.5 197.7 5.5
Taiban Constant	Maximum Average Minimum	0.0% 1.2% [2]	0.0% 0.8% 0.0%
Taiban Variable (45 cfs)	Maximum Average Minimum	0.0% 0.6% [2]	0.0% 0.4% 0.0%
Acme Constant	Maximum Average Minimum	0.0% -0.7% [2]	0.0% -0.7% 4.7%
Acme Variable	Maximum Average Minimum	0.0% 0.0% [2]	0.0% -0.1% 0.0%
Critical Habitat	Maximum Average Minimum	0.0% 1.0% [2]	0.0% 0.7% 0.0%

[1] Flows are provided for the No Action Alternative in cfs, but for the action alternatives, percentage of difference from No Action is provided to show the magnitude of change.
[2] Division by zero is not possible. The minimum flow is 0 cfs for all alternatives.
Source: HRC, 2003b.

Flow exceedance curves for the Near Puerta De Luna, Near Artesia, and Kaiser channel gages differ only slightly between the action alternatives and the No Action Alternative, indicating only minor differences in flows under the alternatives. Therefore, only minor variations in recreation use are expected at these locations, on average, under the alternatives.

Flow exceedance curves for the Taiban, Near Dunlap, Near Acme, Hagerman, and Lake Arthur gages do differ between the action alternatives and the No Action Alternative. At the Near Acme, Hagerman, and Lake Arthur gages, flows are the same as or higher under the Acme Constant Alternative than under the No Action Alternative. Flows are about the same under the Acme Variable and Critical Habitat Alternatives as under the No Action Alternative. Flows are lower under the Taiban Constant and all the Taiban Variable Alternatives than under the No Action Alternative.

At the Taiban and Near Dunlap gages, flows are the same as or higher under the Acme Constant and Acme Variable Alternatives than under the No Action Alternative. Flows are the same as or lower under the Taiban Constant and all the Taiban Variable Alternatives than under the No Action Alternative. Again, the assumption is that greater volume and higher riverflows would provide the potential for more water-oriented recreation.

Table 4.63 presents the percentage difference in average daily reservoir elevations and average daily storage volumes under the No Action Alternative and the action alternatives. Although storage volumes differ, differences in average daily reservoir elevations are less than one-tenth of 1 percent (between 0 and 3 feet of elevation). On average, there is little difference among the alternatives.

Table 4.63 Percentage difference in average daily elevation and storage between action alternatives and the No Action Alternative

Alternative	Elevation (feet) Storage (acre-feet)	Santa Rosa Reservoir	Sumner Lake	Brantley Reservoir
No Action	Elevation Storage	4,729 56,953	4,252 24,472	3,247 24,330
Taiban Constant	Elevation Storage	0.0 0.4	0.0 -2.5	0.0 0.5
Taiban Variable (45 cfs)	Elevation Storage	0.0 1.1	0.0 0.3	0.0 -0.3
Acme Constant	Elevation Storage	0.0 5.3	0.0 11.2	0.0 -3.2
Acme Variable	Elevation Storage	0.0 3.9	0.0 8.8	0.0 -4.4
Critical Habitat	Elevation Storage	0.0 0.6	0.0 -3.5	0.0 0.7

Source: HRC, 2003b.

Reservoir pool exceedance curves vary only slightly between the No Action Alternative and any action alternative, indicating only minor differences in water volumes and elevations under alternative water regimes. Therefore, only minor variations in recreation use are expected, on average, among the alternatives. However, lake elevations at these three reservoirs can vary by several feet during a water year, depending upon precipitation, water supply on hand, and water needs for irrigation and other purposes.

Water available for recreation purposes seems to depend more upon local weather and climate conditions (water year type and thus overall supply) and the demand for other uses of the water (chiefly irrigated agriculture) during a particular water year, rather than on the differences between the alternatives.

8.4 No Action Alternative

The No Action Alternative provides a baseline for reference; however, little visitor use data are available to document thoroughly the current levels of use and related economic impacts.

8.5 Taiban Constant Alternative

Recreation use would be somewhat less under the Taiban Constant Alternative than under the No Action Alternative. Localized effects would occur at individual reservoirs and reaches of the Pecos River. Less recreation use implies less spending and lower net benefits. The effects are negligible to moderate but may be a long-term change. Fiscal and economic impacts are less, corresponding to less water available for recreation.

8.6 Taiban Variable Alternative

Effects would be about the same under the Taiban Variable Alternative as under the Taiban Constant Alternative.

8.7 Acme Constant Alternative

Recreation use would be somewhat greater under the Acme Constant Alternative than under the No Action Alternative. Fiscal and economic impacts are expected to be greater, corresponding to greater water available for recreation. The effects would be negligible to moderate but may be a long-term change. Localized effects would occur near individual reservoirs and reaches of the Pecos River.

8.8 Acme Variable Alternative

Effects would be about the same under the Acme Variable Alternative as under the Acme Constant Alternative.

8.9 Critical Habitat Alternative

Effects on recreation would be negligible to minor under the Critical Habitat Alternative but may be a long-term change. Fiscal and economic impacts are expected to be about the same, corresponding to the small change in water available for recreation.

8.10 Impacts of CPWA and AWA Options

As a secondary impact, some CPWA and AWA options may result in improved or additional water-oriented recreational opportunities, which would provide negligible to moderate benefits to the public. These localized opportunities occur at various places along the Pecos River or at the various reservoirs and may be short term or long term. Because it is relatively easier to change actions under programmatic management options, these options are short term. Options that involve construction and development of structures or features tend to be long term because these actions require commitments of funds and resources to construct physical improvement items that have operational and useful lives of many years. Table 4.64 summarizes the impacts of both CPWA and AWA options on recreation use.

Table 4.64 Impacts of water acquisition options on recreation use

Option category	Impact intensity (negligible, minor, moderate, or major)	Impact location (localized or general)	Impact duration (short-term, long-term)	Impact summary
Water right purchases	Moderate	Localized	Long-term	A permanent acquisition of additional water to remain in the river helps provide additional water for recreational uses.
Water right leases	Moderate	Localized	Short-term	A temporary acquisition of additional water to remain in the river may help provide additional water for recreational uses.
Changes to cropping patterns	Moderate	Localized	Short-term	Less water used for irrigation may result in more water in the reservoirs and Pecos River for recreational use.
Well field development	Negligible	Localized	Long-term	This action may not result in additional water for recreational use.
FSID gravel pit pumping	Negligible	Localized	Long-term	This action may not result in additional water for recreational use.

8.11 Mitigation Measures

No mitigation measures would be required.

8.12 Residual Impacts

No residual impacts would occur.

9. Cultural Resources

As discussed in chapter 3, the following indicators were selected to evaluate changes to cultural resources:

- The known presence or potential for cultural resources that may be eligible for listing on the *National Register of Historic Places* (NRHP) or locations that are important to Native American or other traditional communities in areas affected by the action

- Riverflow and reservoir storage levels and fluctuation resulting from changes in Carlsbad Project operations where there is a potential for directly disturbing resources, increasing access to resources, or exposing submerged resources

- Ground-disturbing activities such as drilling, trenching, grading, or construction where resources may be present; modifications to historic water retention or conveyance infrastructure; or loss or abandonment of historic structures associated with water acquisition options.

9.1 Summary of Impacts

Table 4.65 summarizes the impacts of the alternatives on cultural resources. A narrative summary discussion follows.

Table 4.65 Summary of impacts of alternatives on cultural resources

Indicator	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
Presence or potential for significant cultural resources	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Riverflow and reservoir storage levels and fluctuation where resources could be disturbed	No change	Same as No Action	Same as No Action	Same as No Action	Same as No Action	Same as No Action
Ground-disturbing activities, modification, loss, or abandonment of historic structures	No change	Unknown. Least amount of AWN. Lower potential to exercise water acquisition options which could affect cultural resources.	Unknown. Low AWN. Lower potential to exercise water acquisition options which could affect cultural resources.	Unknown. Most AWN. Highest potential to exercise water acquisition options which could affect cultural resources.	Unknown. High AWN. Higher potential to exercise water acquisition options which could affect cultural resources	Unknown. Low AWN. Lower potential to exercise water acquisition options which could affect cultural resources.

The changes in Carlsbad Project operations proposed under all of the alternatives would result in negligible impacts on cultural resources. Sites in the immediate vicinity of the river or in flood zones have been subject to past disturbances, reducing the likelihood of their intact preservation. Proposed flow levels, flow fluctuations, and changes in reservoir storage would be within the range of normal river and reservoir operations and would not be expected to exacerbate erosion of archaeological resources or exposure of submerged resources. The potential for these kinds of impacts is greater from natural drought cycles and flood events. However, the action alternatives vary in the amount of additional water that would need to be acquired to conserve the Carlsbad Project water supply through exercise of water acquisition options. The Acme Constant Alternative would require the most water, followed by the Acme Variable, Taiban Variable, Critical Habitat, and Taiban Constant Alternatives.

Depending on which options are chosen, potential impacts on cultural resources would range from negligible to major. In most cases, the options are not sufficiently developed to define the intensity of impacts, but those options that require extensive construction are more likely to cause major impacts on archaeological resources through ground-disturbing actions. Alternatives that require the acquisition of higher amounts of water would permit less management flexibility in avoiding options that may impact cultural resources. In all cases, the implementation of these options would require further consideration of cultural resource impacts and completion of the National Historic Preservation Act, section 106 process for actions that are Federal undertakings. Depending on the option, the identification, evaluation, effects determination, and resolution of adverse effects through the section 106 process could require extensive additional fieldwork and the possibility of project redesign to avoid resources. Impacts would be expected to be reduced to negligible or minor in most cases.

9.2 Scope and Methods

Impact analysis for cultural resources incorporates the section 106 process. In the section 106 process, the Federal lead agency determines an Area of Potential Effect (APE) for each undertaking or project. As discussed in chapter 3, the APE is the physical area where the alternatives and water acquisition options may affect cultural resources. The APE for cultural resources for the proposed changes in Carlsbad Project operations includes the existing water channels or active flood zones of the Pecos River corridor and the various reservoir storage pools.

Other actions contemplated in the DEIS include options for acquiring and developing water sources and the consideration of conservation and habitat restoration measures. Some of these actions could affect cultural resources but are not sufficiently defined to determine a precise APE within the broad study area from Santa Rosa Reservoir to the Red Bluff gage. These actions may result in construction, ground disturbance, changes to water storage and delivery infrastructure, and land abandonment. The impact analysis of these options includes a qualitative judgment on the potential geographic scope of each action.

> **Criteria of Adverse Effect**
> **36 CFR 800.5a**
>
> "An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association.
>
> Consideration shall be given to all qualifying characteristics of a historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the *National Register*.
>
> Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance or be cumulative."

Additional cultural resource identification, evaluation, and effects determinations would be required as these undertakings are defined.

Impacts on cultural resources are assessed by applying the criteria of adverse effect as defined in 36 Code of Federal Regulations (CFR) 800.5a. "An adverse effect is found when an action may alter the characteristics of a historic property that qualify it for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, workmanship, feeling, or association. Adverse effects may include reasonably foreseeable effects caused by the action that may occur later in time, be farther removed in distance, or be cumulative." The criteria of adverse effect provide a general framework for identifying and determining the context and intensity of potential impacts on other categories of cultural resources, as well, if these are present. Assessment of effects involving Native American or other traditional community, cultural or religious practices, or resources also requires focused consultation with the affected group.

Given the large study area, the programmatic, undeveloped nature of many of the potential actions, and the lack of inventory coverage and resource evaluation, complete information on the resource base or affected areas is not available. Impact discussion is based on the relative likelihood of resources to be present, the types and significance of resources which might be present, and the potential for impacts associated with each of the alternatives.

Projecting the locations and relative significance of cultural resources in absence of good systematic studies requires a consideration of those elements of the environment that would have attracted or permitted human use. For prehistoric resources, these would include distance to water, elevation, surface geology, slope, aspect, and available food or material sources. Likewise, for historic resources, the availability of water and land suitable for cultivation are important considerations. Travel routes and irrigation networks are also strong indicators of the possible presence of resources. In all cases, post-depositional processes, including both the reuse of site areas and the effects of erosion and other factors, are taken into account.

To address the potential impacts of these actions, the geographic limits of each relevant action are defined to the extent possible. The presence (if known) or potential for intact cultural resources is qualitatively described and the factors that affect resource integrity are assessed. The kinds of cultural resource issues associated with the actions are described and assessed according to context and intensity of potential impact, location, duration, and whether there are reasonably foreseeable indirect and/or cumulative impacts. Where possible, comparisons are made on the basis of measurable components, such as acres of ground disturbance required or relative depth of new disturbance. The impact analysis includes a discussion of additional compliance steps and potential mitigations and their effect on reducing impacts on the resource.

In general, impacts on cultural resources resulting from the alternatives would be similar. Sites in the immediate vicinity of the river or in flood zones have been subject to past disturbances that would reduce the likelihood of their intact preservation. Changes in target flows and block release scheduling would not be substantially different from historic operations.

9.3 Impact Analysis Overview

The alternatives vary in the amount of additional water that would need to be acquired. A variety of impacts on cultural resources and extensive cultural resource compliance work could be associated with implementation of water acquisition options. It is anticipated that alternatives that require the acquisition of greater amounts of water would permit less management flexibility in avoiding options that may affect resources, including cultural resources. Depending on the option, the identification, evaluation, effects determination, and resolution of adverse effects through the section 106 process could require extensive additional fieldwork and the possibility of project redesign to avoid resources. Impacts would be expected to be reduced to negligible or minor in most cases.

9.4 No Action Alternative

The No Action Alternative would generally result in a continuation of current water operations and ongoing programs to conserve the shiner as described in the current BO (Service, 2003). Reclamation also would continue to acquire water to conserve the Carlsbad Project water supply. Consultation with the Service will be required for water operations beyond March 2003, which is unlikely to change operations in a manner that would affect cultural resources. No new actions are proposed that could affect cultural resources. Current water operations include block releases for irrigation and maintaining base inflow targets for fish conservation. Potential impacts would be limited geographically to recorded and unknown cultural resources in the existing water channels and active flood zones of the Pecos River corridor and the various reservoir storage pools. Ongoing impacts on cultural resources resulting from river and reservoir operations include the potential for direct disturbance of the integrity of archaeological sites through erosion, wave action, and cycles of inundation and drawdown, and the potential for vandalism of formerly submerged archaeological resources. The potential for these kinds of impacts, including impacts on resources that may be eligible for listing on the NRHP or may be of traditional importance, is greater from natural drought cycles and flood events. The condition of cultural resources at the various reservoirs has been monitored on multiple occasions. Other ongoing shiner management and conservation programs, including the 500-acre-feet conservation pool, would not affect cultural resources. Future actions to acquire and develop additional water or to conserve the shiner would be expected to continue and may require further consideration of the effects on cultural resources in the section 106 process and the National Environmental Policy Act of 1969 (NEPA) compliance actions.

9.5 Taiban Constant Alternative

Changes in Carlsbad Project operations proposed under the Taiban Constant Alternative would result in negligible changes to Pecos River flows, block release protocols, reservoir storage, and elevation levels. Any changes would be accommodated within the range of existing water operations and current operating conditions, which include drought and flood events. The potential for impacts from direct disturbance of the integrity of archaeological sites through erosion, wave action, and cycles of inundation and drawdown, or the potential for vandalism of formerly submerged archaeological resources resulting from this alternative would be negligible. The Taiban Constant Alternative would use less total water and require less additional water, on average, than any other alternative. Options to acquire additional water may impact cultural resources. Alternatives that require the acquisition of less water would permit more management flexibility in avoiding options that may impact cultural resources.

9.6 Taiban Variable Alternative

Changes in Carlsbad Project operations proposed under the Taiban Variable Alternative would result in negligible impacts on cultural resources, similar to those described for the Taiban Constant Alternative. The Taiban Variable Alternative would use less total water and require less additional water on average than any other alternatives, except the Critical Habitat and Taiban Constant Alternatives. Alternatives that require the acquisition of less water would permit more management flexibility in avoiding options that may impact cultural resources.

9.7 Acme Constant Alternative

Changes in Carlsbad Project operations proposed under the Acme Constant Alternative would result in negligible impacts on cultural resources, similar to the other alternatives. The Acme Constant Alternative would use more total water and require more additional water on average than any other alternative. Alternatives that require the acquisition of more water would permit less management flexibility in avoiding options that may impact cultural resources.

9.8 Acme Variable Alternative

Changes in Carlsbad Project operations proposed under the Acme Variable Alternative would result in negligible impacts on cultural resources, similar to the other alternatives. The Acme Variable Alternative would use more total water and require more additional water, on average, than any other alternative except the Acme Constant Alternative. Alternatives that require the acquisition of more water would permit less management flexibility in avoiding options that may impact cultural resources.

9.9 Critical Habitat Alternative

Changes in Carlsbad Project operations proposed under the Critical Habitat Alternative would result in negligible impacts on cultural resources, similar to the other alternatives. The Critical Habitat Alternative would use less total water and require less additional water, on average, than all of the other alternatives, except the Taiban Constant Alternative. Alternatives that require the acquisition of less water would permit more management flexibility in avoiding options that may impact cultural resources.

9.10 Impacts of CPWA and AWA Options

The CPWA and AWA options are not sufficiently defined to determine a precise APE, and cultural resource inventory information generally would not be available. It is not known whether cultural resources are present or absent, whether those resources would be eligible for listing on the NRHP, or whether they would be considered important to Native American or other traditional communities. Before implementing these options, appropriate cultural resource inventories, evaluation, and effects determination would be conducted and any adverse effects would be resolved in consultation with the SHPO and tribal groups.

Table 4.66 presents a brief summary of the impacts of CPWA options on cultural resources, and table 4.67 presents a brief summary of the impacts of AWA options.

Table 4.66 Impacts of CPWA options on cultural resources

Option	Option description	Impact summary
Q1-BV	Well field development, Buffalo Valley	Potential impacts would be limited geographically to the proposed well fields, construction support areas, access roads, and distribution infrastructure. For new construction, an APE would need to be defined and an appropriate level of inventory conducted. If cultural resources are present, potential impacts include direct disturbance of the integrity of archaeological resources through ground-disturbing activities at facility footprints, distribution infrastructure, construction support areas, access roads, and utility corridors. Roads also could afford greater access to previously undisturbed areas, allowing damage from vehicle use, vandalism, or erosion. Depending on location, new construction could impact the visual or audible setting of cultural resources. The intensity of the impacts is unknown but could be major and could result in permanent loss of resources.
Q1-SR	Well field development, Seven Rivers	
D-1A, D1AX	Surface water right purchase: FSID	Potential impacts would be limited geographically to the farms where land is retired. No direct impacts on cultural resources are expected. Permanently retiring lands from agriculture may result in long-term abandonment and subsequent
D-1B, D1BX	Surface water right purchase: Roswell area	

Table 4.66 Impacts of CPWA options on cultural resources

Option	Option description	Impact summary
D-1C, D-1CX	Surface water right purchase: CID	deterioration of historic farm structures and water conveyance features. The intensity of the impacts is unknown but could result in permanent loss of some resources.
E-1A	Surface water right lease: FSID	Potential impacts would be limited geographically to the farms where land is fallowed. No impacts on cultural resources are anticipated, unless the leases result in long-term abandonment and subsequent deterioration of historic farm structures and water conveyance features. The intensity of the impacts is unknown but could result in permanent loss of some resources.
E-1B	Surface water right lease: Roswell area	
E-1C	Surface water right lease: CID	
L-1	Changes to cropping patterns: CID (average of all crops)	Actions would be limited geographically to the farms where Changes to cropping patterns would occur. No impacts on cultural resources are anticipated.
L-2	Changes to cropping patterns: CID (low water use)	
L-3	Changes to cropping patterns: CID (very low water use)	
L-4	Changes to cropping patterns: CID (medium water use)	
U	FSID gravel pit pumping	Potential impacts would be limited geographically to the previously disturbed gravel pit and the pipeline corridor to the Pecos River and would include the well site, construction support areas, access road, and distribution infrastructure. Potential impacts would include those described for new construction. The intensity of the impacts is unknown but could be major and could result in permanent loss of resources.

Table 4.67 Impacts of AWA options on cultural resources

Option	Option description	Impact summary
A-1, A-1X	Surface water right purchase: CID	Potential impacts would be the same as those described for water right purchase in table 4.59. The sale of water rights and diversion of water from Near Puerto de Luna gage could impact traditional community and cultural practices associated with acequia agriculture.
A-2, A-2X	Surface water right purchase: FSID	
A-4, A-4X	Surface water right purchase: Near Puerto de Luna gage	
B-1	Surface water right lease: CID	Potential impacts would be the same as those described for surface water right lease in table 4.59. The lease of water rights and diversion of water from the Near Puerto de Luna gage could impact traditional community and cultural practices associated with acequia agriculture.
B-2	Surface water right lease: FSID	
B-4	Surface water right lease: Near Puerto de Luna gage	
I	FSID gravel pit pumping	Potential impacts would be the same as those described for FSID gravel pit pumping in table 4.59.

Table 4.67 Impacts of AWA options on cultural resources

Option	Option description	Impact summary
J -1	Fort Sumner area small-capacity well field	Potential impacts would be the same as those described for well field development in table 4.59.
J-2	Fort Sumner area large-capacity well field	
D-1A	Changes to cropping patterns: CID (average of all crops)	Actions would be limited geographically to the farms where Changes to cropping patterns would occur. No impacts on cultural resources are anticipated.
D-1B	Changes to cropping patterns: CID (low water use)	
D-1C	Changes to cropping patterns: CID (very low water use)	
D-1D	Changes to cropping patterns: CID (medium water use)	
D-2	Changes to cropping patterns: FSID (small grain)	
D-4	Changes to cropping patterns: Near Puerto de Luna gage (small grain)	

In addition, actions common to all action alternatives include standard block release protocols, the establishment of a permanent conservation pool, and development of an adaptive management plan. No direct impacts on cultural resources are anticipated from these actions.

9.11 Mitigation Measures

The alternatives addressing changes in Carlsbad Project operations would result in negligible impacts on cultural resources and would not require any mitigation.

Potential impacts on cultural resources would be associated with implementation of water acquisition options. Developing and acquiring these sources of water would require further consideration of cultural resource impacts and completion of the section 106 process for actions that are funded, licensed, or permitted by the Federal Government. Completion of the section 106 process and compliance with other laws, regulations, Executive orders, programmatic agreements, and other requirements listed in the cultural resource technical report would be required (Tetra Tech, Inc., 2004a).

Inventory and consultation may be needed to identify and evaluate resources. In cases in which options may affect cultural resources eligible for listing on the NRHP or associated with the cultural practices of tribal or other community, consultation will be undertaken with the State Historic Preservation Office (SHPO) and appropriate communities. State agencies also must consult with SHPO when their activities would involve nominated or listed New Mexico or

NRHP-eligible properties. State law prohibits the use of State funds for projects or programs that would adversely affect eligible properties unless the State agency or local government demonstrates that there is no feasible and prudent alternative.

If the action would have an adverse effect on a historic property or a place of cultural importance to a tribe or community, the preferred mitigation would be avoidance through project redesign and an in-place preservation of cultural resources. When this is unavoidable, mitigation measures appropriate to the resource type and specific to the resource would be developed. For archaeological sites, mitigation of impacts may be accomplished through excavation, curation of artifacts, interpretation of site data, and publication of results. Mitigations for structures could be accomplished through historic research, photographs, and architectural drawings produced in accordance with the standards for Historic American Building Survey or the Historic American Engineering Record. Mitigations for impacts on any traditional cultural property or sacred site require direct consultations with Native American and other potentially affected communities. Site protection or stabilization measures and monitoring may be appropriate even when resources are avoided.

9.12 Residual Impacts

Mitigations would be designed to reduce impacts on a negligible or minor level. Because options are not well defined, it may be possible to avoid many potential impacts in project design. For options that would require excavation of a large number of archaeological sites, there may be loss of the overall resource base, representative site types, or unique sites that may not be fully mitigatable by data recovery. Impacts on traditional cultural properties or sacred sites are often difficult to mitigate to the satisfaction of affected communities.

10. Indian Trust and Treaty Assets

As discussed in chapter 3, the following resource indicator was selected to evaluate Indian trust and treaty assets:

- The potential for the action to affect Indian real property, physical assets, or intangible property rights. Actions which would adversely affect the value, use, or enjoyment of an ITA would be considered an impact.

10.1 Summary of Impacts

No ITAs have been identified in consultation with tribes and the Bureau of Indian Affairs (BIA). There are no reservations or ceded lands in the region of influence (ROI). Because resources are not believed to be present, no impacts are anticipated to result from the alternatives or water acquisition options. Additional consultation will be conducted throughout the NEPA compliance process to update tribes and BIA on the progress of the DEIS, to provide information on the alternatives under consideration, and to solicit any concerns relative to trust assets or other issues.

10.2 Scope and Methods

The ROI is the Pecos River basin from Santa Rosa Reservoir to the New Mexico-Texas State line. Reclamation contacted representatives of tribal groups with historic ties to the Pecos River basin or tribal groups who had expressed interest in Reclamation activities to identify any tribal trust or treaty interests. Reclamation contacted these groups on a government-to-government basis to identify any concerns about the potential effects of future Reclamation activities connected with this DEIS on trust assets, cultural and biological resources, or tribal health and safety. In addition, Reclamation contacted various representatives and offices of BIA, informing them of the consultation and requesting any feedback that the agency might have regarding the project and possible environmental effects, including the potential to affect ITAs or cultural resources. No ITAs have been identified to date. A copy of this correspondence and list of recipients is included in Appendix 6, “Consultation Letters.”

Impacts on ITAs are any actions that affect Indian real property, physical assets, or intangible property rights. Examples of potential major impacts could include those that result in interference with the exercise of a reserved water right or in the degradation of water quality where there is a water right, reduce the value or alter the use of tribal lands, impact fish or wildlife where there is a hunting or fishing right, or impact cultural resources on trust lands. In some cases, the measure of impact significance on ITAs may be estimated based on the monetary value of the assets to the Indian tribe, but ITAs may also have social and cultural values that will need to be considered in addition to their economic value.

If ITAs are identified, the geographic limits of each relevant action will be defined. Actions that would change the value, use, or enjoyment of an ITA will be assessed for impacts in consultation with the affected Indian group, BIA, and the Reclamation solicitor. Where appropriate, modeling and information from other resource specialists would be used. Key questions to be answered include whether the change would be positive or negative, the context and intensity of the impact, whether the effects are short term or long term, whether there are reasonably foreseeable indirect and/or cumulative impacts, and whether there are reasonable measures that could prevent or reduce adverse impacts (Reclamation, 1998a; 1998b).

10.3 Impact Analysis

Because no resources are believed to be present within the ROI, no impacts on ITAs are anticipated to result from the alternatives or water acquisition options. Additional contacts with the tribes and the BIA are planned throughout the EIS process. No mitigations are anticipated to be needed, and there would be no residual impacts.

11. Environmental Justice

As discussed in chapter 3, the following indicator was selected to evaluate environmental justice:

- The proportion of physical or economic impacts compared to the distribution of specific population characteristics

11.1 Summary of Impacts

As discussed in chapter 3, U.S. Census Bureau data indicate that the distribution of population by race and Hispanic origin is similar for each of the four study area counties, with the exception of Guadalupe County. The percentage of total population that is Hispanic in Guadalupe County is nearly double the percentage for the entire area. Income data indicate that the per capita income for all four study area counties is lower than the average for all of New Mexico and for the entire United States. Data also show Guadalupe County has much lower income than the rest of the study area.

The location of any negative regional economic or social impacts associated with each alternative is difficult to determine because the location of retired/fallowed land or land with changes to cropping patterns cannot be predicted with any certainty. However, environmental justice concerns would be raised if any alternative results in impacts that are primarily imposed on irrigated land or recreation in Guadalupe County. Likewise, there could be an environmental justice impact if acequias are retired since many of these systems support lands owned by Hispanic farmers. Acquiring acequia water would require consensus of the acequia community, which is unlikely; therefore, such an impact would have a low chance of occurring.

The analysis of agricultural economic impacts indicates the greatest potential negative regional impacts are associated with the Acme Constant and Acme Variable Alternatives. The recreation analysis indicates minimal impacts under each alternative, although “somewhat less” recreation is expected to occur under the Taiban Constant and Taiban Variable Alternatives. Therefore, the possibility of potential environmental justice concerns is greatest under these two alternatives.

11.2 Scope and Methods

The impact region for the environmental justice analysis includes Chaves, De Baca, Eddy, and Guadalupe Counties. These counties represent the area with the greatest potential for direct physical or economic impacts. Beyond this area, the economic impacts would become very diffuse and could not be quantified.

Identifying areas of environmental justice concern requires a comparison of areas where impacts are likely to occur and the population characteristics of the affected areas. If the proportion of socioeconomic impacts of an alternative on low-income and/or minority communities identified in the region is greater than the impacts on the total affected population in the region, then environmental justice concerns exist that should be mitigated. The environmental justice analysis relies on demographic data and the ability to clearly locate areas of impact for each alternative. Census data is typically the most complete and comparable demographic and economic data available for individuals and households.

The primary difficulty in assessing the environmental justice impacts associated with changes in agricultural production is uncertainty about location of the land retirement and changes to cropping patterns. Environmental justice impacts associated with recreation are easier to evaluate because these impacts are concentrated at the reservoirs. However, the qualitative recreation impacts presented in Section 8, "Recreation," indicate minimal recreation impacts under each alternative. The impacts on recreation under the No Action and the Critical Habitat Alternatives were considered negligible; "somewhat more" recreation is expected under the Acme Constant and Acme Variable Alternatives; and "somewhat less" recreation is expected under the Taiban Constant and Taiban Variable Alternatives. Two major reservoirs, Santa Rosa Reservoir and Sumner Lake, are located in or adjacent to Guadalupe County. Therefore, if the "somewhat less" recreation use associated with the Taiban Constant and Taiban Variable Alternatives were to occur at these reservoirs or on the stream segment between these reservoirs, then some potential environmental justice issues would exist for these two alternatives.

11.3 No Action Alternative

The potential environmental justice impacts associated with the No Action Alternative appear to be small, due to the relatively small regional economic impacts associated with this alternative.

11.4 Taiban Constant Alternative

The recreation analysis indicates minimal impacts under each alternative, although "somewhat less" recreation use is expected under the Taiban Constant Alternative. Therefore, the likelihood of potential environmental justice concerns associated with recreation is somewhat greater for the Taiban Constant Alternative than for the No Action Alternative.

11.5 Taiban Variable Alternative

The recreation analysis indicates minimal impacts under each alternative, although "somewhat less" recreation use is expected under the Taiban Variable Alternative. Therefore, the likelihood of potential environmental justice concerns associated with recreation is somewhat greater for the Taiban Constant Alternative than for the No Action Alternative.

11.6 Acme Constant Alternative

The analysis of agricultural economic impacts indicates the potential negative regional impacts associated with the Acme Constant Alternative are significantly higher than for the No Action Alternative. If these impacts are associated with land retirement, fallowing, or changes to cropping patterns in Guadalupe County, there is the potential for environmental justice issues under this alternative.

11.7 Acme Variable Alternative

The analysis of agricultural economic impacts indicates the potential negative regional impacts associated with the Acme Variable Alternative are significantly greater than under the No Action Alternative. If these impacts are associated with land retirement, fallowing, or changes to cropping patterns in Guadalupe County, there is the potential for environmental justice issues under this alternative.

11.8 Critical Habitat Alternative

The potential environmental justice issues associated with the Critical Habitat Alternative appear to be small because of the relatively small regional economic impacts associated with this alternative.

11.9 Mitigation Measures and Residual Impacts

No mitigation measures or residual impacts have been identified.

12. Unavoidable Adverse Impacts

Unavoidable adverse impacts are assumed to be long-term impacts on resources that would be affected by implementation of one of the action alternatives or management actions. Resources with notable adverse impacts are water resources, biological resources, agricultural soil and land resources, and the regional economy.

Water acquisition options would be implemented under all alternatives to mitigate the direct impacts on the Carlsbad Project water supply and State-line flows, thereby reducing their magnitude. Flow exceedance curves indicate higher flows occur more frequently under alternatives with higher target flows. Model results show that intermittency occurs less frequently under every alternative than under the pre-1991 baseline. Differences in the frequency of intermittency among the alternatives are minimal.

With AWA options and adaptive management guidance, impacts could be offset or mitigated to levels that would be better than under the No Action Alternative for each action alternative, except for the Critical Habitat Alternative. These flexibilities would provide managers with the ability to augment base inflows, limit intermittency, and provide suitable spawning, rearing, and adult habitat to conserve the Pecos bluntnose shiner. These flexibilities would be extremely important for protecting Pecos bluntnose shiner populations during the irrigation season in dry and average hydrologic conditions. Temporary impacts could occur to riverine habitats under all alternatives because of scouring and/or high water velocities during irrigation releases.

The principal adverse impact to agricultural soil and land resources would be the loss of prime farmlands due to water right purchases and retirement of lands from irrigation. These actions, along with any changes to cropping patterns, would reduce agricultural production and have an adverse impact on the regional economy.

13. Relationship Between Short-Term Uses And Long-Term Productivity and Irreversible and Irretrievable Commitments of Resources

Section 102(2)(c)(iv) of NEPA and 40 CFR 11502.16 require the comparison of the relationship between local short-term uses of the human environment to the maintenance and enhancement of long-term productivity. Section 101(2)(c)(v) of NEPA and 40 CFR 1502.16 require a discussion of irreversible and irretrievable commitment of resources. Irreversible commitments are decisions affecting renewable resources such as soils, wetlands, and waterfowl habitat. Irretrievable commitments of natural resources mean loss of production or use of resources as a result of a decision. They represent opportunities foregone for the period of time that a resource cannot be used.

None of the alternatives propose major construction activity, so there would be minimal to no construction related short-term impacts. The action alternatives would result in operational changes in release patterns from reservoirs and possibly changes in land uses within the basin. These long-term actions would conserve the Pecos bluntnose shiner and the Carlsbad Project water supply.

Retiring agricultural land would be an irretrievable commitment to forego some degree of agricultural production; however, this would only impact less then 1 percent of the agricultural lands in the basin. This decision could be reversed, but returning to productive crops yields would take time. Developing well fields in Buffalo Valley or Seven Rivers would draw upon the local aquifer. In that pumping exceeds recharge rates, this could represent an irretrievable impact.

14. Environmental Commitments

This section provides the environmental commitments that may be implemented with the selection of any of the alternatives. These commitments generally are intended to avoid, mitigate, or compensate for adverse environmental effects that would otherwise occur.

Water acquisition programs: The Carlsbad project water acquisition options and the additional water acquisition options are incorporated as common actions to all alternatives. These options will be implemented as needed to help meet target flows and to conserve the Carlsbad Project water supply. All options that involve water or land leasing or purchasing would be conducted on a willing-seller basis.

Adaptive management plan (AMP): The AMP (appendix 1) is incorporated as common to all alternatives. Uncertainty is an unavoidable component of restoring and managing natural systems. To help address uncertainty, the AMP will be implemented to guide how management actions should be adjusted over time based on results of monitoring. In short, the AMP provides guidance for monitoring EIS targets, addressing actions to be taken for targets that are at risk of being missed, and addressing changing conditions in the future management of river operations by modifying operations within established parameters. The AMP provides a framework to ensure that the selected alternative satisfies the requirements of the EIS and the purpose of and need for the proposed action.

Agricultural lands: To minimize soil erosion, any retired farmlands should be reseeded to perennial grasses. This could require short-term maintenance in order to obtain adequate cover. In retiring lands, marginal or unproductive lands should be targeted rather than prime farmland.

Land disturbance: Any activities that disturb the land would follow best management practices including soil stabilization (e.g., mulching and watering), revegetation, and noxious weed control. Appropriate environmental studies would be conducted to comply with laws and regulations. These could include archeological surveys, biological surveys, Native American consultation, and hazardous waste assessments.

Chapter 5

Cumulative Impacts

Chapter 5
Cumulative Impacts

Council on Environmental Quality regulations implementing the National Environmental Policy Act define cumulative impacts as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of which agency (Federal or non-Federal) or person undertakes such actions"(40 Code of Federal Regulations section 1508.7).

Relevant past, present, and reasonably foreseeable projects evaluated for this cumulative impact analysis are listed in table 5.1. There are numerous past, present, and reasonably foreseeable actions in the study area; however, the analysis focuses on actions that may have a continuing, additive, and significant relationship to the effects of the proposed action. This process was conducted through public scoping, consultation with cooperating agencies and other stakeholders in the study area, and from conversations with staff at the Bureau of Reclamation (Reclamation) and New Mexico Interstate Stream Commission (NMISC).

The identified actions for cumulative effects assessment generally would be implemented within the next 5 years; therefore, in order to capture all potential operational effects, a 15-year time period was assumed. The geographical scope of analysis is the Pecos River basin. The cumulative impacts analysis provides an overview of the likely impacts of the individual actions followed by the likely net cumulative effects when combined together. Unless noted, the cumulative impacts would be similar for all alternatives. The section is organized by resources, as presented in chapters 3 and 4.

Table 5.1 Relevant past, present, and reasonably foreseeable actions for cumulative impact analysis

Project name	Project description	Time period
Pecos River Compact (Compact) and U.S. Supreme Court Amended Decree	Interstate stream compacts are agreements developed between States and ratified by those States and the U.S. Congress. Interstate compacts apportion surface waters of selected streams that cross State borders and are both State and Federal law. The Compact, entered into by Texas and New Mexico in 1948, requires delivery of water from the Pecos River into Texas. The consequences of not complying with Compact delivery obligations can be severe. In 1974, Texas filed a lawsuit against New Mexico for underdelivery of water required by the Compact. In 1988, the U.S. Supreme Court entered an Amended Decree, which appointed a River Master and established an accounting method to	Compact implemented in 1948; Amended Decree in 1988. Ongoing; duration indefinite.

Table 5.1 Relevant past, present, and reasonably foreseeable actions for cumulative impact analysis

Project name	Project description	Time period
	verify State-line water deliveries that the River Master would use to verify proportioning of Pecos River flows. The U.S. Supreme Court Amended Decree further established that, in the future, New Mexico is only permitted to pay its water delivery obligations with water rather than with a monetary payment. NMISC engages annually in projects to augment deliveries to Texas to remain in compliance with the Pecos River Compact.	
Pecos River Carlsbad Project Settlement Agreement (Settlement Agreement), Reclamation and NMISC	The Settlement Agreement was executed by NMISC, Carlsbad Irrigation District (CID), Reclamation, and the Pecos Valley Artesian Conservancy District (PVACD) on March 25, 2003, to settle ongoing litigation in the Pecos River basin and to provide a mechanism to ensure long-term compliance with the Pecos River Compact and the U.S. Supreme Court Amended Decree. The Settlement Agreement includes an acquisition program that authorizes NMISC to purchase up to 6,000 acres of land and water rights in CID and up to 12,000 acres of land and water rights above Brantley Dam, which includes PVACD and the Fort Sumner Irrigation District. Additionally, per the Settlement Agreement, the State will construct or purchase a well field(s) capable of producing 15,750 acre-feet of water per year.	Agreement executed in 2003. Ongoing; duration indefinite.
Long-term Miscellaneous Purposes Contract, Reclamation and NMISC	Reclamation is proposing to execute a long-term contract with CID to allow NMISC to use water up to 50,000 acre-feet for purposes other than irrigation. Like the Settlement Agreement, the project is needed to maintain long-term compliance with the Compact and meet State-line flows in accordance with the Pecos River Compact and U.S. Supreme Court Amended Decree. An EIS evaluating the execution of the contract and any third party contracts is being conducted concurrently with the Carlsbad Project Water Operations and Water Supply Conservation EIS and, as scheduled, would be completed first.	Anticipated Record of Decision (ROD) in 2006
Pecos River Basin Water Salvage Project, Reclamation	The Pecos River Basin Water Salvage Project is a Reclamation-funded project designed to control salt cedar growth from the Sumner Dam area to the New Mexico-Texas State line. Clearing activities conducted by Reclamation began in 1967 and continued until 1971, during which about 53,950 acres were cleared at various locations between Sumner Lake, New Mexico, and Pecos, Texas, a distance of about 370 miles. After a hiatus, the clearing program was reinitiated. Since 1995, the program has been limited to about 30,000 acres in the Pecos River basin of New Mexico.	Project began in 1967 and is expected to continue indefinitely.
Carlsbad Project Vegetation Management Program, Reclamation	An environmental assessment/biological assessment is in progress for the implementation of the Carlsbad Project Vegetation Management Program. The program consists of research and treatment components, both targeting the pest salt cedar (*Tamarix* sp.) and potentially other invasive plants such as kochia. The research component includes studies of biological agents, herbicides, and mechanical methods;	2004-14

Table 5.1 Relevant past, present, and reasonably foreseeable actions for cumulative impact analysis

Project name	Project description	Time period
	revegetation; and herbicide residue. The treatment component includes potential aerial application of an herbicide that would be implemented in cooperation with CID and the Carlsbad Soil and Water Conservation District.	
Pecos River Restoration Project, U.S. Army Corps of Engineers and Chaves County, New Mexico	The U.S. Army Corps of Engineers, Albuquerque District, in conjunction with Chaves County, New Mexico, proposes to restore 84 acres (10,013) linear feet of Pecos River channel and eradicate 52 acres of salt cedar. The work would be carried out at four separate sites. At the first site, 2,960 feet of river restoration south of the U.S. Highway 380 bridge, blocked segments of the channel would be reconnected to the river and the degraded channel would be redesigned. At the second site, at the confluence of the Rio Hondo and the Pecos River, the river channel would be redesigned to prevent flooding of adjacent agriculture fields. This work is also intended to improve aquatic and riparian habitat. At the third site, 4,500 linear feet of channel would be restored above the Wichita Bridge near Dexter. The channel would be modified to allow for a smooth transition through the bridge to protect the bridge. At the fourth site, bridge drains would be installed through Wichita Bridge. The drains installed through the highway embankment would alleviate the negative effect the bridge restriction imposes upon the natural riverine, the upstream effect, and the channel restriction through the bridge. Salt cedar would be removed at each of the sites.	Feasibility studies to be funded in fiscal year 2005. Anticipated implementation in 2007-2008.
Pecos River Restoration at Bitter Lake National Wildlife Refuge, U.S. Fish and Wildlife Service (Service)	The Service is preparing an environmental assessment on actions to restore portions of the Pecos River channel through the Bitter Lake National Wildlife Refuge, near Roswell. In the 1940s, channels were excavated to straighten portions of the river and decrease damage to the bordering agricultural lands from flooding and bank erosion. These channels cut off natural meanders from the mainstem of the Pecos River. The excavation of straight channels, encroachment by non-native vegetation, and reservoir control of flows have degraded the ecological functioning of the river. The Service proposes to restore riverflows into these meanders with the intention of improving habitat for the threatened Pecos bluntnose shiner (shiner) and other aquatic and riparian species. Five reaches or river segments have been identified for potential restoration. Restoration options will be tailored to the specific characteristics of each reach and include mechanical diversion of the river into original meanders, reworking of channel morphology, vegetation removal, and bank lowering.	Anticipated implementation beginning in 2006.

Table 5.1 Relevant past, present, and reasonably foreseeable actions for cumulative impact analysis

Project name	Project description	Time period
State Water Plan, New Mexico Office of the State Engineer (NMOSE) and NMISC	The State Water Plan is a strategic management tool for the purposes of: (1) promoting stewardship of the State's water resources (2) protecting and maintaining water rights and their priority status (3) protecting the diverse customs, culture, environment, and economic stability of the State (4) protecting both the water supply and water quality (5) promoting cooperative strategies, based on concern for meeting the basic needs of all New Mexicans (6) meeting the State's interstate compact obligations (7) providing a basis for prioritizing infrastructure investment (8) providing Statewide continuity of policy and management relative to our water resources	Approved 12/2003. Ongoing; duration indefinite.
Regional water plans, NMOSE and NMISC	There are ongoing regional planning efforts overseen by NMISC to develop information, analysis, and documentation, to address the region's available water supply, projected future demand, and means of meeting future demand. This planning is done at the regional level and brings together stakeholders including elected officials, representatives of private industry, public agencies, and private citizens. The Lower Pecos Valley Water planning (LPVWP) region includes Chaves County, Eddy County, and portions of De Baca, Lincoln, and Otero Counties. The principal river basin is the lower Pecos River. The principal aquifers underlay the Fort Sumner basin, the Roswell basin, the Hondo basin, the Peñasco basin, the Carlsbad basin, and the Capitan basin. The Northeastern New Mexico Regional Water Planning (NENMWP) region encompasses a large portion of the northeastern part of the State and includes Guadalupe County and DeBaca County, except that portion downstream from Sumner Dam on the Pecos River.	LPVWP completed. NENMWP is in progress. Ongoing; duration indefinite.
Water Resources Conservation Program, NMISC	This program was established by New Mexico Statutes, Annotated (NMSA) sections 72-1-2.2, which called for NMISC to purchase, retire, and place in a State water conservation program adequate water rights over a period of years to increase the flow of water in the Pecos River and diminish the impact of manmade depletions of the streamflow and, therefore, meet the State's future obligations under the Pecos River Compact and the U.S. Supreme Court Amended Decree.	Implemented 1991. Ongoing; duration indefinite.
Agricultural Conservation Reloan Program, NMISC	Under the Agricultural Conservation Reloan Program, NMISC makes low-interest loans available to irrigation entities in the Pecos River basin to reloan to farmers for various farming improvements. These low-interest loans are used for leveling irrigated lands, lining irrigation ditches, installing underground and low-energy precision application sprinkler irrigation systems, constructing irrigation return flow conservation systems, lining irrigation reservoirs, installing meters, drilling and equipping irrigation wells, and constructing	1950s. Ongoing; duration indefinite.

Table 5.1 Relevant past, present, and reasonably foreseeable actions for cumulative impact analysis

Project name	Project description	Time period
	similar facilities for the distribution and application of water for irrigation so that waters of the State of New Mexico may be conserved.	
New Mexico Salt Cedar Control Project, New Mexico Department of Agriculture (NMDA)	NMDA is currently administering the New Mexico Salt Cedar Control Project through local soil and water conservation districts along the Pecos River. This project primarily uses aerial spraying to control salt cedar along the river banks with the hopes of reducing water loss caused by this plant.	Ongoing; duration indefinite.
Environmental Quality Incentives Program (EQIP), Natural Resource Conservation Service (NRCS)	Under the Farm Security and Rural Investment Act of 2002, EQIP provides a voluntary conservation program for farmers and ranchers to promote agricultural production and environmental quality. Conservation programs (e.g., land leveling or improved irrigation systems) are subject to NRCS technical standards adapted for local conditions. EQIP may cost-share up to 75 percent of the costs of certain conservation practices.	Ongoing; program is subject to annual Congressional appropriations.
Cascades at Carlsbad, City of Carlsbad Community Development Department	The Cascades at Carlsbad is an educational/ scientific, commercial, and entertainment destination on a 35-acre Burlington Northern, Santa Fe Railway brownfield site centered on a canal. A water park and the National Cave and Karst Research Institute are currently under construction. The institute is dedicated to research and education in cave and karst science and will include labs, offices, and a visitor's center. Future mixed-use developments are planned for the site.	Initial development scheduled to open in late 2005.
Cheese processing facility, Curry County, Glanbia Foods	Glanbia Foods is constructing a $192-million, 300,000-square-foot facility near Clovis, New Mexico, which will be North America's largest cheddar cheese plant. Glanbia's plant will employ 205 workers and will receive about 766,000 gallons or 6.6 million pounds of milk a day. Dairies supporting this plant would employ up to 8,800 persons. Annually, the plant will produce more than 250 million pounds of cheese and 16.5 million pounds of whey-protein products, generating a projected $340 million in sales.	Will open late 2005.
Active Water Resource Management (AWRM), NMOSE	In response to legislation (section 72-2-9.1 NMSA 1978), NMOSE adopted Rules and Regulations for Active Water Resources Management on December 30, 2004. The regulations are designed to establish a framework for NMOSE to supervise the physical distribution of water and to administer the available water supply by priority date or alternative administration, as appropriate. These Statewide rules and regulations provide that, when necessary, junior water rights that otherwise would be curtailed will be able to temporarily acquire senior water rights from owners participating in the water rights marketplace in an expedited manner. Ultimately, rules and regulations specific to the Pecos River basin will be drafted and promulgated.	Initiated 2005; duration indefinite.

Table 5.1 Relevant past, present, and reasonably foreseeable actions for cumulative impact analysis

Project name	Project description	Time period
Potash mining activity, Lee and Eddy Counties	Potash mining continues to be an important part of the economy of Lee and Eddy Counties and a major user of ground water and generator of wastes. There are three potash projects that may be developed east of Carlsbad, subject to approval of mining plans and market prices. These would use ground water from wells east of the river. Intrepid Potash is developing plans to extract potash out of old mines by putting water into the mines and precipitating the potash out in ponds. The pond would occupy 250 acres and would require water use at a rate of 500-700 gallons per minute intermittently over a 30-year period. The proposed mining operation is located about 20 miles east of Carlsbad. Mosaic Potash is proposing to develop a salt tailings disposal operation at the old Laguna Grande mine approximately 20 miles east-southeast of Carlsbad. No additional water would be needed because they would use water from existing operations. The tailings disposal area may cover several square miles. Intrepid Potash also proposes to develop a langbeinite extraction operation about 25 miles east of Carlsbad.	Ongoing; duration indefinite. Industry is very sensitive to world markets and government incentives. Implementation of new ventures is unknown.
Oil and gas exploration and development, multiple counties	The leasing, exploration, and development of oil and gas resources within in the Pecos River basin are administered by the Bureau of Land Management (BLM). In recent years, these activities have increased in the basins. These activities are associated with ground-water use, ground disturbance, noise, and impacts to water and air quality.	Ongoing; duration indefinite.
Closure of Cannon Air Force Base, Clovis, NM	Cannon Air Force Base has been recommended by the Pentagon for closure under the Base Realignment and Closure (BRAC) process. The BRAC Commission and eventually the President has to act on approving the closure. The Pentagon forecasts that about 2,700 jobs on base and another 2,000 positions off the base would be lost, with an economic loss to the Clovis area estimated at about $200 million a year.	2006 or 2007

1. Water Resources

Table 5.2 summarizes the cumulative impacts of the proposed action on water resources in relation to other projects or programs (ongoing or reasonably foreseeable future actions) in the Pecos River basin. Impacts are mostly described qualitatively; selected water resource indicators, including flow frequency, changes to Carlsbad Project water supply, and changes to flows at the New Mexico-Texas State line, were used to differentiate these impacts.

Table 5.2 Cumulative impacts on water resources

Ongoing or reasonably foreseeable future actions	Impact
Pecos River Compact and U.S. Supreme Court Amended Decree	**Carlsbad Project water supply**: No cumulative impacts are anticipated. **State-line flows**: Partially analyzed as part of this draft environmental impact statement (DEIS). Model results for State-line flows indicate direct impacts to State-line flows. Compact compliance will be cumulatively impacted because only State-line flows were considered as a resource indicator. Because Compact "annual flood inflow" will be impacted by greater releases at Sumner Dam under certain alternatives, State-line flows alone underestimate impacts to the Pecos River Compact for some alternatives. Although the Pecos River Master's Manual does contain provisions for depletions upstream of Alamogordo (Sumner) Dam, it does not appear to have provisions addressing additional bypassing and the subsequent saved evaporation and additional outflow from Sumner Dam as a result of the bypassing. The higher releases will not mitigate for the increased obligation, because much (if not all) of the bypasses will be depleted for shiner habitat purposes. Average annual modeled increases in Sumner Dam releases as compared to the pre-1991 baseline were tabulated for alternatives (without Carlsbad Project water acquisition [CPWA] or additional water acquisition [AWA] options). In addition, modeled differences in Compact obligation for the alternatives were also tabulated. This value includes net depletions to State-line flows and the additional obligation added for some alternatives by increased Sumner Dam outflow. These numbers are presented here only for comparison and are not a prediction of actual Compact departures. **No Action Alternative**: No change in average Sumner Dam outflow; 1,400 acre-feet per year in compact obligation. **Taiban Constant Alternative**: 200 acre-feet per year less of Sumner Dam outflow, 400 acre-feet per year of additional compact obligation; **Taiban Variable Alternative**: 200 to 300 acre-feet per year additional Sumner Dam outflow; 700 to 1,800 acre-feet per year additional Compact obligation. **Acme Constant Alternative**: 1,500 acre-feet per year additional Sumner Dam outflow; 3,500 acre-feet per year additional Compact obligation.

Table 5.2 Cumulative impacts on water resources

Ongoing or reasonably foreseeable future actions	Impact
	Acme Variable Alternative: 1,200 acre-feet per year additional Sumner Dam outflow; 2,800 acre-feet per year additional Compact obligation. **Critical Habitat Alternative**: 300 acre-feet per year less of Sumner Dam outflow; 500 acre-feet per year additional Compact obligation. The analysis of CPWA options showed that the addition of this water to the system only acts to reduce the amount of Sumner Dam outflow. The additional outflow amounts for alternatives without water acquisition options, shown above, would be greater than for alternatives coupled with water acquisition options. The analysis of AWA options showed that the addition of Puerto de Luna (PDL) water as AWA (ranging in volume from 900 to 4,300 acre-feet per year) would increase the historical Sumner Dam outflow by 2,300 to 5,200 acre-feet per year when coupled with the Acme Constant Alternatives. The PDL-AWA option would increase the Sumner Dam outflow by 300 to 3,500 acre-feet per year when coupled with the Taiban Constant Alternative. It is not anticipated that any other cumulative impacts will be evident considering the obligation ("index outflow") computations from "annual flood inflow" as they are outlined in the Pecos River Master's Manual (Pecos River Master's Manual, 2003). **Riverflow frequency**: Negative impacts to flow frequency at the Near Acme gage are not anticipated. In a priority call situation, Reclamation will bypass all incoming flows (up to channel capacity) to provide flow in the river and potentially increase conditions for the shiner.
Long-term Miscellaneous Purposes Contract, Reclamation and NMISC	**Carlsbad Project water supply, State-line flows, and riverflow frequency**: No cumulative impacts are anticipated. See the following entry for anticipated impacts of the Settlement Agreement.
Pecos River Carlsbad Project Settlement Agreement, Reclamation, NMISC	**Carlsbad Project water supply**: Under the Settlement Agreement, retirement and subsequent fallowing of 4,500 to 6,000 acres of farmland in CID is anticipated, with redistribution of those rights for the purpose of meeting Compact deliveries and increasing CID's average annual allotment. Model results indicate the Settlement Agreement will have a 0.2- to 0.4-foot entitlement increase for the remaining farmers in the Carlsbad Project after retirement of project lands. Because retirement within CID is also anticipated as a CPWA option, cumulative retirement could be as great as 6,000 acres for the Settlement Agreement and nearly 2,000 acres for the reoperations considered in this DEIS. Impacts may be nonlinear when superimposed, which is mostly due to differences in Avalon Dam spills. In other words, the two projects may not result in a total retirement of 8,000 acres. **State-line flows**: The Settlement Agreement will have positive impacts on State-line flows for alternatives coupled with land retirement water acquisition options. However, impact analysis of changes to cropping pattern options considered in this DEIS shows that medium-water-use options are a detriment to State-line flows, while low-water-use options are a benefit to State-line flows. The medium-water-use cropping pattern

Table 5.2 Cumulative impacts on water resources

Ongoing or reasonably foreseeable future actions	Impact
	water acquisition option could undermine at least part of the positive impacts from the Settlement Agreement. When only considering CID return flows and ground-water gains, all of the changes to cropping pattern water acquisition options would undermine at least part of the positive impacts from this project. **Riverflow frequency**: No additional impacts to the shiner are anticipated from this project.
Pecos River Basin Water Salvage Project, Reclamation	**Carlsbad Project water supply and shiner flow frequency**: This project has cleared a total of 33,230 acres from Sumner Dam to the New Mexico-Texas State line. Either salvage or increased losses from this project, translating to accretions or depletions to Carlsbad Project water supply, could occur due to changes in evapotranspiration. Bank destabilization may also occur, which, in turn, may increase depletions to the Carlsbad Project water supply. Without quantification (and demonstration of actual salvage or loss), hydrologic impacts to both the Carlsbad Project water supply and the shiner are unknown. Assuming cleared and maintained acreages will change (arguably) implies that this project will have cumulative impacts. **State-line flows**: If salt cedar is cleared using Federal dollars and actual salvage amounts are measured, this project could increase the State of New Mexico's delivery obligation to Texas.
Water leases, Reclamation	**Carlsbad Project water supply**: Leases from river pumpers were analyzed in chapter 4 as CPWA option impacts. No cumulative impacts are anticipated. **State-line flows:** Leases from river pumpers were analyzed in chapter 4 as water acquisition option impacts. (Impacts to State-line flows are inferred from impacts to the Carlsbad Project water supply.) No cumulative impacts are anticipated. **Riverflow frequency**: No cumulative impacts are anticipated.
Carlsbad Project Vegetation Management Program, Reclamation	**Carlsbad Project water supply and shiner flow frequency:** Without further details of this project, including cleared and maintained acreage and estimated water salvage, cumulative impacts cannot be quantified. Either salvage or increased losses from this project could occur. Without quantification (and demonstration of actual salvage or loss), hydrologic impacts to both the Carlsbad Project water supply and the shiner are unknown. Assuming cleared and maintained acreages will change (arguably) implies that this project will have cumulative impacts. **State-line flows**: If salt cedar is cleared using Federal dollars and actual salvage amounts are measured, this project could increase the State of New Mexico's delivery obligation to Texas. **Riverflow frequency**: No cumulative impacts are anticipated.
Pecos River Restoration Project, U.S. Army Corps of Engineers and Chaves County, New Mexico	**Carlsbad Project water supply**: This project will create additional depletions between Sumner Dam and Brantley Reservoir from river widening (increased seepage and evaporation) and bank lowering (increased overbank flooding and subsequent increased evaporation and infiltration). However, because the restored areas are so small, it is likely that these depletions will not be measurable or quantifiable. If salt cedar clearing is demonstrated to provide water salvage, the

Table 5.2 Cumulative impacts on water resources

Ongoing or reasonably foreseeable future actions	Impact
	cleared salt cedar areas may reduce or eliminate additional depletions caused by other restoration activities. **State-line flows**: Restoration activities, other than clearing salt cedar, will cause new net depletions. However, the proposed area is so small that these depletions may not be quantifiable (and/or may be negligible). If salt cedar is cleared using Federal dollars and actual salvage amounts are measured, this project could increase the State of New Mexico's delivery obligation to Texas. **Riverflow frequency**: Flow frequency and intermittency cumulative impacts are not anticipated because these areas are well into the river reaches known to be kept perennial by base inflows between the Near Acme and Artesia gages.
Pecos River Restoration at Bitter Lake National Wildlife Refuge, Service	**Carlsbad Project water supply**: Restoration activities may create additional depletions between Sumner Dam and Brantley Reservoir as a result of river widening (increased seepage and evaporation) and bank lowering (increased overbank flooding and subsequent increased evaporation and infiltration). Quantification is dependent on the length of river and adjacent acreage restored. If salt cedar clearing is demonstrated to provide water salvage, the cleared salt cedar areas may reduce or eliminate additional depletions caused by other restoration activities. **State-line flows**: Restoration activities, other than clearing salt cedar, will cause new net depletions. If salt cedar is cleared using Federal dollars and actual salvage amounts are measured, this project could increase the State of New Mexico's delivery obligation to Texas. **Riverflow frequency**: Restoration activities could introduce negative hydrologic impacts in terms of flow frequency and intermittency. Further study is warranted, because restoration activities upstream of the point where large river base inflows (between the Near Acme and Near Artesia gages) accrue to the Pecos River may cause the river to have less water or go dry more frequently in this region.
Water Conservation Program, NMISC	**Carlsbad Project water supply**: Increased retirement or curbing of manmade depletions to increase Pecos Riverflows will only positively impact the Carlsbad Project water supply. **State-line flows**: Increased retirement or curbing of manmade depletions to increase Pecos Riverflows will only positively impact flows at the State line. **Riverflow frequency:** Increased retirement or curbing of manmade depletions to increase Pecos River flows will only positively impact flows needed for the shiner.
Agricultural Conservation Reloan Program, NMISC	**Carlsbad Project water supply**: Conservation of water diverted (pumped) from the deep artesian aquifer in the Roswell basin will negatively impact return flows from the Pecos Valley Artesian Conservation District over the short term. The State has funded programs for reducing the application of water to irrigated acreage using such technology as laser-leveling or low energy precision application (LEPA) technology. Smaller PVACD return flows will cause a cumulative (negative) impact to the Carlsbad Project water supply in the short term.

Table 5.2 Cumulative impacts on water resources

Ongoing or reasonably foreseeable future actions	Impact
	However, it is anticipated that these impacts will be reduced or eliminated from increasing base inflows (as a result of water conservation in PVACD) 20 to 100 years in the future. Impacts from all other (surface water) irrigation efficiency improvement activities (assuming these activities immediately increase riverflows) will be positive cumulative impacts. It should be noted that these conservation programs could also result in the same diversion and an increased consumptive irrigation requirement and yield from the irrigated lands. Recent modeling also shows that large retirements and increased aquifer levels can cause increased losses through evapotranspiration or directly from the ground surface. **State-line flows**: Inferred. Will follow the same depletion trends described for Carlsbad Project water supply. **Riverflow frequency**: The program will result in lower riverflows between the Near Acme and Near Artesia gages due to conservation of pumped irrigation water (and subsequent reduction in return flows) in the short term. It is not anticipated that reduced return flows in PVACD as a direct result of conservation will cause intermittency, but lower flows over the short term are anticipated. The reach where these impacts will occur overlaps with lower critical habitat for the shiner. Impacts from all other (surface water) irrigation efficiency improvement activities (assuming these activities immediately increase riverflows) will be positive cumulative impacts to the shiner.
New Mexico Salt Cedar Control Project, NMDA	**Carlsbad Project water supply and riverflow frequency**: Without further details of this project, including annual cleared amounts, maintained acreage, and estimated water salvage, cumulative impacts cannot be quantified. Either salvage or increased losses from this project, translating to accretions or depletions to the Carlsbad Project water supply, could occur due to changes in evapotranspiration. Bank destabilization may also occur, which, in turn, may increase depletions to the Carlsbad Project water supply. Without quantification (and demonstration of actual salvage or loss), hydrologic impacts to both the Carlsbad Project water supply and the shiner are unknown. Assuming cleared and maintained acreages will change (arguably) implies that this project will have cumulative impacts. **State-line flows**: If salt cedar is cleared using Federal dollars and actual salvage amounts are measured, this project could increase the State of New Mexico's delivery obligation to Texas.
Cascades at Carlsbad, City of Carlsbad Community Development Department	**Carlsbad Project water supply, State-line flows, riverflow frequency:** No cumulative impacts are anticipated.
Cheese processing facility, Curry County, Glanbia Foods	**Carlsbad Project water supply, State-line flows, riverflow frequency:** No cumulative impacts are anticipated.
AWRM, NMOSE	**Carlsbad Project water supply, State-line flows, riverflow frequency:** No cumulative impacts are anticipated.

Table 5.2 Cumulative impacts on water resources

Ongoing or reasonably foreseeable future actions	Impact
Potash mining activity, Lee and Eddy Counties	**Carlsbad Project water supply, State-line flows, riverflow frequency:** No cumulative impacts are anticipated.
Oil and gas exploration and development, multiple counties	**Carlsbad Project water supply, State-line flows, riverflow frequency:** No cumulative impacts are anticipated.

The most apparent significant cumulative impact to water resources in the study area results from the Settlement Agreement. Because this project also uses agricultural land retirement as a solution to water resource supply problems, it will additionally impact farmers in the basin. Water conservation projects may augment Carlsbad Project water supplies and help increase State-line flows, but the level of this conservation may reach a point of diminishing returns and, in fact, may introduce new net depletions if taken too far (losses from rising ground-water tables). Other projects, such as restoration and water salvage activities along the river, are small, and will not have a significant cumulative impact on water resources in the basin because of their limited size.

2. Water Quality

Table 5.3 summarizes the cumulative impacts of the proposed action on water quality in relation to other projects or programs (ongoing or reasonably foreseeable future actions) in the Pecos River basin.

Table 5.3 Cumulative impacts on water quality

Ongoing or reasonably foreseeable future actions	Impact
Pecos River Compact and U.S. Supreme Court Amended Decree	This requires additional flows in the river at the State line. There are inflows with high specific electrical conductance (EC) in the vicinity of Roswell and Malaga Bend. The additional flows will dilute these saline inflows and result in a reduction in EC in the river between Malaga Bend and the State line and, possibly, between Roswell and Brantley Reservoir.
Long-term Miscellaneous Purposes Contract, Reclamation and NMISC	See the Compact. The acquisition of the water rights from 6,000 acres of CID land would increase the project water supply relative to the amount of irrigated acreage, which would likely have negligible to mildly positive impacts on water quality (i.e., decrease salinity).
Pecos River Carlsbad Project Settlement Agreement, Reclamation, NMISC	See the Compact. The acquisition of the water rights from the 12,000 acres of land in PVACD would reduce the amount of lands in the Roswell basin subject to leaching through irrigated agriculture, leading to a net benefit of decreased additions of salinity to the water resources of Pecos River basin.

Table 5.3 Cumulative impacts on water quality

Ongoing or reasonably foreseeable future actions	Impact
Pecos River Basin Water Salvage Project, Reclamation	This project involved the removal of salt cedar from 33,230 acres prior to 1973. The current activity is restricted to maintaining that acreage free of salt cedar. No cumulative impacts are anticipated.
Carlsbad Project Vegetation Management Program, Reclamation	Salt cedar deposits salt on its leaves and on the soil in the immediate vicinity of the plant. The salt can subsequently be washed off into surface drainages or into the ground water, in either case increasing the total dissolved solids (TDS) of the water. The vegetation management program is experimental, but would reduce salt cedar and, to some extent, TDS. No cumulative impacts are anticipated.
State Water Plan, NMOSE and NMISC	Section C.8 of the State Water Plan addresses watershed restoration that focuses on protecting water supplies and complying with the Endangered Species Act of 1973, as amended. Water quality improvement is also a consideration. The State Water Plan also formalizes the regional plans and their effects. (See next entry.)
Regional water plans, NMOSE and NMISC	Several of the alternatives described in the regional water plan for the Pecos Valley are similar to CPWA options evaluated but not carried forward in this document. These include water conservation, dewatering the Lake McMillan delta, watershed management, desalination, cloud seeding, and importing water from the Salt River basin. Insofar as the water plan alternatives are implemented, they could be additive. The cumulative impact would be dependent upon the quality of the source water.
Water Conservation Program, NMISC	The water conservation program is designed to extend existing water supplies to provide water for other uses through retirement of lands that historically had been irrigated and, thus, subject to salinity leaching from the soil profile. If there are no additional changes in flow in the Pecos River that are related to the effects of the Carlsbad Water Conservation Program, there would be no cumulative impacts.
Agricultural Conservation Reloan Program, NMISC	This program should have the same effect as any other water conservation program. The specific effects would depend on the location and use to which the conserved water is put.
New Mexico Salt Cedar Control Project, New Mexico Department of Agriculture	Effects likely would be the same as any of the other salt cedar control projects.
Cascades at Carlsbad, City of Carlsbad Community Development Department	Water quality impacts would be more like those related to increased storm water runoff and the types of pollutants it carries. No cumulative impacts are anticipated.

Overall, many of the cumulative actions strive to increase or maintain riverflows, which would have a beneficial net effect on water quality. Likewise, less agricultural use of water could reduce salinity, as less drain and tailwater would enter the Pecos River system. Conversely, any future development in the basin likely would degrade water quality as a result of increased waste loadings to the river. Only activities directly related to agricultural development likely would be considered cumulative to the Carlsbad Project water operations addressed in this DEIS.

3. Agricultural Soil and Land Resources

Table 5.4 summarizes the cumulative impacts of the proposed action on agricultural soils and land in relation to other projects or programs (ongoing or reasonably foreseeable future actions) in the Pecos River basin.

Table 5.4 Cumulative impacts on agricultural soils and lands

Ongoing or reasonably foreseeable future actions	Impact
Pecos River Compact and U.S. Supreme Court Amended Decree	Reductions of historic water supplies could reduce prime farmland (PF) and farmland of Statewide importance (FSI) acreage in New Mexico. Soil salinity could also increase due to reduced leaching for salt balance.
Long-term Miscellaneous Purposes Contract, Reclamation and NMISC	If the contract is fully implemented, it could fallow around 11,500 acres of land currently under agricultural production. Fallowing of lands and water rights could reduce PF and FSI acreage; however, site specific parcels for fallowing have not been identified. Therefore, the exact acres of PF and FSI acres cannot be calculated.
Pecos River Carlsbad Project Settlement Agreement, Reclamation, NMISC	Retirement of irrigated lands called for in the Settlement Agreement would reduce PF and FSI acreage by up to 6,000 acres in CID. Because retirement within CID is also anticipated as a water acquisition option, cumulative retirement and subsequent fallowing of acreage for the settlement and this DEIS combined could be as much as 9,000 acres.
Pecos River Basin Water Salvage Project, Reclamation	This project would result in the beneficial reduction of noxious weeds and soil salinity in areas currently infested with salt cedar, as well as a general improvement in soil salinity on irrigated lands.
Water leases, Reclamation	Water leases would result in slight adverse effect associated with long-term fallowing and loss of PF and FSI acreage.
Carlsbad Project Vegetation Management Program, Reclamation	This program would result in beneficial reduction of noxious weed infestations and a reduction in soil salinity.
Pecos River Restoration Project, U.S. Army Corps of Engineers and Chaves County, New Mexico	This project would result in slight beneficial reduction in the acreage infested with noxious weeds and protection of agricultural lands from flooding.
State Water Plan, NMOSE and NMISC	The plan itself would have no effect; some elements of plan are evaluated above.
Water Conservation Program, NMISC	The program would result in less PF and FSI acreage.
Agricultural Conservation Reloan Program, NMISC	The program would benefit soil salinity. Improved water application efficiencies would "even out" water applications and deep percolation in a field. Salinity would be reduced in portions of fields that were underirrigated, and water salvage would occur in portions of field that were overirrigated. The average yield of the entire field should increase.

Table 5.4 Cumulative impacts on agricultural soils and lands

Ongoing or reasonably foreseeable future actions	Impact
New Mexico Salt Cedar Control Project, New Mexico Department of Agriculture	This project would result in the beneficial reduction in the acreage infested with noxious weeds and an associated beneficial effect on soil salinity levels, especially in areas formerly infested with salt cedar.
Environmental Quality Incentives Program, NRCS	This program would result in improvements in agricultural efficiency on participating farms, which could increase instream flows; conversely, if such lands are retired or fallowed under this or any other program, the yield may not be as high as projected.
Cheese processing facility, Curry County, Glanbia Foods	This facility may increase the demand for alfalfa hay and alfalfa production. Increased alfalfa acreage would lead to farmers stacking their water allotments on lands growing alfalfa. Stacking water on alfalfa would increase fallowing of other lands and reduce the acreages of other crops, reduce irrigated acreage, and slightly decrease PF and FSI acreage.

The only significant cumulative adverse impact of the actions considered in this DEIS and the other related actions would be a reduction in the acreages of prime farmland and farmland of Statewide importance in New Mexico, because lands must be irrigated to qualify for these important farmland designations in the Pecos River area. A small portion of the retired lands would not be well suited for irrigation. On the basis of net depletions of about 3,000 acre-feet, the maximum acreage of retired farmland needed for water right retirement under this action would be about 1,500 acres. This acreage is less than 1 percent of the irrigated land in the impact evaluation area and is not considered significant. However, when all the actions listed in table 5.4 are considered, land retirement and fallowing for water right acquisition could easily exceed 23,000 acres. This acreage is well over 5 percent of the irrigated land in the Pecos River impact evaluation area and would be considered a significant adverse impact to PF or FSI.

Important farmlands are a valuable natural resource and are generally decreasing in other areas of the Nation. This decrease is reducing the long-term food security of the Nation. Loss of PF in arid Western States is considered serious; however, it may not be as serious as losses in humid areas because water, not arable land, is the most limiting factor in these areas. It is important to protect lands retired from irrigation from wind and water erosion and soil salinity damage. In any case, irrigation structures and other onfarm infrastructure tend to deteriorate following land retirement. In the event water supplies become available in the future, these lands would probably require releveling and installation of updated irrigation systems.

Beneficial cumulative impacts include a reduction in the acreages infested with salt cedar and other noxious weeds. Reduction of salt cedar acreage would reduce nonbeneficial consumptive use, which would provide more water for crop yields and leaching of salts from croplands. Salt cedars use large amounts of water and concentrate salts in the shallow aquifer systems connected to the river. Salt cedars also increase soil salinity locally in infested areas. This increase is associated with the salts in the leaf tissue that are deposited on the ground surface following annual leaf fall. In the absence of present and past State and Federal programs, the acreage infested with salt cedar in the impact evaluation area would almost certainly exceed 100,000 acres, compared to the present infestation of about 25,000 acres. This is considered a major beneficial cumulative impact to agricultural land and soil resources. Only about 10,000 acres are currently heavily infested with salt cedar suitable for full water salvage potential (estimated by Reclamation at about 1 acre-foot per acre under optimum conditions) of land reclaimed from salt cedar infestation.

A significant beneficial decrease in soil salinity and an increase in crop yields per acre are expected with onfarm irrigation infrastructure improvements planned for both State reloan programs and Federal programs, including EQIP, and the water conservation option plan proposed in this DEIS. The current Federal and State programs have improved many existing farmlands to the point that the proposed water acquisition option may not be able to provide as much onfarm water savings as originally predicted.

The large cheese processing facility in Curry County could increase the acreage of alfalfa, which could counteract the beneficial effects of the proposed options involving changing cropping patterns from alfalfa to crops that consume less water. An increase in alfalfa demand could also increase the price of hay, which would increase the cost of these cropping pattern change options. These changes would not result in any significant cumulative impacts.

4. Biological Resources

Table 5.5 summarizes the cumulative impacts of the proposed action on biological resources in relation to other projects or programs (ongoing or reasonably foreseeable future actions) in the Pecos River basin.

Table 5.5 Cumulative impacts on biological resources

Ongoing or reasonably foreseeable future actions	Impact
Pecos River Compact and U.S. Supreme Court Amended Decree	Actions and projects to ensure that Compact delivery obligations are met generally would have little effect on biological resources. Aquatic ecosystem components in the river reaches between Brantley Reservoir and the State line could be subject to some impacts dependent upon the timing or magnitude of State-line deliveries. Additional, localized impacts to terrestrial and/or aquatic ecosystem components might occur in response to specific projects that would be implemented to meet Compact requirements.

Table 5.5 Cumulative impacts on biological resources

Ongoing or reasonably foreseeable future actions	Impact
Long-term Miscellaneous Purposes Contract, Reclamation and NMISC	Effects to aquatic ecosystem components would be likely because of changes in the use and delivery of waters under the Long-term Miscellaneous Purposes Contract. These effects would likely be greatest in the river reaches between Brantley Reservoir and the State line and would result from potential changes in delivery schedules, return flows to the river, and base inflow conditions.
Pecos River Carlsbad Project Settlement Agreement, Reclamation, NMISC	Retirement of irrigated lands might have an impact on terrestrial ecosystems. Some organisms dependent upon agricultural crops for food or cover could be affected by this conversion. However, some terrestrial ecosystem components could benefit from the conversion if lands were fallowed and native plants were allowed to recolonize the former agricultural areas. Construction of the augmentation well field would have temporary impacts on terrestrial ecosystems during construction and operations. The well field likely would affect aquatic ecosystems through changes in riverflows downstream from the point of discharge and could potentially affect reservoir fishes by changing reservoir levels in Brantley Reservoir.
Pecos River Basin Water Salvage Project, Reclamation	Clearing of land, such as mechanical removal of non-native riparian vegetation or watershed thinning, would directly disturb terrestrial ecosystems and could affect the riparian ecosystem and the organisms that use those habitats.
Carlsbad Project Vegetation Management Program, Reclamation	This program may affect terrestrial and avian species that rely on vegetation that is removed.
Pecos River Restoration Project, U.S. Army Corps of Engineers and Chaves County, New Mexico	Removal of non-native riparian vegetation would directly disturb terrestrial ecosystems and would affect the riparian ecosystem and the organisms that use those habitats. These disturbances would be localized for this project. Long-term river restoration efforts could improve the native riparian ecosystem and improve habitat for aquatic organisms.
Pecos River restoration at Bitter Lake National Wildlife Refuge, Service	Removal of non-native riparian vegetation would directly disturb terrestrial ecosystems and would affect the riparian ecosystem and the organisms that use those habitats. These disturbances would be localized for this project. River restoration efforts could improve the native riparian ecosystem and improve habitat for aquatic organisms.
Water Resources Conservation Program, NMISC	Retirement of irrigation lands might have an impact on terrestrial ecosystems. Some organisms dependent upon agricultural crops for food or cover could be affected by this conversion. However, some terrestrial ecosystem components could benefit from the conversion if lands were fallowed and native plants were allowed to recolonize the former agricultural areas. Increased riverflows that may occur under this program would likely benefit aquatic ecosystems by improving year-round base inflows.
Agricultural Conservation Reloan Program, NMISC	Modifications to acequias, dams, drains, canals, laterals could affect terrestrial and aquatic ecosystem components during construction or modification projects.

Table 5.5 Cumulative impacts on biological resources

Ongoing or reasonably foreseeable future actions	Impact
New Mexico Salt Cedar Control Project, New Mexico Department of Agriculture	Removal of non-native riparian vegetation would directly disturb terrestrial ecosystems and would affect the riparian ecosystem and the organisms that use those habitats.
Potash mining activity, Lee and Eddy Counties	Actions could impact biological resources through ground-disturbing activity potential discharge of waters off-site.

The net cumulative impact on biological resources generally would be positive as most of the listed projects are focused on increasing riverflows for Compact delivery purposes and the Carlsbad Project water supply. Higher and more reliable base inflows would benefit aquatic ecosystems throughout the study area. Current riparian ecosystems and the species dependent upon the habitats provided likely would not benefit from the listed projects. However, long-term benefits might be realized through the removal of non-native phreatophytes that would allow for possible reestablishment of native vegetated communities and associated wildlife species.

5. Regional Economy

Table 5.6 summarizes the cumulative impacts of the proposed action on the regional economy in relation to other projects or programs (ongoing or reasonably foreseeable future actions).

Any of the projects and programs included in the cumulative impact analysis that could potentially affect the amount of irrigated acreage, crop yields, or cropping patterns would also potentially affect the regional agricultural economy. In addition, projects that would affect the regional economy through nonagricultural sectors are identified.

Table 5.6 Cumulative impacts on the regional economy

Ongoing or reasonably foreseeable future actions	Impact
Pecos River Compact and U.S. Supreme Court Amended Decree	These actions could possibly have negative impacts on crop production and the regional economy if prime farmlands are reduced, as identified in agricultural soils and lands analysis.
Long-term Miscellaneous Purposes Contract, Reclamation and NMISC	Fallowing of lands and sale of water rights would likely result in reduced irrigated acreage, which could have negative regional economic impacts.
Pecos River Carlsbad Project Settlement Agreement, Reclamation, NMISC	Irrigated land retirement would have negative regional economic impacts.
Water leases, Reclamation	Slight long-term negative impact possible as a result of increased fallowing.

Table 5.6 Cumulative impacts on the regional economy

Ongoing or reasonably foreseeable future actions	Impact
Pecos River Restoration Project, U.S. Army Corps of Engineers and Chaves County, New Mexico	Slight positive regional economic impacts possible to the extent that flood damages are prevented on agricultural land and other land.
Water Resources Conservation Program, NMISC	Negative regional economic impacts possible due to potential decrease in cropland acreage.
Agricultural Conservation Reloan Program, NMISC	Potential positive regional economic impacts associated with yield increases described in the agricultural soil and land resources cumulative impacts section.
Cheese processing facility, Curry County, Glanbia Foods	Potential increase in local demand for alfalfa could lead to increase in alfalfa production. While this could lead to a decrease in acreage of other crops as described in the agricultural soil and land resources cumulative impacts section, alfalfa is a relatively high-value crop. Therefore, positive regional economic impacts are likely.
Potash mining activity, Lee and Eddy Counties	Potential positive regional economic impacts associated with the mine. Impacts not directly related to agriculture.
Oil and gas exploration and development, multiple counties	Potential positive regional economic impacts associated with increased oil and gas activity. Impacts not directly related to agriculture.
Closure of Cannon Air Force Base, Clovis	Significant economic impacts related to employment and income.

The continuing trend in the region for land fallowing, retirement, and changes to cropping patterns has a cumulative negative impact to local economies. Without specific data on where lands would be retired or fallowed, a cumulative assessment of long-term losses in economic output and employment is crop value loss and job loss is uncertain. Assuming the Long-Term Miscellaneous Purposes Contract and Settlement Agreement would result in the combined retirement of about 22,000 to 23,000 acres, economic impacts would range from about $14.4 to $16.8 million in the total value of regional output lost annually and the losses of 187 to 218 jobs annually. These impacts represent less than 1 percent of the total value of regional output and less than one-half of 1 percent of employment in the six-county economic impact area. Other actions would serve to either mitigate this impact, such as increased oil and gas production and new developments, including the cheese factories. Other actions, such as the closure of Cannon Air Force Base, could increase the net adverse impact to the regional economy.

6. Recreation

There are no cumulative impacts of the proposed action on recreation in relation to other projects or programs (ongoing or reasonably foreseeable future actions) in the Pecos River basin. Most of these projects affect the use or delivery of water. Water moves through space and time to affect or provide opportunities for recreation. Recreation use at the reservoirs and along the Pecos River is affected by the amount or flow of water at a particular location and many other factors. Less water in the reservoirs and lower flows in the river tend to curtail recreational opportunities and result in lesser amounts of recreation use. A chain of cause-and-effect linking past, present, or ongoing or reasonably foreseeable future actions and the actions of the preferred alternative in an additive or interactive process to generate cumulative impacts has not been identified.

7. Cultural Resources

Table 5.7 summarizes the cumulative impacts of the proposed action on water resources in relation to other projects or programs (ongoing or reasonably foreseeable future actions) in the Pecos River basin.

Table 5.7 Cumulative impacts on cultural resources

Ongoing or reasonably foreseeable future actions	Impact
Pecos River Compact and U.S. Supreme Court Amended Decree	Actions and projects to ensure that Compact delivery obligations are met generally would have little or no effect on cultural resources.
Long-term Miscellaneous Purposes Contract, Reclamation and NMISC	Land retirement may result indirectly in the long term of the abandonment and subsequent deterioration of historic farm structures and features.
Pecos River Carlsbad Project Settlement Agreement, Reclamation, NMISC	Land retirement may result indirectly in the long term of the abandonment and subsequent deterioration of historic farm structures and features.
Pecos River Basin Water Salvage Project, Reclamation	Clearing of land, such as mechanical removal of non-native riparian vegetation or watershed thinning, could cause direct disturbance of the integrity of archaeological resources through grading, chaining, equipment use and subsequent erosion. Clearing also could afford greater access to previously undisturbed areas, allowing damage from vehicle use and vandalism.
Carlsbad Project Vegetation Management Program, Reclamation	Clearing of land, such as mechanical removal of non-native riparian vegetation or watershed thinning, could cause direct disturbance of the integrity of archaeological resources through grading, chaining, equipment use and subsequent erosion. Clearing also could afford greater access to previously undisturbed areas, allowing damage from vehicle use and vandalism.
Pecos River Restoration Project, U.S. Army Corps of Engineers and Chaves County, New Mexico	Clearing of land, such as mechanical removal of non-native riparian vegetation or watershed thinning, could cause direct disturbance of the integrity of archaeological resources through grading, chaining, equipment use and subsequent erosion. Clearing also could afford greater access to previously undisturbed areas, allowing damage from vehicle use and vandalism.

Table 5.7 Cumulative impacts on cultural resources

Ongoing or reasonably foreseeable future actions	Impact
Pecos River restoration at Bitter Lake National Wildlife Refuge, Service	Clearing of land, such as mechanical removal of non-native riparian vegetation or watershed thinning, could cause direct disturbance of the integrity of archaeological resources through grading, chaining, equipment use and subsequent erosion. Clearing also could afford greater access to previously undisturbed areas, allowing damage from vehicle use and vandalism.
State Water Plan, NMOSE and NMISC	This planning effort would have little or no effect on cultural resources, with the exception of affirming the role of traditional water uses and acequias systems.
Regional water plans, NMOSE and NMISC	This planning effort would have little or no effect on cultural resources, with the exception of affirming the role of traditional water uses and acequias systems.
Agricultural Conservation Reloan Program, NMISC	Modifications to acequias, dams, drains, canals, laterals, and other structures could alter the physical integrity of these structures if they are historic. Improvements to water distribution laterals and canals often are not considered to have major impacts on these properties, unless they are architecturally significant, because they would still retain integrity of function and location.
New Mexico Salt Cedar Control Project, New Mexico Department of Agriculture	Clearing of land, such as mechanical removal of non-native riparian vegetation or watershed thinning, could cause direct disturbance of the integrity of archaeological resources through grading, chaining, equipment use, and subsequent erosion. Clearing also could afford greater access to previously undisturbed areas, allowing damage from vehicle use and vandalism.
Cascades at Carlsbad, City of Carlsbad Community Development Department	Ground-disturbing and other site preparation actions could affect cultural resources.
Cheese processing facility, Curry County, Glanbia Foods	The facility is being developed outside of the region of influence for cultural resources. Ground-disturbing and other site preparation actions could affect cultural resources.
AWRM, NMOSE	AWRM is primarily administrative, and no direct or indirect effects on cultural resources are anticipated.
Potash mining activity, Lee and Eddy Counties	Activity could impact cultural resources and landscapes through ground-disturbing activity and alterations to setting; subject to BLM cultural resource review.
Oil and gas exploration and development, multiple counties	Actions could impact cultural resources and landscapes through ground-disturbing activity and alterations to setting; subject to BLM cultural resource review.

Past agricultural, water conveyance, residential, commercial, mining and energy development and the effects of natural processes in Pecos River basin have resulted in the damage to or the loss of cultural resources. More recent projects, such as Brantley Dam, were constructed in the context of laws that require assessing the significance of cultural resources and minimizing impacts. When resources cannot be avoided, often the adverse effects of the loss of the resource can be partially mitigated by the scientific information gained by research-oriented excavation or other actions.

Although few surveys have been conducted to confirm their presence, it is likely that there are many unrecorded cultural resources that could be impacted by this project or ongoing or reasonably foreseeable future actions. The changes in Carlsbad Project operations (block releases, target flows, reservoir levels) proposed under all of the alternatives would result in negligible effects to cultural resources. Sites in the immediate vicinity of the river or in flood zones have been subject to past disturbances that would reduce the likelihood of their intact preservation. Proposed flow levels, flow fluctuations, and changes in reservoir storage would be within the range of normal river and reservoir operations and would not be expected to exacerbate erosion of archaeological resources or exposure of submerged resources.

Implementation of CPWA options could be associated with negligible to major impacts to cultural resources, but the options are not sufficiently developed to define the precise location of the action, whether cultural resources would be present, or the intensity of impact. The water acquisition options would be subject to further consideration under Federal and/or State cultural resource statutes and regulatory protections, which require consultation to avoid or mitigate adverse effect on cultural resources. In general, alternatives that require larger amounts of water acquisition would permit less management flexibility in avoiding options or locations which may cause cultural resource impacts.

The potential for effects to cultural resources resulting from ongoing or reasonably foreseeable future regional water commitments and plans, restoration efforts, land retirement, infrastructure improvements, construction, and extractive industries are similar in type, intensity, timeframe and general location to those identified for the water acquisition options. Potential impacts could result from ground-disturbing activities; modifications, removal, or abandonment of historic structures; alterations to visual or audible setting; and greater access to resources, resulting in inadvertent damage or intentional vandalism. The precise location of these actions, their status regarding cultural resource compliance, the presence or absence of cultural resources and intensity of impact is not known.

For actions on Federal land or actions that are funded, licensed, or permitted by the Federal government, compliance is required with the National Historic Preservation Act and other laws, statutes, and regulations. State agencies must also consult when their activities would involve nominated or listed New Mexico or *National Register of Historic Places* eligible properties, and State law prohibits the use of State funds for projects or programs that would adversely affect eligible properties unless the State agency or local government demonstrates that there is no feasible and prudent alternative. Impacts on cultural resources of many of the regional Federal and State-sponsored or permitted actions could be avoided or partially mitigated through data recovery. Actions that are not protected by

Federal or State cultural resource statutes and regulatory protections could impact cultural resources without any consideration or mitigation.

Negligible to major impacts to cultural resources could result from CPWA options and regional actions. Although cultural resource impacts are assessed on a site- and project-specific basis, cumulative impacts can occur if the regional actions would have additive, interactive, or synergistic effects on the resources or the resource base. Implementation of the water acquisition options and many of the regional actions would be subject to further consideration under Federal and/or State cultural resource statutes and regulatory protections. Some regional actions would not be subject to further cultural resource consideration. The intensity of cumulative impacts is unknown because of uncertainty about water acquisition options and the cultural resource impact, but it is anticipated that cumulative impacts are possible because of the additive effect and the location and timing of other regional actions.

8. Indian Trust and Treaty Assets

No cumulative impacts of the proposed action on Indian trust and treaty assets (ITA) in relation to other projects or programs (ongoing or reasonably foreseeable future actions) in the Pecos River basin would occur. No ITAs have been identified in consultation with tribes and the Bureau of Indian Affairs (BIA). Because resources are not believed to be present, no impacts are anticipated to result from the alternatives or from water acquisition options. Because no impacts to ITAs are anticipated resulting from the alternatives or from water acquisition options, no cumulative impacts are anticipated. Additional consultation will be conducted throughout the EIS process to update tribes and the BIA on the progress of the EIS, to provide information on the alternatives under consideration, and to solicit any concerns relative to trust assets or other issues.

9. Environmental Justice

A continuing trend of ongoing and proposed programs to fallow, retire, or change farming practices exists within the Pecos River basin. The exact location of where retirement or fallowing would occur cannot be predicted with certainty; however, the majority is expected to occur within CID and Fort Sumner Irrigation District, where a large percentage of the irrigated acreage is located. To the extent that some land retirement could also occur in Guadalupe County, there could be some cumulative impacts that would affect low-income or minority populations.

Chapter 6

Consultation and Coordination

Chapter 6
Consultation and Coordination

This chapter serves as the public involvement summary report of activities to date on the environmental compliance process pursuant to the National Environmental Policy Act (NEPA). It also includes information on consultation and coordination activities that have occurred to date.

1. Public Involvement

Public involvement is a process for including interested and affected individuals, organizations, agencies, and governmental entities in an agency's decisionmaking process. In preparing this draft environmental impact statement (DEIS), formal and informal input was encouraged. Formal input is being solicited in four phases, as follows:

Scoping: Public scoping was conducted prior to conducting the NEPA analysis to obtain public input on issues and proposed alternatives. Results of the scoping process are summarized in this chapter.

DEIS Review: A 60-day public review and comment period on the DEIS will be initiated by the publication of the Notice of Availability (NOA) in the *Federal Register*. Public meetings will be held in Carlsbad, Roswell, Fort Sumner, and Santa Rosa, New Mexico.

Final EIS Review: A 30-day final review period on the final EIS will be initiated by publication of the NOA in the *Federal Register*.

Record of Decision: After the 30-day review period on the final EIS, a Record of Decision (ROD) will be prepared and distributed.

1.1 Scoping

Scoping is a public process designed to inform the public about the project and to determine the scope of issues and alternatives to be addressed in the EIS. The scoping process for the Carlsbad Project Water Operations and Water Supply Conservation EIS began on October 4, 2002, with the publication of a notice of intent (NOI) in the *Federal Register*, which notified the public of the Bureau of Reclamation's (Reclamation) intent to re-operate Sumner Dam and implement a water acquisition program in the Pecos River basin.

To inform interested parties of the EIS, the location of scoping meetings, and the opportunity to comment, a newsletter, *River Notes*, was mailed to more than

200 contacts on the distribution list on October 10, 2002. Newspaper advertisements were published, and a press release was issued to notify the public of the project, to announce the four public scoping meetings, to request public comments, and to provide contact information. A display advertisement was published on October 16, 2002, in the *Hobbs News-Sun*, *Current Argus*, and *Roswell Daily Record*. It was also published in the *DeBaca County News* and the *Santa Rosa Communicator* on October 17, 2002, and in the *Santa Rosa News* on October 18, 2002. The same text used in the display advertisement also was published as a legal notice in the October 16, 2002, edition of the *Albuquerque Journal.*

Public scoping meetings were held in Santa Rosa, Fort Sumner, Carlsbad, and Roswell, New Mexico, on October 21, October 22, October 23, and October 24, 2002, respectively. These meetings provided an opportunity for the public to receive information, ask questions, and provide input. Fact sheets about the project were distributed. A total of 94 members of the public attended the scoping meetings.

A total of 121 verbal comments were recorded during the four scoping meetings: 24 in Santa Rosa, 42 in Fort Sumner, 38 in Carlsbad, and 17 in Roswell. Six written submissions were received during the comment period. Comments were grouped into one of eight categories; the majority of the comments addressed the ecology of the Pecos bluntnose shiner (shiner) (figure 6.1). Comments generally focused on the following: the habitat and riverflow requirements of the shiner; impacts to property owners, particularly farmers and to industries dependent upon the river; concern over water rights; dam operations; the possibility of using watershed management and brush removal to improve conditions on the river; and obtaining accurate readings to determine current flow rates prior to altering them. Details on the scoping process and results are provided in the Scoping Report (Tetra Tech, Inc., 2003a).

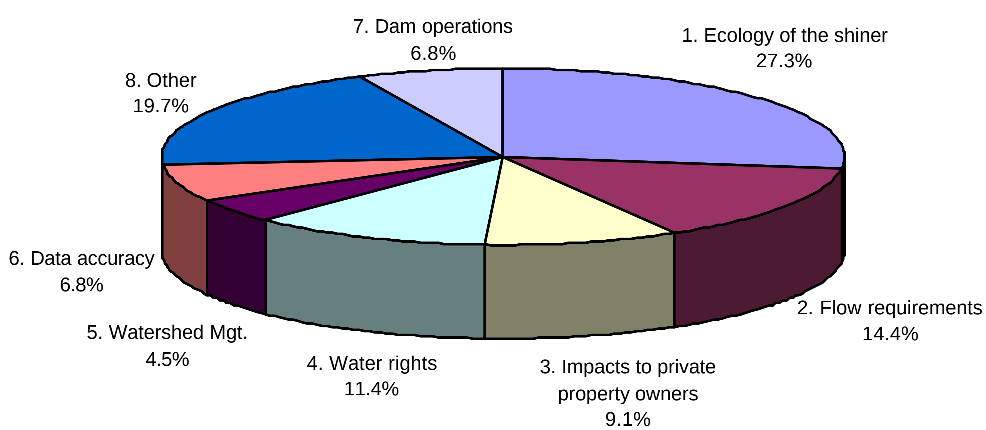

Figure 6.1 Comment categories.

1.2 Ongoing Public Involvement Activities

During the preparation of this DEIS, Reclamation and the New Mexico Interstate Stream Commission (NMISC) have continued to update the public through newsletters, phone, e-mail, and informal meetings. Five additional issues of the *River Notes* newsletter have been produced and distributed. The mailing list now includes more than 400 contacts. The comments and questions solicited through the newsletters are part of the project record. Reclamation and NMISC have met on several occasions with interested parties and stakeholders. An informal workshop, including a PowerPoint presentation, poster session, and sessions with resource specialists was held in Roswell on December 8, 2004, to inform the public, solicit input about the alternatives being addressed in the DEIS, and to provide preliminary results from the impact analysis.

2. Agency Coordination and Consultation

2.1 Cooperating and Participating Agencies and Organizations

The following agencies and organizations are serving as cooperating and participating agencies in the preparation of this DEIS. As such, they are invited to serve on the NEPA interdisciplinary team (ID team) and review committee. Representatives of these agencies are also participating in technical working groups which assisted the ID team in supporting studies and other tasks:

U.S. Fish and Wildlife Service
U.S. Army Corps of Engineers
New Mexico Department of Game and Fish
Carlsbad Irrigation District
Pecos Valley Water Users Association
Fort Sumner Irrigation District
Pecos Valley Artesian Conservancy District
Chaves County Flood Control District
Guadalupe County
Chaves County
De Baca County
Eddy County

2.1.1 Interdisciplinary Team

The EIS is being prepared using an interdisciplinary approach as required by NEPA. The ID team includes representatives of the technical workgroups, EIS authors, and the cooperating and participating agencies. Videoconference meetings have been conducted throughout the EIS process, and call-in numbers have been provided for remote access. The ID team is responsible for:

- Developing and evaluating alternatives
- Coordinating technical workgroups

- Ensuring information exchange among technical workgroups
- Providing information to support the public involvement program
- Drafting and assembling the EIS
- Reviewing and responding to comments on the DEIS

Leadership for the ID team is provided by the management team, consisting of representatives of the joint lead agencies. The management team is responsible for the day-to-day management of the EIS process, schedule, budget, documentation, public involvement activities, and consultations. The management team works under the under the direction of the executive committee, consisting of the Manager of Reclamation's Albuquerque Area Office and NMISC's Interstate Stream Engineer.

2.1.2 Review Committee

The review committee was formed to provide direct communication between the executive committee and representatives of cooperating and participating agencies. The review committee has no decisionmaking role. The purpose of the review committee is to facilitate coordination and information exchange and to review important EIS documentation prior to public release. Meetings are held periodically, and members are formally notified of the time and location.

2.1.3 Technical Workgroups

Technical workgroups provide technical and task support to the ID team. They perform studies and evaluations for a variety of disciplines and topics. Each workgroup is self-directed and has a designated leader(s). Leaders are responsible for coordinating workgroup activities and communicating with the ID team and management team. Workgroup membership includes technical staff and representatives of the joint lead agencies, cooperating and participating agencies, and key citizen stakeholders with interest in the discipline or focus of the group. Use of the workgroups allowed both the pooling of technical resources and early collaborative input into the NEPA process. Workgroups also have a major role in writing and reviewing EIS sections.

An alternative development workgroup was formed to identify, compile and screen the EIS alternatives for the ID team and management team. A water offset options workgroup systematically developed and ranked options for acquiring additional water for the Carlsbad Project water supply and for the benefit of the shiner. The biology workgroup synthesized available information on the needs of the shiner and other species, screened alternatives, and is providing input into the EIS analysis and development of the Biological Assessment. The hydrology workgroup provides modeling support and synthesis of modeling information essential to the impact analysis for many resources and is writing and reviewing water resource sections. An adaptive management guidelines workgroup is drafting the adaptive management plan which is proposed under the action alternatives. New working groups could be formed or inactive groups could be reactivated if the ID team determines that there is a need.

2.2 Consultation

Reclamation and NMISC are consulting with a number of other agencies. In many cases, the consultations are an extension of existing dialogs with the cooperating and participating agencies. Table 6.1 provides a general list of agencies that are being consulted on a formal or informal basis, along with the regulatory driver for such consultation. Specific consultations are discussed following the table.

Table 6.1 Preliminary list of organizations and consultations

Organization	Consultation
U.S. Fish and Wildlife Service	Endangered Species Act of 1973, as amended (ESA); Fish and Wildlife Coordination Act
State of New Mexico agencies (State Historic Preservation Office, New Mexico Department of Game and Fish, New Mexico Environment Department)	Section 106 of National Historic Preservation Act, NEPA, and Clean Water Act
Tribal governments	National Historic Preservation Act, Archeological Resources Protection Act, Native American Graves Protection and Repatriation Act, NEPA, American Indian Religious Freedom Act, and Executive Order 13007. Government-to-government consultation, NEPA, tribal assets, cultural, and archaeological resources, environmental justice
Bureau of Indian Affairs	Informal, NEPA, tribal assets, cultural and archaeological resources, environmental justice
U.S. Army Corps of Engineers	Clean Water Act (wetlands protection); water management
County governments and agencies (Chaves County, Eddy County)	NEPA, socioeconomics, environmental justice
Water districts (Carlsbad Irrigation District, Fort Sumner Irrigation District, Pecos Valley Artesian Conservancy District)	Water management/acquisition, NEPA
U.S. Forest Service	Informal, NEPA
Bureau of Land Management	Informal, NEPA
National Park Service	Informal, NEPA
Natural Resource Conservation Service	Prime farmland soils
Private landowners	Water management/acquisition, NEPA, environmental justice

2.3 Endangered Species Act, Section 7 Consultation

Section 7 of the Endangered Species Act of 1973, as amended (ESA) prohibits Federal agencies from authorizing, funding, or carrying out activities that are likely to jeopardize the continued existence of a listed species or destroy or adversely modify its critical habitat. Given the purpose of this EIS is related to a listed species, Reclamation has entered into formal consultation with the U.S. Fish and Wildlife Service. On the basis of the preferred alternative identified in the DEIS, Reclamation has submitted a Biological Assessment identifying the potential impact on the Pecos bluntnose shiner and other listed species. On the basis of this analysis, the U.S. Fish and Wildlife Service will prepare its

Biological Opinion on if the preferred alternative jeopardizes the continued existence of the shiner or other listed species. The Biological Opinion will be issued prior to Reclamation's signing the ROD.

2.4 Tribal Coordination

Federal law requires Federal agencies to consider the effects of their undertakings on cultural resources. The National Historic Preservation Act of 1966 (NHPA, 36 Code of Federal Regulations [CFR] 800), as amended, is the basic Federal law governing preservation of cultural resources of national, regional, State, and local significance. Specifically, section 106 of NHPA requires each Federal agency to consider the effect of its actions on any district, site, building, structure, or object that is included in, or eligible for inclusion, in the *National Register of Historic Places*. Furthermore, an agency must give the Advisory Council on Historic Preservation an opportunity to comment on any undertakings that could affect historic properties.

NHPA and other Federal legislation require consultation with American Indian tribes and nations, and the protection of historic and archeological resources by the Federal Government. Among these laws are the Archeological Resources Protection Act, the Native American Graves Protection and Repatriation Act, NEPA, the American Indian Religious Freedom Act, and Executive Order 13007. In terms of consultations, regulations require that Federal agencies consult with State Historic Preservation Office and identify American Indian tribes and nations that "might attach religious and cultural significance to historic properties in the Area of Potential Effect" [36 CFR 800.3(4)(f)(2)].

As part of the tribal outreach process, Reclamation solicited government-to-government consultation with potentially affected tribal governments regarding cultural resources and Indian trust assets. Letters were sent to eight tribes and pueblos, along with copies to the Bureau of Indian Affairs and New Mexico Historic Preservation Division on November 21, 2002. The following tribes and pueblos were contacted: Pueblo of Jemez, Pueblo of Ysleta del Sur, Pueblo of Isleta, Kiowa, Mescalero Apache, Fort Sill Apache, Comanche, and Hopi. No tribal concerns were raised from this process. Reclamation will continue the consultation process throughout the preparation of the EIS.

Concerning cultural resources survey work, because of the programmatic nature of this DEIS, a definite Area of Potential Effect cannot yet be completely delineated, which means that, although some Class I survey work was completed, the majority of the survey work will be completed later. The SHPO has been informed about the project.

Distribution List

U.S. REPRESENTATIVES
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Senator Pete Domenici, Roswell, NM
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Joe M. Stell, Carlsbad, NM
Avon W. Wilson, Roswell, NM

FEDERAL GOVERNMENT
Advisory Council on Historic Preservation, Lakewood, CO
Department of Agriculture, Natural Resources Conservation Service, Albuquerque, NM
Department of Defense, Army Corps of Engineers, Albuquerque District Office, Albuquerque, NM
Department of Defense, Army Corps of Engineers, Santa Rosa Recreation Area, Santa Rosa, NM
Department of the Interior, Bureau of Indian Affairs, Mescalero Agency, Mescalero, NM
Department of the Interior, Bureau of Indian Affairs, Southern Plains Region, Anadarko, OK
Department of the Interior, Bureau of Indian Affairs, Southern Pueblos Agency, Albuquerque, NM
Department of the Interior, Bureau of Indian Affairs, Southwest Region, Albuquerque, NM
Department of the Interior, Bureau of Land Management , Carlsbad Field Office, Carlsbad, NM
Department of the Interior, Office of Environmental Policy and Compliance, Washington, DC
Department of the Interior, U.S. Fish and Wildlife Service, Bitter Lake National Wildlife Refuge, Roswell, NM
Department of the Interior, U.S. Fish and Wildlife Service, Ecological Services, Albuquerque, NM
Department of the Interior, U.S. Fish and Wildlife Service, Fishery Resources, Albuquerque, NM
Environmental Protection Agency, Washington, DC
Environmental Protection Agency, Region 6, Dallas, TX
Natural Resources Library, Washington, DC
Office of Management and Budget, Washington, DC
Pecos River Compact Commissioner for the United States, Lucedale, MS

Distribution List

STATE OF NEW MEXICO GOVERNMENT
Cooperative Extension Service, Carlsbad, NM
Department of Agriculture, Las Cruces, NM
Department of Game and Fish, Santa Fe, NM
Economic Development Department, Santa Fe, NM
Energy, Minerals and Natural Resources Department, Santa Fe, NM
Environment Department, Surface Water Quality Board, Santa Fe, NM
New Mexico State University, Artesia, Carlsbad, Roswell, NM
New Mexico Interstate Stream Commissioners, Santa Fe, NM
Pecos River Compact Commissioner for New Mexico, Roswell, NM
State Historic Preservation Officer, Office of Cultural Affairs, Santa Fe, NM
State Land Office, Santa Fe, NM
State Parks, Brantley Lake State Park, Carlsbad, NM
State Parks, Living Desert Zoo and Garden State Park, Carlsbad, NM
State Parks, Santa Fe, New Mexico
University of New Mexico, New Mexico Natural Heritage Program, Albuquerque, NM

STATE OF TEXAS GOVERNMENT
Assistant Attorney General, Austin, TX
Pecos River Compact Commissioner for Texas, Monahans, TX
Texas Natural Resource Conservation Division, Austin, TX

COUNTY GOVERNMENT
Chaves County Commission, Roswell, NM
Chaves County Extension Service, Roswell, NM
Chaves County Flood Control, Roswell, NM
De Baca County Extension Service, Fort Sumner, NM
De Baca County Commission, Fort Sumner, NM
Eddy County Commission, Carlsbad, NM
Eddy County Cooperative Extension Service, Carlsbad, NM
Eddy County Extension Service Commission, Carlsbad, NM
Eddy County Manager, Carlsbad, NM
Guadalupe County, Santa Rosa, NM
Lincoln County Commission, Carrizozo, NM

LOCAL GOVERNMENT
Carlsbad Community Development Department, Carlsbad, NM
City of Artesia, Artesia, NM
City of Carlsbad, Carlsbad, NM
City of Roswell, Roswell, NM
City of Santa Rosa, Santa Rosa, NM
Village of Carrizozo, Carrizozo, NM
Village of Cloudcroft, Cloudcroft, NM
Village of Dexter, Dexter, NM
Village of Fort Sumner, Fort Sumner, NM
Village of Hagerman, Hagerman, NM
Village of Hope, Hope, NM
Village of Lake Arthur, Lake Arthur, NM
Village of Loving, Loving, NM
Village of Ruidoso Downs, Ruidoso Downs, NM
Village of Ruidoso, Ruidoso, NM

INDIAN TRIBES
Apache Tribe of Oklahoma, Anadarko, OK
Comanche Nation, Lawton, OK
Fort Sill Apache Business Committee, Apache, OK
Hopi Tribe, Kykotsmovi, AZ
Jicarilla Apache Tribe, Dulce NM
Kiowa Nation, Carnegie, OK
Mescalero Apache Tribe, Mescalero, NM
Navajo Nation, Window Rock, AZ
Pueblo of Isleta, Isleta Pueblo, NM
Pueblo of Jemez, Jemez Pueblo, NM
Pueblo of Ysleta del Sur, El Paso, TX

IRRIGATION AND CONSERVATION DISTRICTS
Carlsbad Irrigation District
Carlsbad Soil and Water Conservation District, Carlsbad, NM
De Baca Soil and Water Conservation District, Fort Sumner, NM
East Puerto de Luna Ditch, Puerto de Luna, NM
Fort Sumner Irrigation District, Fort Sumner, NM
Hagerman Irrigation Company, Hagerman, NM
Hope Community Ditch, Hope, NM
Ortega Ditch Association, Santa Rosa, NM
Pecos Valley Artesian Conservancy District, Roswell, NM
Pecos Valley Water Users Organization, Cloudcroft, NM
Reeves County Water Improvement District #2, Pecos, TX
West Puerto de Luna Ditch, Puerto de Luna, NM

ENVIRONMENTAL GROUPS
American Fisheries Society, Bethesda, MD
American Rivers, Washington, DC
Chihuahuan Desert Conservation Alliance, Carlsbad, NM
Defenders of the Wildlife, Washington, DC
Ducks Unlimited, Inc., Memphis, TN
Environmental Defense Fund, New York, NY
Forest Guardians, Santa Fe, NM
National Audubon Society, New York, NY
National Wildlife Federation, Washington, DC
Natural Resources Defense Council, Inc., New York, NY
Quivira Coalition, Santa Fe, NM
Sierra Club, San Francisco, CA
Sierra Club, Rio Grande Chapter, Albuquerque, NM
Southwest Center for Biological Diversity, Tucson, AZ
The Fund for Animals, Inc., New York, NY
The Nature Conservancy, Arlington, VA
The Nature Conservancy, Santa Fe, NM
The Trust for Public Land, Santa Fe, NM
The Wildlife Society, Bethesda, MD
Trout Unlimited, Arlington, VA

ENTITIES AND ORGANIZATIONS
American Southwest Ichthyological Consulting, Albuquerque, NM
American Water Resources Association, Middleburg, VA
Artesia Agricultural Science Center, Artesia, NM

Cibola Ranch, Fort Sumner, NM
Citizens Bank, Fort Sumner, NM
Cooney Watson & Associates, Albuquerque, NM
Dairy Producers of New Mexico, Roswell, NM
De Baca Soil and Water Conservation District, Fort Sumner, NM
Environmental Science Associates, Santa Fe, NM
ERO Resources Corporation, Denver, CO
Farm Credit Services of New Mexico, Roswell, NM
Grandi Farms, Carlsbad, NM
Guadalupe Mountain Association, Carlsbad, NM
Gunn Farm, Fort Sumner, NM
Hinkle Law Firm, Roswell, NM
Marbob Energy Corporation, Artesia, NM
McKnight, Salmon, Lewis & Weldon, PLC, Phoenix, AZ
National Water Resources Association, Arlington, VA
New Mexico Association of Conservation Districts, Carlsbad, NM
New Mexico Cattle Growers Association, Artesia, NM
New Mexico Farm and Livestock Bureau, Fort Sumner, Roswell, NM
Public Lands Council, Artesia, Roswell, NM
Rio Grande/Rio Bravo Basin Coalition, El Paso, TX
Sheehan, Sheehan & Stelzner, P.A., Albuquerque, NM
Steele Ranch Inc., Fort Sumner, NM
SWCA, Inc., Flagstaff, AZ
Tetra Tech, Inc., Breckinridge, CO; Carlsbad, NM; Seattle, WA
Think New Mexico, Santa Fe, NM
URS Corporation, Albuquerque, NM
Vaughan Ranch, Fort Sumner, NM
Waste Isolation Pilot Plant, Environmental Monitoring, Carlsbad, NM
Western Network, Santa Fe, NM
Westinghouse Environmental Services, Waste Isolation Division, Carlsbad, NM

INDIVIDUALS

Ahrens, Bill, Malaga, NM
Barnett, Jon, Clovis, NM
Billberry, Jeff, Elida, NM
Black, Jack and Lee, Carlsbad, NM
Bonney, Robert, San Pedro, CA
Bradley, Robert, Roswell, NM
Brady, Alice, Fort Sumner, NM
Buckman, B. Rex, Fort Sumner, NM
Burns, Darrin, Fort Sumner, NM
Campbell, R. H., Carlsbad, NM
Campos, Jose, Santa Rosa, NM
Carnell, L. L., Fort Sumner, NM
Cibak, Richard, Roswell, NM
Clark, Ann, Carlsbad, NM
Cordova, Gary L., Conchas Dam, NM
Cortese, Gerald Don, Fort Sumner, NM
Crancton, Craig C., Carlsbad, NM
Davis, Bill, Roswell, NM
Davis, Stella, Carlsbad, NM
Davis, V. West, Fort Sumner, NM
Dawson, Jim, Carlsbad, NM
Doyal, Curtis, Carlsbad, NM

Drake, Desiree D., Roswell, NM
Drake, Raymond, Fort Sumner, NM
Dunn, Eddie, Carlsbad, NM
Dunn, Ellen, Fort Sumner, NM
Dickerman, Burton, Fort Sumner, NM
Fallon, Emmet, Fort Sumner, NM
Farney, Denzel, Fort Sumner, NM
Finny, Herbert, Fort Sumner, NM
Forrest, Dick, Carlsbad, NM
Gant, III, Joe, Carlsbad, NM
Gardner, Ridley, Carlsbad, NM
Giovejo, Johnnie, Loving, NM
Graham, Kevin, Carlsbad, NM
Grandi, Henry J. Carlsbad, NM
Gunn, G.P., Fort Sumner, NM
Haight, Jim L., Puerto De Luna, NM
Harrison, Jim, Carlsbad, NM
Hart, Ratrina, Carlsbad, NM
Head, Dub, Fort Sumner, NM
Houghtaling, Sonny and Ann, Lake Arthur, NM
Hughes, Debra, Carlsbad, NM
Jaromello, John, Taiban, NM
Jueva, Charlie, Carlsbad, NM
Kidd, Don, Carlsbad, NM
Knowles, Richard T., Roswell, NM
Koontz, Jim, Fort Sumner, NM
Kyle, Billy, Fort Sumner, NM
Labrier, Billy, Fort Sumner, NM
Light, Robert S., Carlsbad, NM
Lochhead, Jim, Glenwood Springs, CO
Mack, Michael, Fort Sumner, NM
Martinez, Paul, Albuquerque, NM
McMillan, John, Fort Sumner, NM
McRee, Frank, Fort Sumner, NM
Meachan, Walter, Fort Sumner, NM
Merritt, Frances, Carlsbad, NM
Moran, Chuck, Artesia, NM
Nelson, Morgan, Roswell, NM
Nichols, Oral, Carlsbad, NM
Ogden, Alisa, Carlsbad, NM
Olson, Richard E., Roswell, NM
Page, Cecilio and Ann, Puerto De Luna, NM
Parsons, David M., Roswell, NM
Patchet, Stanley, Carlsbad, NM
Paulson, Steve, Austin, TX
Payne, Robbie, Fort Sumner, NM
Pena, Eddie, Fort Sumner, NM
Perea Casey, Barbara A., Las Vegas, NM
Ponce, Pauline, Roswell, NM
Rangham, Henry and Betty, Fort Sumner, NM
Ratliff, Bob, Fort Sumner, NM
Rhodes, Denise, Austin, TX
Rhodes, Frank, Roswell, NM

Riviera, Serundino, Santa Rosa, NM
Roberts, Earlene, Lovington, NM
Rogers, Raphael, Carlsbad, NM
Sairbeth, Dan, Fort Sumner, NM
Sanchez, Rudy, Santa Rosa, NM
Sena, Edward A., Fort Sumner, NM
Sheehan, David, Santa Rosa, NM
Shoup, Jr., George M., Carlsbad, NM
Sibley, Bill, Carlsbad, NM
Sisneros, Silvano and Seferina, Santa Rosa, NM
Sparks, Allen, Fort Sumner, NM
Sparks, Jerry, Fort Sumner, NM
Spitz, Eddie, Fort Sumner, NM
Stalder, Jerry, Santa Rose Lake, NM
Stallard, Kim, Fort Sumner, NM
Stennett, Scott, Fort Sumner, NM
Trotter, Jon, Fort Sumner, NM
Vasquez, Henry, Carlsbad, NM
Walterscheid, Bonnie, Carlsbad, NM
Watterschied, James, Carlsbad, NM
Watts, Marvin, Carlsbad, NM
Weld, Juan, Carlsbad, NM
West, Bob, Fort Sumner, NM
West, James and Kathy, Fort Sumner, NM
West, Mike, Fort Sumner, NM
West, Steve, Carlsbad, NM
West, V. Davis, Fort Sumner, NM
Western Commerce Bank, Carlsbad, NM
Williams, Dane, Carlsbad, NM
Williamson, Bobby, Fort Sumner, NM
Wolver, Chester E., Carlsbad, NM

LIBRARIES

Albuquerque Public Library, Albuquerque, NM
Carlsbad Public Library, Carlsbad, NM
Fort Sumner Public Library, Fort Sumner, NM
Moise Memorial Library, Santa Rosa, NM
New Mexico State Library, Santa Fe, NM
Roswell Public Library, Roswell, NM
Santa Fe Public Library, Santa Fe, NM

MEDIA

Artesia Daily Press, Artesia, NM
Carlsbad Current Argus, Carlsbad, NM
DeBaca County News, Fort Sumner, NM
Guadalupe County Communicator, Santa Rosa, NM
KAMQ-AM – 1240, Carlsbad, NM
KATK, Carlsbad, NM
KBCG-FM - 97.1, Roswell, NM
KBIM-AM – 910, Roswell, NM
KBIM-FM - 94.9, Roswell, NM
KBIM-TV – 10, Roswell, NM
KCCC-AM -930, Carlsbad, NM
KCDY - FM 104.1, Carlsbad, NM

KCKN-AM -1020, Roswell, NM
KEND-FM -106.5, Roswell, NM
KMOU-FM - 104.7, Roswell, NM
KOBR-TV – 8, Roswell, NM
KRDD-AM – 1320, Roswell, NM
KSSR - AM 1340, Santa Rosa, NM
KSVP-AM - 990 - FM 92.9, Artesia, NM
KVIA-TV – 6, El Paso, TX
Roswell Daily Record, Roswell, NM
Santa Rosa News, Santa Rosa, NM

List of Preparers

Name	Contribution	Organization	Title/Years of Experience	Education
David Batts	Reclamation project management support	Tetra Tech, Inc.	Environmental Planner, 15 years	B.S., International Development, Lewis & Clark College M.S., Natural Resource Management, Michigan State University
Laura Belanger	Water resources analysis	Hydrosphere Resource Consultants	Water Resource Engineer, 4 years	B.A., University of Massachusetts M.S., University of Colorado
Alaina Briggs	Water resources analysis	Tetra Tech, Inc.	Hydraulic Engineer, 10 years	B.S., Civil Engineering, University of Vermont M.S., Civil Engineering, University of New Hampshire
Joe Brummer	Agricultural soil and land resources analysis	Bureau of Reclamation	Soil Scientist, 30 years	B.S., Agricultural Science, Fresno State University
Craig B. Boroughs	RiverWare model development; water resources analysis	BH&H Engineering, Inc.	Hydraulic Engineer, 11 years	B.S., Civil Engineering, Virginia Tech M.S., Hydraulic Engineering, Colorado State University Ph.D., Hydraulic Engineering, Colorado State University
Peter Burck	Water resources analysis	New Mexico Interstate Stream Commission, Pecos Bureau	Hydrologist, 17 years	A.B., Princeton University M.S., New Mexico Institute of Mining and Technology
Marsha Carra	Reclamation project management	Bureau of Reclamation	Environmental Protection Specialist, 8 years	B.S., Anthropology, Geography, Eastern New Mexico University
John Carron	Water resources analysis	Hydrosphere Resource Consultants	Water Resource Engineer, 13 years	B.S., Colorado College M.S., University of Colorado Ph.D., University of Colorado
Dianne Clark	Document management and editing	Bureau of Reclamation	Technical Writer-Editor, 17 years	B.S., Journalism, University of Colorado
Jodi Clark	Water resources analysis	Hydrosphere Resource Consultants	Hydrogeologist, 9 years	B.S., Appalachian State University M.S., New Mexico Tech
Kelly Close	Water resources analysis	Hydrosphere Resource Consultants	Environmental Planner, 13 years	B.Envd, University of Colorado
Gary Dean	Biological resources analysis	Bureau of Reclamation	Fisheries Biologist, 20 years	B.S., Fishery Science, Colorado State University

List of Preparers

Name	Contribution	Organization	Title/Years of Experience	Education
Kevin Doyle	Reclamation project management support; cultural resources and Indian trust and treaty assets analysis	Tetra Tech, Inc.	Environmental Planner/Cultural Resource Specialist, 20 years	B.A., Sociology, University of California, Santa Barbara
Laila Hall	Water resources analysis	Hydrosphere Resource Consultants	Hydrologist, 2 years	B.S. and M.S., New Mexico Institute of Mining and Technology
Jack Jibson	Agricultural soil and land resources analysis	Bureau of Reclamation	Soil Scientist	B.S., Agronomy, University of Idaho
Jon Kehmeier	Biological resources analysis	SWCA Environmental Consultants	Aquatic Ecologist, 8 years	B.S., Fisheries and Wildlife Biology, University of Wyoming M.S., Bioresource Engineering, Oregon State University
Richard Lichtkoppler	Recreation analysis	Bureau of Reclamation	Natural Resource Economist, 15 years	B.S., Business Administration, Ohio State University M.S., Park and Recreation Administration, Ohio State University Ph.D., Resource Economics, Auburn University
John Longworth	New Mexico Interstate Stream Commission project management	New Mexico Office of the State Engineer	Environmental Engineer	B.S., State University of New York, Buffalo M.S., New Mexico State University
Teri Manross	Document management and editing	Bureau of Reclamation	Technical Editor, 13 years	A.A., English, Psychology (completing), Red Rocks Community College
Jim McCord	Co-lead, water resources analysis	Hydrosphere Resource Consultants	Water Resources Engineer, 20 years	B.S., Civil Engineering (minor Geology), Virginia Tech M.S. Hydrology, New Mexico Tech Ph.D., Geoscience, New Mexico Tech
Nic Medley	Biological resources analysis	New Mexico Interstate Stream Commission, Pecos Bureau	Ecologist, 10 years	B.S., University of Sheffield M.S., Colorado State University

List of Preparers

Name	Contribution	Organization	Title/Years of Experience	Education
Steve Piper	Regional economy and environmental justice analyses	Bureau of Reclamation	Economist, 20 years	B.S., Economics, Colorado State University M.S., Natural Resource Economics, Colorado State University Ph.D., Environmental Economics, Colorado School of Mines
Bhasker Rao	New Mexico Interstate Stream Commission general review	New Mexico Interstate Stream Commission, Pecos Bureau	Civil and Environmental Engineer, 25 years	M.S., Utah State University Ph.D., Utah State University
Sara L. Rhoton	New Mexico Interstate Stream Commission project management	New Mexico Interstate Stream Commission, Pecos Bureau	Water Resources Engineer, 8 years	B.S., New Mexico State University M.S., University of Alaska, Fairbanks
Miguel Rocha	Water resources analysis	Bureau of Reclamation	Civil Engineer, 8 years	B.S., Civil Engineering, New Mexico State University
Coleman Smith	New Mexico Interstate Stream Commission project management	New Mexico Interstate Stream Commission, Pecos Bureau	Water Resource Specialist, 1 year	B.S., Oklahoma State University M.P.A./M.S., Indiana University
Jennifer Smith	Water resources analysis	Hydrosphere Resource Consultants	Hydrogeologist, 1.5 years	B.S., Juniata College M.S., New Mexico Tech
Phil Soice	Co-lead, Water Offset Options Group	Southwest Water Consultants	Water Resources Engineer, 33 years, Attorney, 26 years	B.S., Civil Engineering, University of Kansas M.S., Water Resources Engineering, University of Kansas J.D., University of Denver
Tomas B. Stockton	Water resources analysis	Tetra Tech, Inc.	Hydraulic Engineer, 6 years	B.S., Civil Engineering, University of New Mexico M.S. Civil (Geotechnical) Engineering, University of New Mexico
Gene E. Valdez	Water resources analysis; mapping	Tetra Tech, Inc.	Hydraulic Engineer, 3 years	B.S., Civil Engineering, University of New Mexico
Jim Yahnke	Water quality analysis	Bureau of Reclamation	Hydrologist, 31 years	B.S., Biology, West Liberty State College 3 years graduate work in limnology, aqueous geochemistry, West Virginia University

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Glossary

A

active capacity: The reservoir capacity that can be used for irrigation, power, municipal and industrial use, fish and wildlife, recreation, water quality, and other purposes.

additional water acquisition (AWA): Additional water acquisitions provide additional flows to meet target flows upstream where the shiner are found, to avoid intermittency in the river, and, at a minimum, to keep flows in the critical habitat.

additional water needed (AWN): If the demand needed to achieve the flow target stipulated by an alternative is not completely met, the additional water needed is referred to as AWN.

acequia: An irrigation ditch or canal.

acre-foot: The volume of water which would cover an area of 1 acre to a depth of 1 foot; equal to 43,500 cubic feet or 325,851 gallons.

active conservation storage: Water storage for later release for purposes such as municipal and industrial (M&I) uses, hydropower, or irrigation.

affected environment: Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as the result of a proposed human action. Also, the chapter in an environmental impact statement describing current environmental conditions.

air quality: Measure of the health-related and visual characteristics of the air, often derived from quantitative measurements of the concentrations of specific injurious or contaminating substances.

algae: Mostly aquatic single celled, colonial, or multicelled plants, containing chlorophyll and lacking stems, roots, and leaves.

algal bloom: Rapid and flourishing growth of algae. A heavy growth of algae in and on a body of water as a result of high nutrient concentrations such as from farm fertilizers and detergents.

alternatives: Courses of action which may meet the objectives of a proposal at varying levels of accomplishment. Alternatives include no action, the most likely future conditions without the project or action.

anthropogenic: Human-created.

aquatic: Living or growing in or on the water.

aquifer: Stratum or zone below the surface of the earth containing water.

archaic: In American archeology, a cultural stage following the earliest known human occupation in the New World (about 5,500 B.C. to A.D. 100). This stage was characterized by a hunting and gathering lifestyle and seasonal movement to take advantage of a variety of resources.

archeology: Study of human cultures through the recovery and analysis of their material relics.

artifact: A human-made object.

augment: To increase in size, quantity, or strength.

average hydrologic condition: Effective Brantley storage is greater than 75,000 acre-feet and less than 110,000 acre-feet.

B

bank storage: Volumes of water which are temporarily retained by reservoir or stream banks and may be gradually released to partially sustain base inflow.

bank storage flux: Flow of bank storage into or out of the bank.

base inflow: Water which may seep from the ground-water aquifer to a river or stream.

bench-leveled: Nearly level terraces.

Biological Opinion: This is a document that is part of the Section 7 consultation process required by the Endangered Species Act of 1973. Section 7 of the Act is specific to Federal agency actions. The BiOp is required by Federal law anytime a Federal agency proposes an action which “may affect” a listed species or its habitat. It includes: (1) the opinion of the Fish and Wildlife Service as to whether or not a Federal action is likely to jeopardize the continued existence of listed species, or result in the destruction or adverse modification of designated critical habitat; (2) a summary of the information on which the opinion is based;

and (3) a detailed discussion of the effects of the action on listed species or designated critical habitat [50 Code of Federal Regulations (CFR) section 402.02, 50 CFR section 402.14(h)]

block release: Large-volume releases of water from northern reservoirs (i.e. Santa Rosa Reservoir and Sumner Lake) made over a number of days to transmit water downstream to Brantley Reservoir and subsequently to irrigators.

block release efficiency: The ratio of the volume of water released from a reservoir as a block release to the amount of water which reaches the downstream endpoint; usually smaller-volume block releases have lower efficiency, due to the relative amount of evaporation from the water surface and seepage.

bypass(ing): Water that is not diverted at a structure but is allowed to flow downstream.

C

caliche: A hard deposit, mostly consisting of crusted calcium carbonate found in the subsoil in arid regions. It is created by the evaporation of mineral-laden capillary water, which leaves a residue that serves as a cementing material.

Carlsbad Project: Carlsbad Irrigation District (CID) operates the Carlsbad Project to provide water for water users who are members of CID. The Secretary of the Interior authorized the Carlsbad Project for the purpose of irrigation in 1905.

Reclamation owns the Carlsbad Project dams and reservoirs, and CID operates the dams and reservoirs. Carlsbad Project operations include diverting to storage and releasing water to deliver project water to CID water users.

Carlsbad Project water acquisition (CPWA): CPWAs provide water to the Carlsbad Project for use in CID in compensation for depletions incurred as a result of changes in operations.

candidate species: Plant or animal species that are not yet officially listed but which are undergoing a status review as published in the Federal Register by the U.S. Fish and Wildlife Service, are candidates for possible addition to the list of threatened and endangered species.

channelization: Straightening a stream or river to allow water to travel through the area more quickly.

channel storage: The volume of water at a given time in a river channel.

community: A group of one or more interacting populations of plants and animals in a common spatial arrangement at a particular point in time.

concentration: Relative quantities of physicochemical parameters. The density or amount of a substance in a solution.

conserve: Conserving the shiner means that Reclamation would ensure that any discretionary action they authorize, fund, or carry out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. Reclamation would continue to participate in interagency actions to protect federally-listed species and designated critical habitats, within their legal and discretionary authority.

conservation spill: Water that is released from a reservoir to meet irrigation demand.

conservation storage: The allowable entitlement or "conservation storage" limit is the amount of water that the Carlsbad Project can store for irrigation. For example, the portion of conservation storage allocated for the Carlsbad Project in the Santa Rosa Reservoir is approximately 100,000 acre-feet; whoever, the entire storage limit is approximately

consumptive irrigation requirement: The amount of irrigation water, exclusive of precipitation, stored soil moisture, or ground water, needed consumptively for crop production.

cooperative agreement: Formal document that states the obligations of Reclamation to one or more other parties. A cooperative agreement provides the authority for the Bureau of Reclamation to issue funding to the other party(ies) listed in the agreement. The legal instrument used to reflect a relationship between the Federal Government and a state, local, or tribal government or other recipient whenever the principal purpose of the relationship is the transfer of money, property, services, or anything of value to a recipient to accomplish a public purpose of support or stimulation authorized by Federal law; and substantial involvement is anticipated between the Federal Government, and the state, local, or tribal government, or other recipient during performance of the contemplated activity.

critical habitat: Defined in section 3(5)(A) of the Endangered Species Act of 1973, as amended (ESA) as:

(1) The specific areas within the geographical area occupied by the species at the time it is listed, on which are found those physical and biological features essential to the conservation of the listed species and which may require special management considerations for protection; and

(2) Specific areas outside the geographical area occupied by a species at the time it is listed upon a determination by the Secretary of the Department of Interior that such areas are essential for the conservation of the species. These areas have been legally designated via Federal Register notices.

cubic foot per second (cfs): As a rate of streamflow, a cubic foot of water passing a reference section in 1 second of time; 1 cfs = 2 acre-feet per day; 651,702 gallons per day. A measure of a moving volume of water (1 cfs = 0.0283 cubic meter per second);

cultural resource: Any building, site, district, structure, or object significant in history, architecture, archeology, culture, or science.

cumulative impact: The incremental additive impacts of the proposed project and other projects in the area of influence. Cumulative impacts are reasonably foreseeable in the future. For example, a new highway may be proposed and have direct impacts on the project corridor. Cumulative impacts would occur other projects and activities expected to occur in the general vicinity of the project corridor such as other road construction, new residential developments, shopping centers, and associated infrastructure, such as electric and water utilities.

cyprinid: Any of a family of freshwater bony fishes, including carp, minnows, and dace.

D

delta: A formation created by sediment deposit and/or channel incision at a river mouth from upstream erosion.

detention: Storage of streamflow or surface runoff, and control of the release of such stored water. Used for flood regulation.

depletion: The loss of water from surface water reservoirs or ground-water aquifers.

discharge: All water that passes a specific location, including all water that flows out of a particular facility. In the case of a lake or reservoir, discharge includes all water that passes through the outlet facilities, passes over the spillway, is pumped from the reservoir, seeps through the dam or foundation into the stream, or in any other fashion flows from the lake or reservoir into the stream channel downstream from the lake or reservoir. Expressed in acre-feet per year.

dissolved oxygen (DO): Amount of free oxygen in water.

diversion: A structure in a river or canal that diverts water from the river or canal to another watercourse.

dry hydrologic condition: Effective Brantley storage is less than 75,000 acre-feet.

E

economic benefits: Economic benefits attempt to measure changes in societal or national welfare based on net value concepts, including consumer surplus and producer profitability.

ecosystem: Complex system composed of a community of animals and plants as well as the chemical and physical environment.

efficiency: Ratio of useful energy output to total energy input, usually expressed as a percent. Effective operation as measured by a comparison of production with cost.

electrical conductivity (EC): In the context that it is being used in the EIS, EC stands for specific electrical conductivity (or conductance). As this indicated, it is a measure of the ability of water to conduct electricity. The conductivity of water varies with temperature; the term "specific" means that the reading has been corrected (or standardized) to a temperature of 25 degrees Celsius (°C). Pure water does not conduct electricity. The ability of water to conduct electricity is proportional to the amount of salts (also known as electrolytes) dissolved in the water.

employment: Total of hourly wage, salary, and self-employed jobs (part-time and full-time), measured in terms of jobs, not full-time equivalents

endangered species: A species or subspecies whose survival is in danger of extinction throughout all or a significant portion of its range.

environmental assessment (EA): A NEPA compliance document used to determine if an action would have a significant effect on the human environment. If not, a finding of no significant impact (FONSI) is written. If so, an environmental impact statement (EIS) is written.

environmental impact statement (EIS): A NEPA compliance document used to evaluate a range of alternatives when solving the problem would have a significant effect on the human environment. The EIS is more than a document, it is a formal analysis process which mandates public comment periods. An EIS covers purpose and need, alternatives, existing conditions, environmental consequences, and consultation and coordination.

environmental justice: Executive Order 12898 defines Federal agency responsibilities with respect to environmental justice. Federal agencies are expected to identify and address disproportionate high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.

ephemeral: Streams that contain running water only for brief periods of time in direct response to precipitation.

erosion: Refers to soil and the wearing away of the land surface by water, wind, ice, or other physical processes.

eutrophication: Overenrichment of a lake or other water body with nutrients, resulting in excessive growth of organisms and depletion of oxygen.

evaporation: A part of the hydrologic cycle in which liquid water is converted to vapor and enters the atmosphere.

evapotranspiration: A collective term that includes water discharged to the atmosphere as a result of evaporation from the soil and surface-water bodies and as a result of plant transpiration.

extirpated: A species of plant or animal that is no longer found in a particular area.

F

facilities: Manmade structures, such as dams, spillways, and outlet works.

Fish and Wildlife Service (FWS) Species of Concern: Species identified by the FWS for which further biological research and field study are needed to resolve these species' conservation status.

flood plain: Nearly level land, susceptible to floods, that forms the bottom of a valley. An area, adjoining a body of water or natural stream, that has been or may be covered by floodwater.

flow frequency: The probability of a certain flow rate occurring at a given location, based on historical data.

flow frequency curve: A graph showing the number of times per 100 years, or the average interval of times within which a flood of a given magnitude will be equaled or exceeded.

G

gage: Specific location on a stream where systematic observations of hydrologic data are obtained through mechanical or electrical means.

geomorphology: Geological study of the configuration, characteristics, origin, and evolution of land forms and earth features.

ground water: Water beneath the ground, consisting mostly of surface water that has seeped down.

ground-water recharge: The flow to ground water storage from precipitation, infiltration from streams, and other sources of water.

ground-water/surface-water interaction: the exchange or mixing of water between the ground water (such as an aquifer) and the surface water (such as a river or lake); one common example is through seepage into or out of a river bottom.

H

habitat: The area or type of environment in which a plant or animal normally lives or occurs.

historic properties: Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe and that meet the National Register of Historic Places criteria.

hydrologic: Pertaining to the quantity, quality, and timing of water.

hypolimnion: The lower layer of a stratified lake. In a thermally stratified lake, this layer is coldest. In a salinity stratified lake, this layer has the highest salt concentration.

I

incidental take: The taking of an endangered species or a threatened species incidental to the agency action.

incubation: Eggs in the process of hatching.

Indian tribe: An Indian tribe, band, nation, or other organized group or community, which is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians.

indigenous: Native plant or animal species.

intermittency: A condition under which something is started at stopped at intervals. For example, a lake that normally contains water for only part of a year or that is seasonally dry, or a stream that flows only at certain times of the year when it receives water from springs or from some surface source.

invertebrate: An animal lacking a spinal column.

irrigation district: A cooperative, self-governing public corporation set up as a subdivision of the State government, with definite geographic boundaries, organized and having taxing power to obtain and distribute water for irrigation of lands within the district; created under the authority of a State legislature with the consent of a designated fraction of the landowners or citizens.

irrigation season: March 1 thru October 31 each year.

J

jeopardy opinion: U.S. Fish and Wildlife Service or National Marine Fisheries Service (NMFS) opinion that an action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. The opinion includes reasonable and prudent alternatives, if any.

K

L

lacustrine: Of or pertaining to a lake.

lake: A relatively large natural body of water.

laminar flow. Flow in which the head loss is proportional to the first power of the velocity. The flow field can be characterized by layers of fluid, one layer not mixing with adjacent ones. The flow is laminar or turbulent depending on the value of the Reynolds number, which is a dimensionless ratio of the inertial forces to the viscous forces. In laminar flow, viscous forces are dominant and the Reynolds number is relatively small. In turbulent flow, the inertial forces are very much greater than the viscous forces and the Reynolds number is large. Laminar flow occurs very infrequently in open channel flow.

land classification: Reclamation's systematic placing of lands into classes based on their suitability for sustained irrigated farming. Land classes are defined by productivity, with Class 1 being the most productive. For other classes, the equivalent acreage to Class 1 for the same productivity is defined (Class 1 equivalency). For example, (the productivity of) X acres of Class 2 land is equal to (the productivity of) 1 acre of Class 1 land.

life history: Life cycles through which organisms pass, with emphasis on reproduction and survival mechanisms.

lithic: Physical characteristics of specified sedimentary rock or formations, including grain or crystal size, mineral constituents, and bedding planes.

lower critical habitat: Thirty-seven miles long, from Hagerman, New Mexico, to Artesia, New Mexico.

M

M&I: Municipal and industrial use.

microSiemens: The typical measure of electrical conductivity in fresh water. 1 Siemens/cm is equal to the reciprocal of 1 ohm of resistance per cm. 1 µS/cm is 1 millionth of a Siemens/cm.

mesohabitat: Habitat types that provide suitable combinations of microhabitat features such as depth, velocity, substrate, turbulence, cover, and food.

mitigation (measures): Action taken to avoid, reduce the severity of, or eliminate an adverse impact. Mitigation can include one or more of the following:

(1) avoiding impacts

(2) minimizing impacts by limiting the degree or magnitude of an action

(3) rectifying impacts by restoration, rehabilitation, or repair of the affected environment

(4) reducing or eliminating impacts over time

(5) compensating for the impact by replacing or providing substitute resources or environments to offset the loss

modeling: Use of mathematical equations to simulate and predict real events and processes.

multipurpose project: A project designed for irrigation, power, flood control, municipal and industrial, recreation, and fish and wildlife benefits, in any combinations of two or more (contrasted to single-purpose projects serving only one need).

N

National Register of Historic Places: A federally maintained register of districts, sites, buildings, structures, architecture, archeology, and culture.

No Action Alternative: The most likely future conditions without the project or action.

nonirrigation season: November 1 through February 28 each year.

O

overgrazing: Excessive grazing use of area by livestock, resulting in detrimental impacts on the environment.

overstory: The portion of the trees or shrubs that form the uppermost portion of the canopy layer.

oxbow: 1. A bow-shaped bend in the river. 2. A bow-shaped lake formed in an abandoned channel of the river.

P

Pecos River Compact (Compact): An interstate agreement between New Mexico and Texas that was later approved by the Congress in the Act of June 9, 1949. The Compact apportions Pecos River water between the two States. The major purposes of this Compact are to provide for the equitable division and apportionment of the use of the waters of the Pecos River; to promote interstate (New Mexico and Texas) comity; to remove causes of present and future controversies; to make secure and protect present development within the States; to facilitate the construction of works for (a) the salvage of water, (b) the more efficient use of water, and (c) the protection of life and property from floods.

perennial: Refers to plants that have a life cycle that lasts for more than 2 years.

pool elevation: The elevation of the water surface in a reservoir.

population viability: Probability that a population will persist for a specified period across its range despite normal fluctuations in population and environmental conditions.

potentiometric: Measurement of an electromotive force by comparison with a known potential difference.

potentiometric surface: A surface that represents the level to which water will rise; the water table is an example of a potentiometric surface in an unconfined aquifer.

precipitation: Liquid or solid water particles that fall from the atmosphere and reach the Earth's surface. It includes drizzle, rain, snow, snow pellets, snow grains, ice crystals, ice pellets, and hail.

predation: The consumption of one organism (the prey) by another (predator).

prior water rights: Senior water rights.

public involvement: Process of obtaining citizen input into each stage of development of planning documents. Required as a major input into any EIS.

pump-back operation: A return-flow operation in which tailwater is pumped back to the head of an irrigation ditch for reuse.

Q

quality habitat: Meets all criteria for critical habitat.

R

ramp down: Decrease of flow rates of block releases of water.

ramp up: Increase of flow rates of block releases of water.

raptor: Any predatory bird, such as a falcon, eagle, hawk, or owl, that has feet with sharp talons or claws and a hooked beak.

reach: Any specified length of a stream, river, channel, or other water conveyance.

reasonable and prudent alternative: The regulations implementing section 7 of the Endangered Species Act define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that (1) can be implemented in a manner consistent with the intended purpose of the action, (2) can be implemented consistent with the scope of the action agency's legal authority, (3) are economically and technologically feasible, and (4) would, NMFS believes, avoid the likelihood of jeopardizing the continued existence of listed species and avert the destruction or adverse modification of critical habitat.

recruitment: Survival of young plants and animals from birth to a life stage less vulnerable to environmental change.

release: The portion of the discharge from a lake or reservoir that supplies identified demands (for diversions, storage, instream flow, flood control). Expressed in cfs.

reptile: Coldblooded vertebrate of the class Reptilia, comprised of turtles, snakes, lizards, and crocodiles.

reservoir: Artificially impounded body of water.

reservoir storage capacity, conservation: The total volume within a reservoir specifically set aside for a project (for example, the Carlsbad Project can store up to a certain amount of water in a reservoir for its irrigation purposes).

reservoir storage capacity, total: The total volume of water that can be stored in a reservoir.

resident: A wildlife species commonly found in an area during a particular time; summer, winter, or year round.

residual: The difference between the measured and predicted values of some quantity.

resource indicator: A particular measure of a resource used to assess impacts on the overall resource.

return flow: The water that reaches a ground or surface water source after release from the point of use and thus becomes available for further use.

riparian: Of, on, or pertaining to the bank of a river, pond, or lake.

riparian corridor: River and streams with their associated vegetation.

riverine: Pertaining to a river.

rodents: Small mammals with incisors such as mice, squirrels, and beavers.

roost site: Place where a bat or bird will rest during the day or night, typically protected from weather and predators.

runoff: The discharge of incident precipitation that occurred over a land area or water which travels over the ground surface to a channel (or other water collection structure). That part of precipitation that appears in surface streams. Runoff contributes to streamflow, groundwater, lakes, and reservoir storage.

S

sacred site: See Executive Order 13007. Any specific, discrete, narrowly delineated location on Federal land that is identified by an Indian tribe or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, an Indian religion; provided that the tribe or appropriately authoritative representative of an Indian religion has informed the agency of the existence of such a site.

saline: Bodies of water which have excessive or high salt concentrations.

salinity: A measure of the quantity of the total dissolved solids or salts in water.

scour: Water forces removing debris and sediments from a channel.

sediment: Unconsolidated solid material that comes from weathering of rock and is carried by, suspended in, or deposited by water or wind.

self-sustaining: Maintaining a population of organisms by natural means.

significance: CEQ Guidance, 43 CFR section 1508.27, explains that significantly requires considerations of the context of the action (society as a whole, the affected region, affected interests, and locality) and intensity (the severity of impact).

site: In archeology, any location of past human activity.

slough: An inlet or backwater swamp, bog, or marsh. In the Southwest, it tends to be synonymous with a wash.

snag: A standing dead tree.

soil sodicity: The presence of excess sodium.

spawn: To lay eggs, especially in reference to fish.

special status species: Rare animal and plant species that have been identified by Federal or State agencies as needing protective measures. Special status species as defined and used in this document, include the following:

- Plant and animal species listed as federal threatened or endangered under provisions of the Endangered Species Act of 1973, as amended (ESA).
- Plant and animal species proposed for listing as federal threatened or endangered under the ESA with the proposed listing published in the Federal Register.
- Animal species listed as state endangered or threatened under provisions of New Mexico Statutory Chapter 17, Article 2:17-17-2-37 through 17-2-46.
- Plant species listed as state endangered under provisions of New Mexico Statutory Chapter 75, Article 6: 17-6-1.
- Species designated as sensitive or species of concern by State and/or Federal management

spill: Water that is released from a reservoir, either inadvertently or through precautionary releases, in excess of that required to compensate for system losses and to meet irrigation demand.

stock: See strain.

storage: The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel. See “reservoir capacity.”

strain: A genetically distinct group of fish maintained as a self-sustaining, interbreeding population with definable characteristics, through either artificial or natural production (also called stock).

stranding: The isolation of an organism out of its original habitat, generally caused by an event such as high flows which then decline, intermittent streamflows, changes in habitat, or other event.

stratification: The formation of separate layers in a lake or reservoir. In thermal stratification, cold water, which is denser than warm water, sinks, forming a layer at the bottom. In salinity stratification, saline water (which is denser than fresh water) forms a layer at the bottom.

streamflow: Water flowing within the bounds of a channel (mostly natural channels). Contributing components of streamflow include tributaries from other streams, baseflow (from groundwater), surface runoff, and direct precipitation.

T

terrestrial: Growing or living on land.

thermocline: Boundary layer in a lake in which the temperature changes sharply with depth.

threatened species: Any species which could become endangered in the near future.

threshold of significance: A quantitative or qualitative standard, or set of criteria, pursuant to which the significance of a given environmental effect may be determined.

tilth: Physical condition of the soil in respect to its fitness for the growth of a specific crop.

topographic: Measuring and displaying on maps of physical surface features such as rivers, mountains, or roads.

total dissolved solids (TDS): The total concentration of solids (or salts) dissolved in water. Specific conductance is a surrogate measure of dissolved solids. This value is an aggregate of carbonates, bicarbonates, chlorides, sulfates, phosphates, calcium, magnesium, manganese, sodium, potassium, and other cations that form salts in water.

total storage: The volume of a reservoir below the maximum controllable storage, including dead storage.

traditional cultural property: A site or resource that is eligible for inclusion in the *National Register of Historic Places* because of its association with cultural practices or beliefs of a living community.

transient: A wildlife species not commonly found in an area but which may occasionally pass through.

transmission depletion: Water that is lost, generally to seepage to the ground and/or evaporation from the water surface, when water is transported downstream.

transmission efficiency: The ratio of the amount of water that reaches the (downstream) endpoint to the amount of water that was released at the (upstream) starting point.

transpiration: The process by which water is absorbed by plants, usually through the roots, and is evaporated into the atmosphere from the plant surface, usually from the leaves.

trophic: Of or pertaining to nutrition.

trophic dynamics: Nourishment dynamics of the various segments of the food chain.

tributary: River or stream flowing into a larger river or stream.

turbidity: The measure of how much the water scatters light; it is due to both the amount and shape of suspended solids.

U

unconfined aquifer: An aquifer containing water that is not under pressure; the water level in a well is the same as the water table outside the well. An aquifer that discharges and recharges with an upper surface that is the water table.

upper critical habitat: Upper portion of critical habitat for Pecos bluntnose shiner; 64 miles long, from the Taiban Creek confluence downstream.

V

vertebrate: An animal having a segmented backbone or vertebral column. Includes mammals, birds, fish, amphibians, and reptiles.

W

"watch list" species: A U.S. Forest Service term to indicate plant species of limited distribution.

water quality standard: In water quality regulations, waters are assigned specified uses, such as municipal, irrigation, etc. Each use has various water quality criteria associated with it. When a water body or river reach is assigned a specified use, the criteria become water quality standards for that water body or river reach.

water table: The depth below which the ground is saturated with water.

water year: Period of time beginning October 1 of one year and ending September 30 of the following year and designated by the calendar year in which it ends.

wet hydrologic condition: Effective Brantley storage is greater than 110,000 acre-feet.

wetland habitat: Habitat provided by shallow or deep water (but less than 6 feet deep), with or without emergent and aquatic vegetation in wetlands.

wetlands: Lands transitional between aquatic and terrestrial systems where the water table is usually at or near the land surface or the land is covered by shallow water. Often called marshes or wet meadows.

PENDING

Attachment

Biological Assessment of Proposed Carlsbad Project Water Operations and Water Supply Conservation