Chapter 4

Environmental Consequences

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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, biological resources, 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 attributable to wind and temperature; seepage; riverbed forms and substrate; local geology affecting surface and ground water systems; diversions from both surface water 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 initial input reservoir storages and reach flows for the Pecos River RiverWare surface water model. Initial model conditions describe the state of the modeled environment at the beginning of the simulation period (60 years). "Inflow" and "outflow" initial reach flows describe the respective upstream or downstream flow condition in the model simulation for a model reach segment. 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 ground water levels, 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 Santa Rosa Reservoir to Puerto de Luna reach	0 cubic feet per second (cfs)
	Inflow in the Sumner Lake to Taiban reach	17 cfs
	Inflow in the Taiban to Near Dunlap reach	13 cfs
	Inflow in the Near Dunlap to Near Acme reach	11 and 8 cfs
	Outflow in the Near Acme to Hagerman reach	10 cfs
	Outflow in the Hagerman to Lake Arthur reach	6 cfs
	Outflow in the Lake Arthur to Near Artesia reach	60 cfs
	Outflow in the Near Artesia to Kaiser Channel reach	60 cfs
	Inflow in the Brantley to Dam Site 3 reach	20 cfs

[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 was developed for use in this environmental impact statement (EIS) 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 EIS, 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 (Red Bluff Accounting Model). (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], 2003b, 2003c, 2003d; 2003e; Barroll, et al., 2004; Tetra Tech, Inc., 2000a, 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. Computer models can capture important processes and parameters and can provide valuable predictions, but can rarely, if ever, represent physical conditions fully. Three key assumptions involve the following: (1) computed transmission losses because of 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 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 on the basis of average historical conditions. As with all hydrologic models, a database of many

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 EIS, 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.

hydrologic parameters, such as streamflows and reservoir water levels, was assembled and used to build this model. 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 and ground water levels, so the model results also would include the same uncertainty as the respective databases used to create these models. The most prudent use of the modeled results in this document would be to compare between and among the alternatives and baseline only. The results cannot be used to exactly predict future conditions and are not intended for actual implementation.

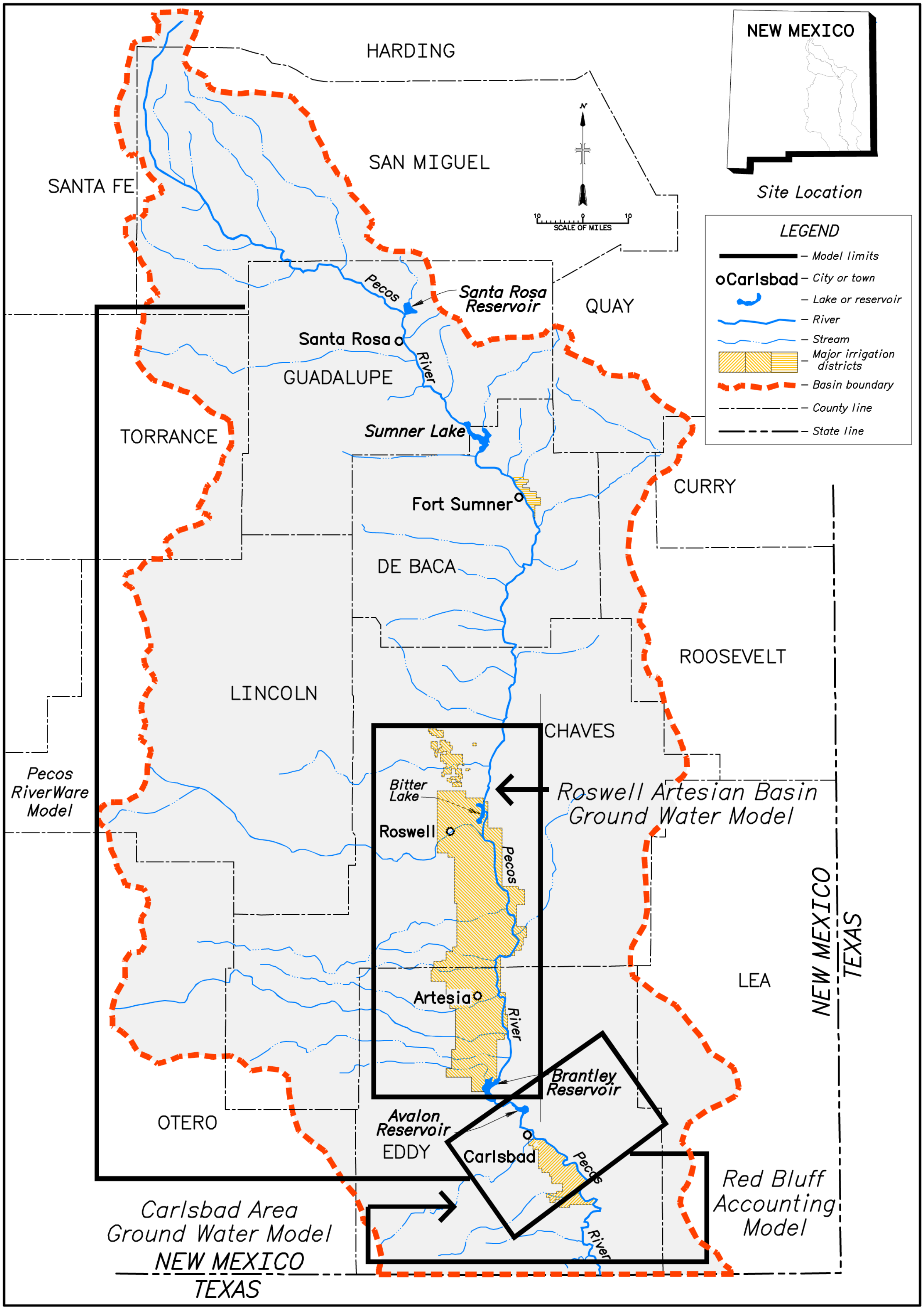
1.2.2 Results for Specific Locations Along the River

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 and reservoir storages at the four major reservoirs in the study area (also shown on map 2.1). 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 because of 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



Map 4.1 Pecos River Decision Support System (PRDSS)

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 diversions replicate an average diversion record on the basis of 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.

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 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. The importance of those variations in results for each resource is discussed in each resource section, along with how best to interpret the results presented.

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 from 1940 to 1999**. 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 because of 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.

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 CPWA or AWA options. In the case of recreation, the interest is predominantly on expected changes to reservoir water 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 also were 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 important 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 water levels. Model results were used to evaluate whether flows would be sufficient to conserve and protect the shiner and, specifically, to review the expected occurrence of intermittency (river drying or 0 cubic feet 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 water 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
- Pecos River Compact (Compact) delivery obligation
- 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.

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 shiner. The pre-1991 baseline was used primarily to compare resource indicators to a period when operations were focused on operating the Pecos River system for maximum irrigation 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.

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**
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**
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 the 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**

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.

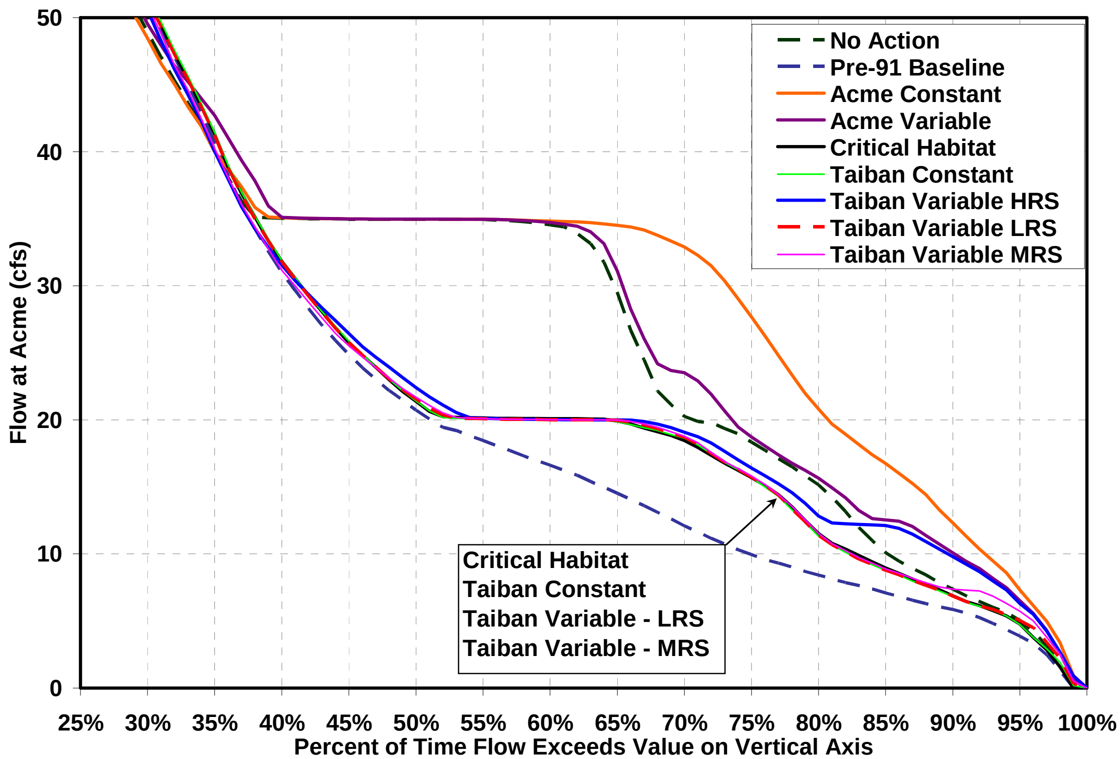


Figure 4.1 Flow exceedance curves under each alternative at the Near Acme gage.

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 always available for bypass flows; consequently, the flow frequency is 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 illustrated by flow exceedance curves for the Acme Constant and Taiban Constant Alternatives, 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. 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 for all the alternatives only indicate intermittency in the 1951 to 1981 model period. In that period, modeled intermittency events range from occurring 6 years out of 30, under the Taiban Variable high-range summer (HRS; 55 cfs) and Acme Constant Alternatives, to occurring 11 years out of 30 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

[1] The USGS gage Below Taiban Creek Near Fort Sumner is referred to as the Taiban gage in this document.

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 caused primarily 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 practices in CID, 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.

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., 2003a, 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 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 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.

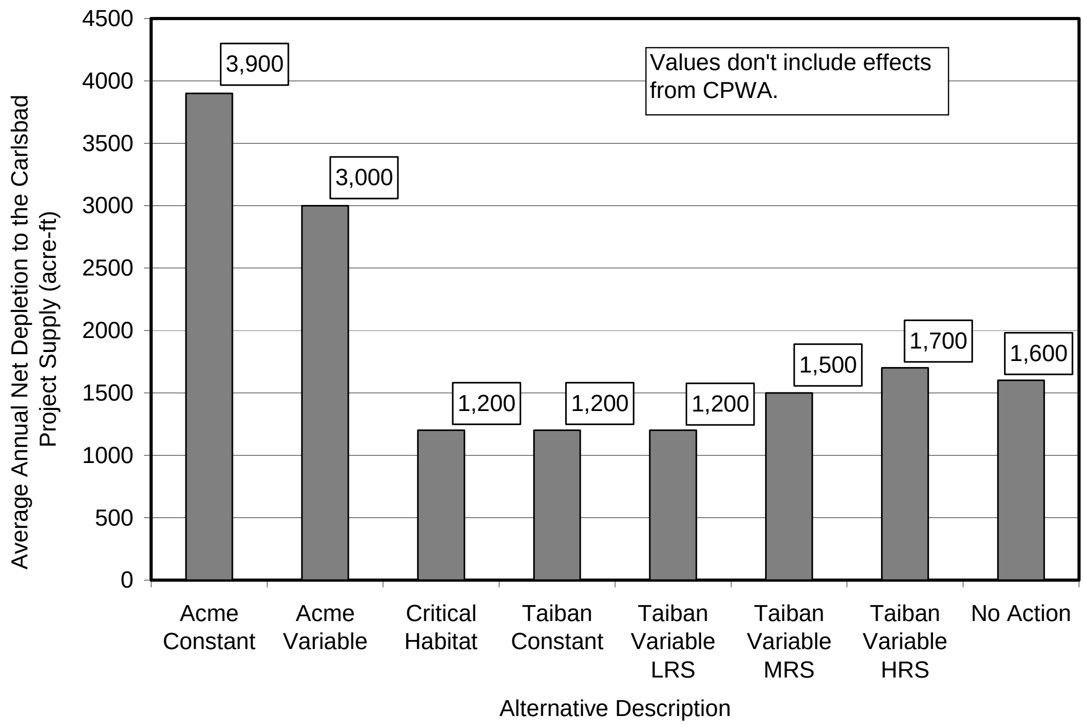


Figure 4.2 Average annual net depletions to the Carlsbad Project water supply under each alternative without CPWA.

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).

Changes to New Mexico's delivery obligation under the Pecos River Compact are shown in figure 4.4. These average annual values are based on application of each alternative's Sumner Dam releases to the Compact's inflow-outflow relationship. Effects of modified Sumner Dam releases were quantified for each alternative. Additional effects resulting from implementation of a fish conservation pool (FCP) and/or AWA options were not quantified but are mentioned briefly in the appropriate section(s) dealing with those options.

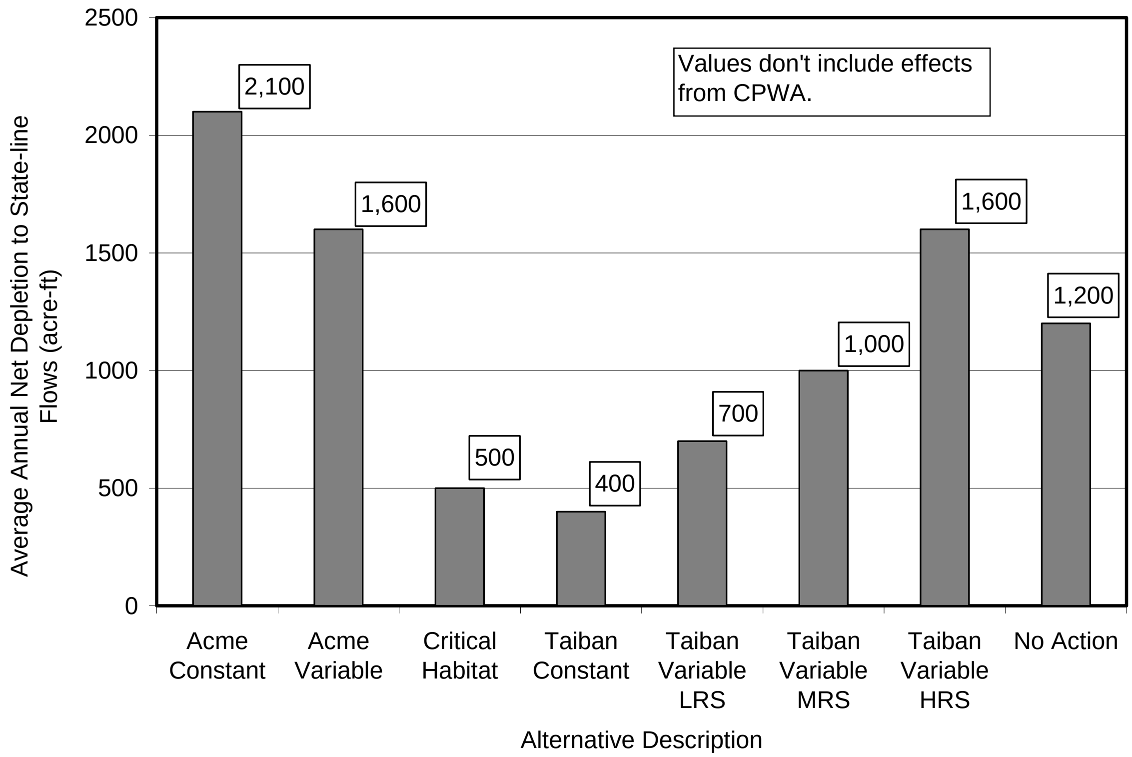


Figure 4.3 Average annual net depletions to State-line flows under each alternative without CPWA.

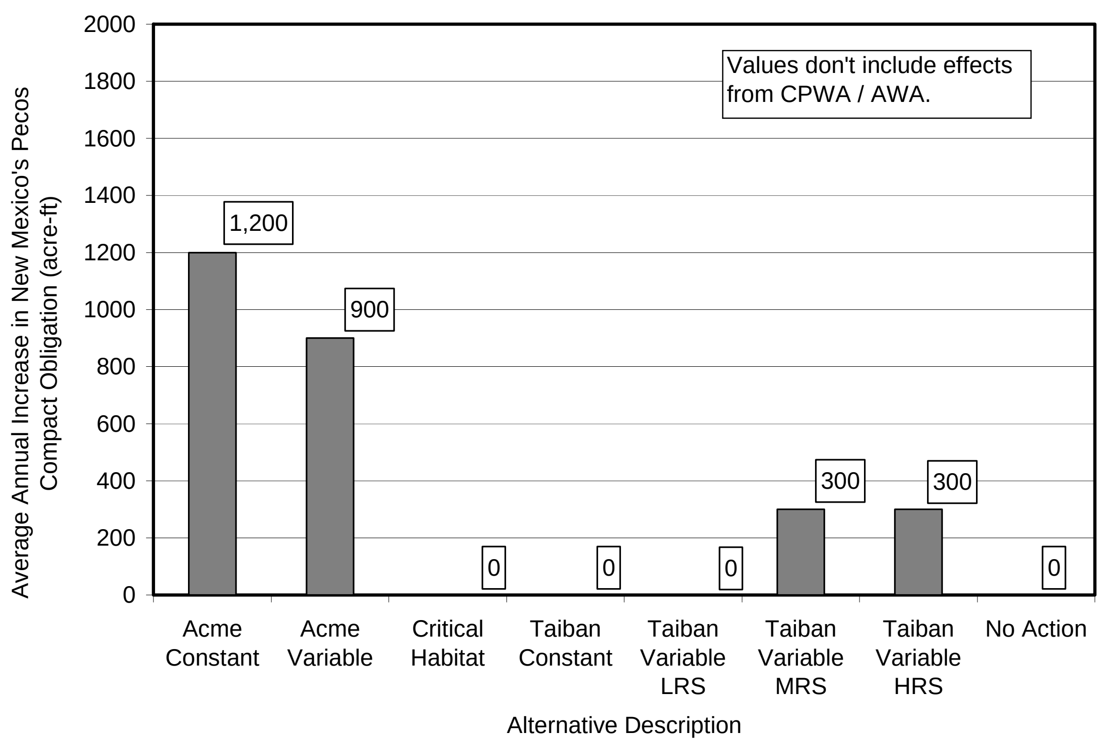


Figure 4.4 Average annual increase in New Mexico’s Pecos River Compact delivery obligation without CPWA or AWA.

Changes to Pecos River Compact Delivery Obligation

Changes in the volume of water released from Sumner Dam will directly affect New Mexico's Compact delivery obligation. The delivery obligation is a function of four hydrologic indices: three flood inflow estimates based on gage data, plus Sumner Dam releases. These inflows are applied to an empirically derived relationship in order to compute New Mexico's delivery obligation. Average total releases from Sumner Dam are likely to increase as additional water is released or bypassed to meet the flow targets specified in the alternatives. Additionally, it is possible that AWA activities would include water sources upstream of Sumner Dam. These waters would be passed through the dam and would become part of the Sumner Dam release used to calculate the delivery obligation.

To mitigate the effects of 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 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 support the economics work in section 7 of this chapter. In addition to water acquisition options for reducing net depletions, AWA options were reviewed to identify those that would directly augment flows in critical habitat for the shiner (Tetra Tech, Inc., 2005b). An analysis of 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 also were 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 4.5 demonstrates this relationship for net depletions to the Carlsbad Project water supply. In the figure, representative target flows at the Near Acme gage 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).

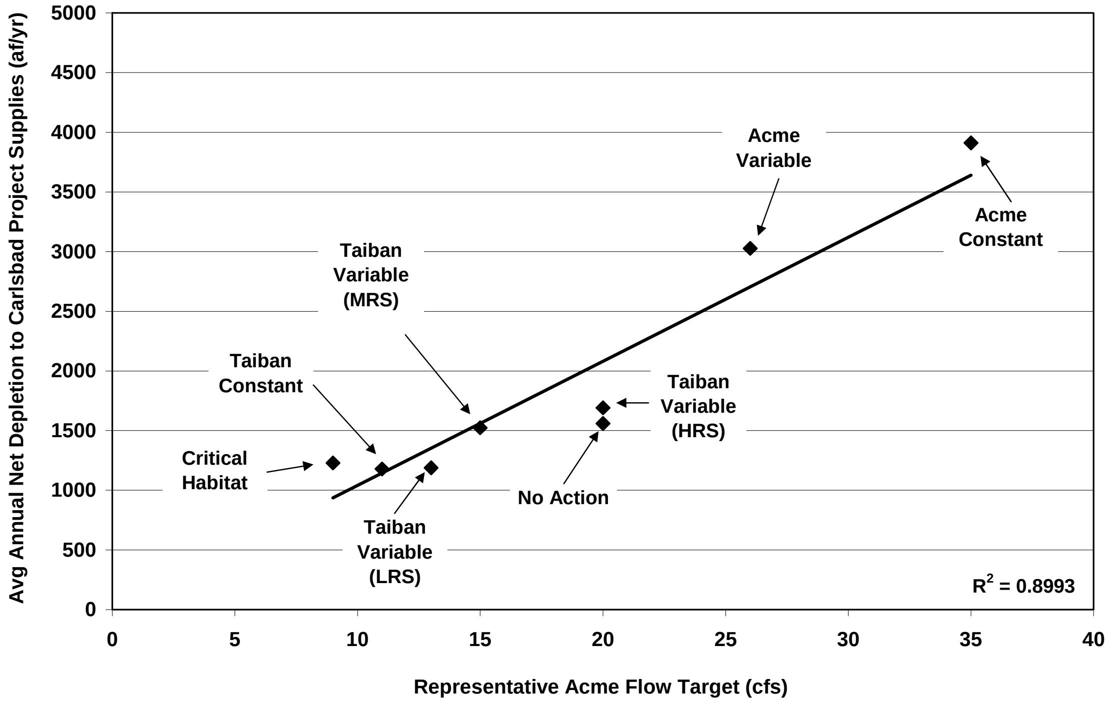


Figure 4.5 Relationship between net depletions to the Carlsbad Project water supply and representative target flows under each alternative with no CPWA.

Taiban gage target flows were converted to representative Near Acme gage target flows using average loss relationships developed for the RiverWare model. As figure 4.5 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 completely attributable to the lack of available inflows to bypass for the shiner during the irrigation season, and the greatest positive change to flow frequency and intermittency is in the nonirrigation season when available inflows are always plentiful. Differences in the frequency of intermittency among the alternatives are quite small and may be considered negligible.

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, 2004; HRC, 2005b).
- Simulation of alternatives with CPWA water added (Tetra Tech, Inc., 2005a; HRC, 2005c)

- Estimation of AWN (Tetra Tech, Inc., 2004b; 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 (1940-99). 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 on the basis of 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., 2003a). The total amount

[1] Water available for bypass is that amount flowing into Sumner Lake that exceeds the downstream diversion right of FSID.

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.

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 (For example, the average annual amount shown in table 4.2 under No Action is 2,900 acre-feet per year). 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 (AWA options and their respective annual estimated available amounts are shown in table 2.5 in chapter 2.)

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.

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 4.6 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

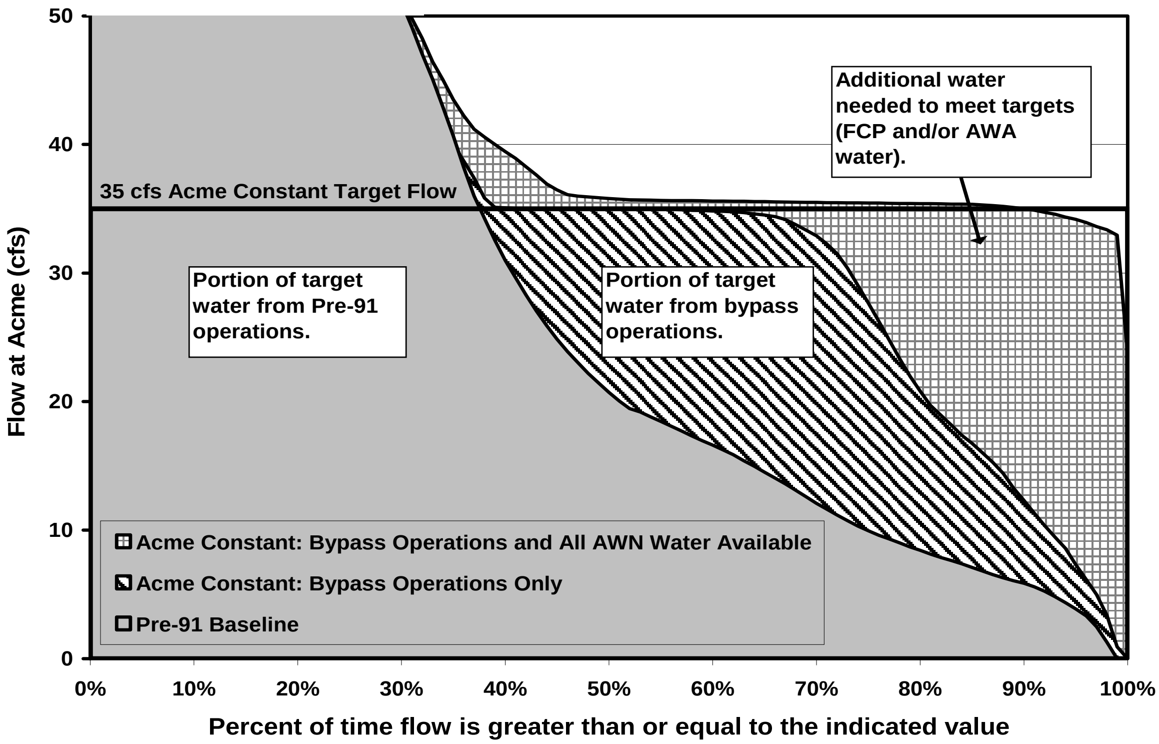


Figure 4.6 Flow exceedance curves resulting from bypass flows and AWN (example: constant target flows of 35 cfs) at the Near Acme gage.

inflows above FSID's diversion right would substantially augment flows at the Near Acme gage as compared to the pre-1991 baseline. Additionally, as shown on figure 4.6, 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 4.6 that was augmented by the AWN above the target flows of 35 cfs. An 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.

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; 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 a well field developed near Fort Sumner, 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 nearly 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). Table 4.2 presents modeled values for water resources indicators under the No Action Alternative and pre-1991 baseline. Targets for augmenting flows in critical habitat for the shiner are between the extremes that were analyzed for other alternatives. 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 gage over the 60-year period (0.94 percent of the time). 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 resulting average annual net depletions to the Carlsbad Project (1,600 acre-feet per year) and State line flows (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 in the reach from Sumner Lake to Brantley Reservoir is 5,400 acre-feet per year, and the maximum annual net depletion to State-line flows is 3,000 acre-feet per year. This alternative has no long-term average affect on Compact obligations.

The level of flow augmentation is depicted by the flow exceedance curves presented in figure 4.7**,** 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. Additional hydrology results, analyses, and method descriptions are shown in the Hydrologic and Water Resources Appendix (appendix 3, sections A through G; Briggs, 2004; HRC, 2005b, 2005c; Tetra Tech, Inc., 2005a, 2005b, 2005c).
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), because of 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 attributable 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 attributable to bypass operations specified by an alternative. Bypassing inflows through the reservoirs saves water from evaporating. Note that the average annual bypass minus the average annual saved evaporation results in the annual average reduction in block release volume.

How to Read the Summary Tables – Part II

- Water lost to additional conservation spills: the additional annual average volume of water that spilled from the reservoirs attributable to an alternative and, subsequently, becomes unavailable for use in the Carlsbad Project.

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—between Sumner Lake and Brantley Reservoir: 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 primarily caused by bypass operations.

- Maximum additional transmission loss—between Sumner Lake and Brantley Reservoir: the maximum annual amount of additional water lost in transit between Sumner Lake and Brantley Reservoirs attributable to an alternative's bypass operations. This modeled maximum is only attributable to the effects of bypass operations. The modeled year this maximum occurred appears in the next column to the right.

- Minimum additional transmission loss—between Sumner Lake and Brantley Reservoir: the minimum annual amount of additional water lost in transit between Sumner Lake and Brantley Reservoir because of an alternative's bypass operations. This modeled minimum is only because of 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. Methods for computing net depletions to State-line flows are shown in the Hydrologic and Water Resources Appendix (appendix 3; section E; HRC, 2005c). 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 attributable 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 attributable to an alternative.

- Water gained from additional conservation spills: water that contributes to State-line flows from additional conservation spills attributable 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 attributable 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 attributable 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 attributable 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)	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

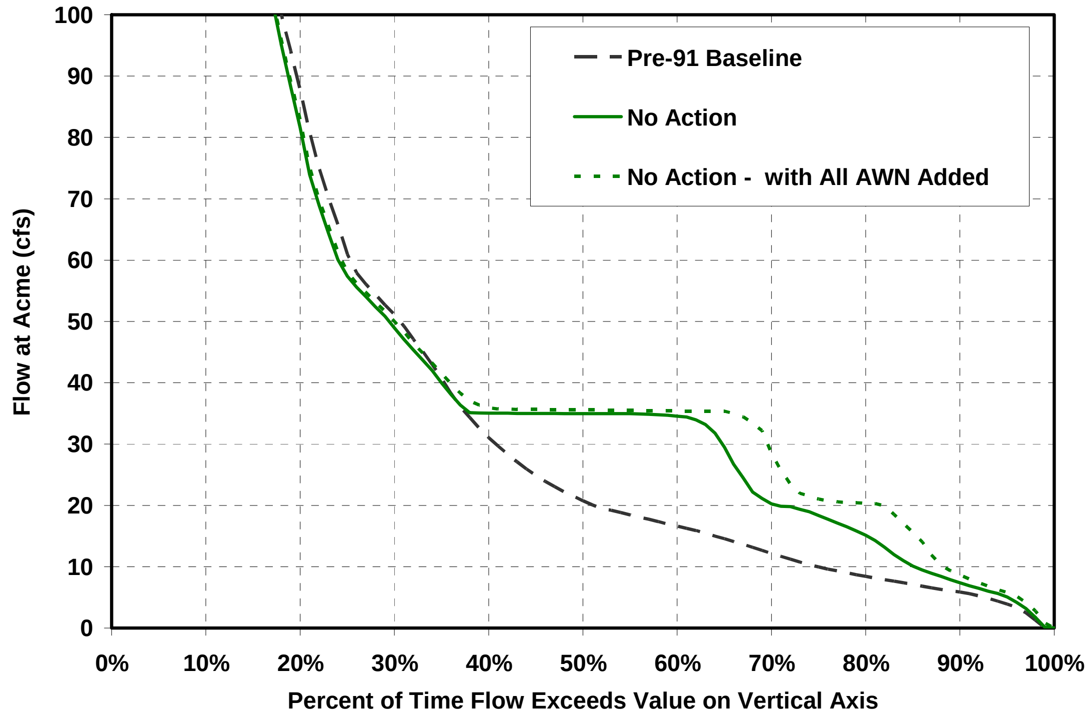


Figure 4.7 Impact of No Action Alternative on flows at the Near Acme gage.

3.3.2 Taiban Constant Alternative

Table 4.3 presents modeled values for water resources indicators under the Taiban Constant and No Action Alternatives and pre-1991 baseline. 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 period). 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. For the Taiban Constant Alternative, 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. 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 net 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. Annual average net depletions to the Carlsbad Project water supply and to State-line flows do not exhibit the same trend for the Taiban Constant, Critical Habitat, and Taiban Variable (40 cfs) Alternatives because the annual average conservation spills for each of these alternatives differ. The maximum annual additional transmission loss in the reach from Sumner Lake to Brantley Reservoir is 1,700 acre-feet per year, and maximum annual net depletions to State-line flows are 4,000 acre-feet per year. This alternative has no long-term average effect on Compact delivery obligations.

Figure 4.8 presents flow exceedance curves at the Near Acme gage. Modeled flow exceedance results at the Taiban gage (not shown in figure 4.8) indicate that the target flow of 35 cfs is met 92 percent of the time.

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

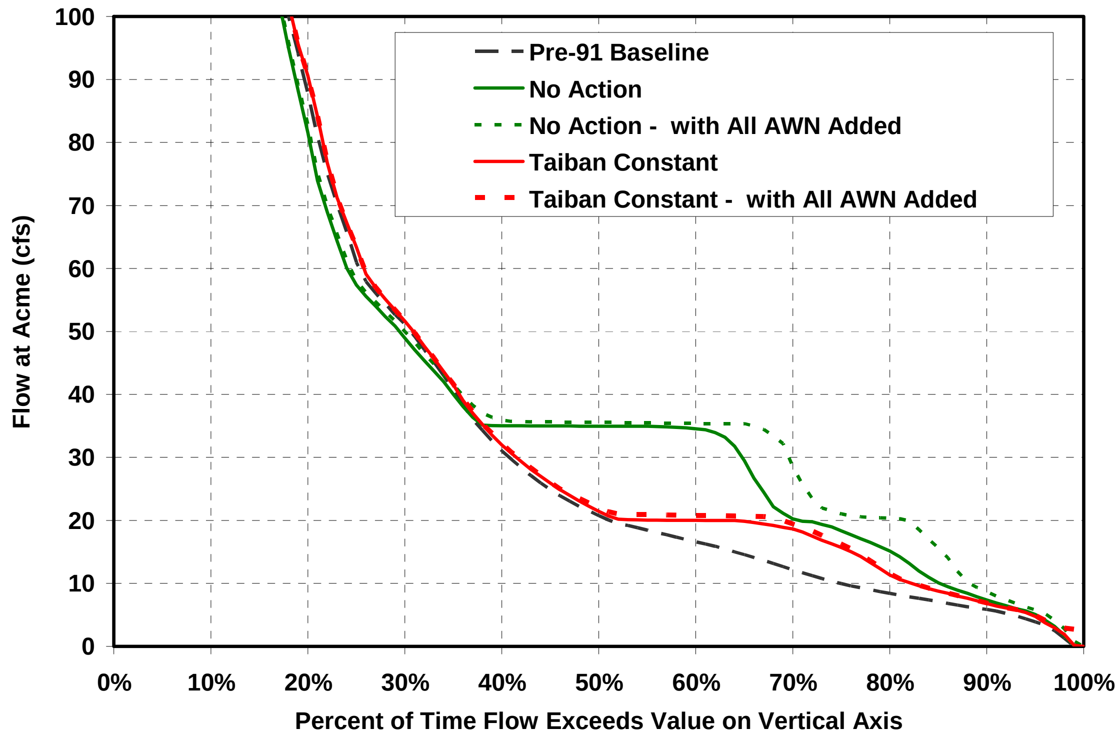


Figure 4.8 Impact of Taiban Constant Alternative on flows at the Near Acme gage.

3.3.3 Taiban Variable Alternative

The Taiban Variable Alternative has three formulations of target flows at the Taiban gage during the irrigation season: low-range summer (LRS or 40 cfs), mid-range summer (MRS or 45 cfs), and high-range summer (HRS or 55 cfs). Table 4.4 presents modeled values for water resources indicators under the Taiban Variable and No Action Alternatives and the pre-1991 baseline. 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 period with target flows of 40 cfs; 0.80 percent (176 days) with target flows of 45 cfs; and 0.63 percent (137 days) with target flows of 55 cfs. 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. 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 in the reach from Sumner Lake to Brantley Reservoir of 3,700 acre-feet per year. The average additional transmission loss for all the reaches combined ranges from 1,200 to 2,500 acre-feet per year, and the annual average amount of water lost to spills ranges from 210 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.

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

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 transmission loss (all reaches; acre-feet per year)	Saved evaporation (all reservoirs; acre-feet per year)	Water lost to additional conservation spills (acre-feet per year)	Average additional transmission loss (acre-feet/ 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 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

Table 4.4 Summary of impacts on water resources indicators for the Taiban Variable 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
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

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.

This alternative ranges from no long-term average effect on Compact obligations for the low-range target (40 cfs) to a 300-acre-feet average annual increase on Compact obligations for the high-range target (55 cfs).

Figures 4.9 through 4.11 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 to 100-percent frequency range.

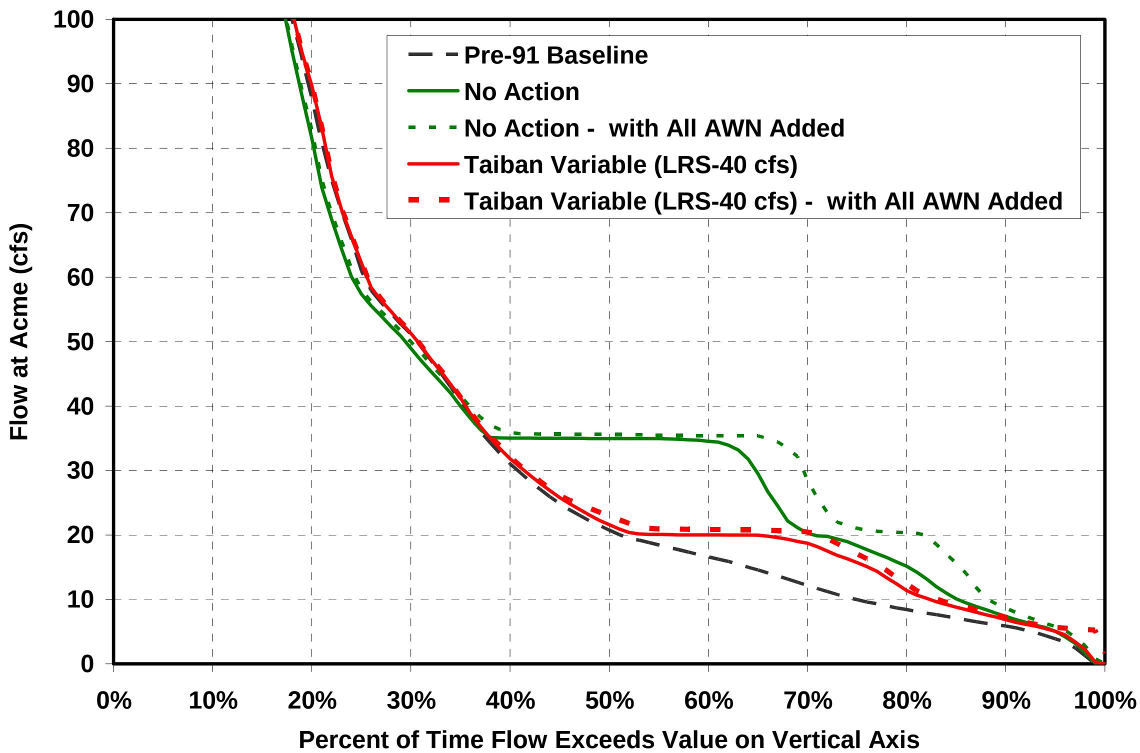


Figure 4.9 Impact of Taiban Variable Alternative (40 cfs) on flows at the Near Acme gauge.

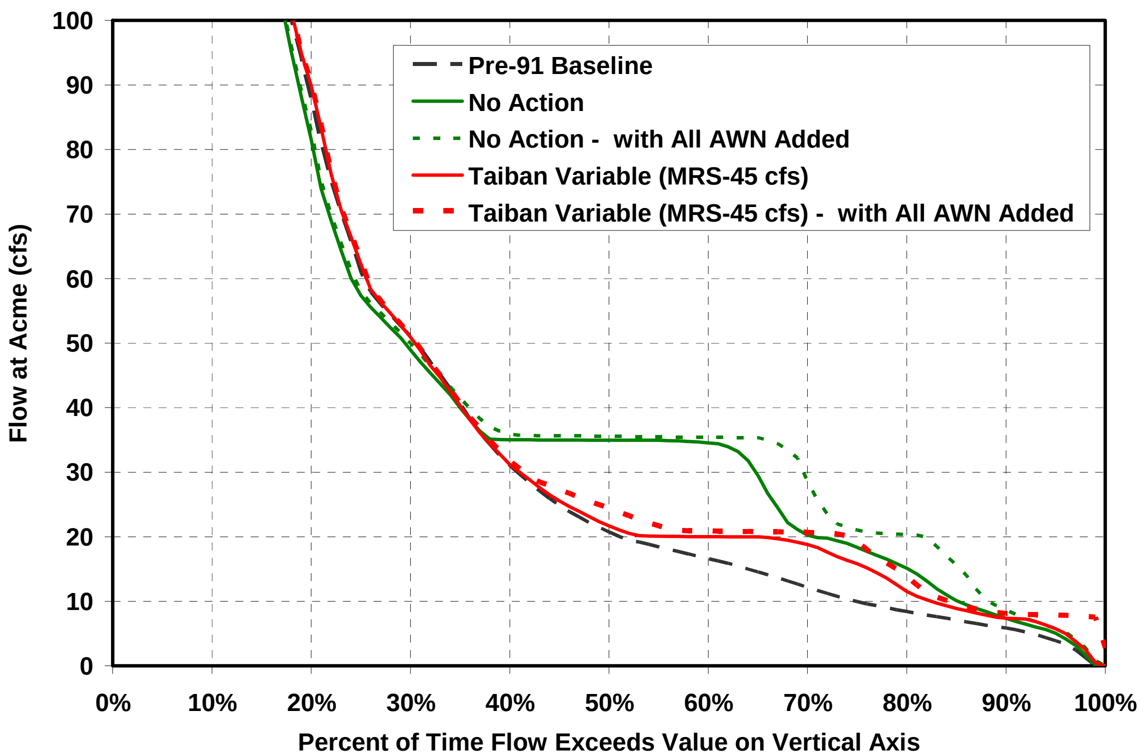


Figure 4.10 Impact of Taiban Variable Alternative (45 cfs) on flows at the Near Acme gage.

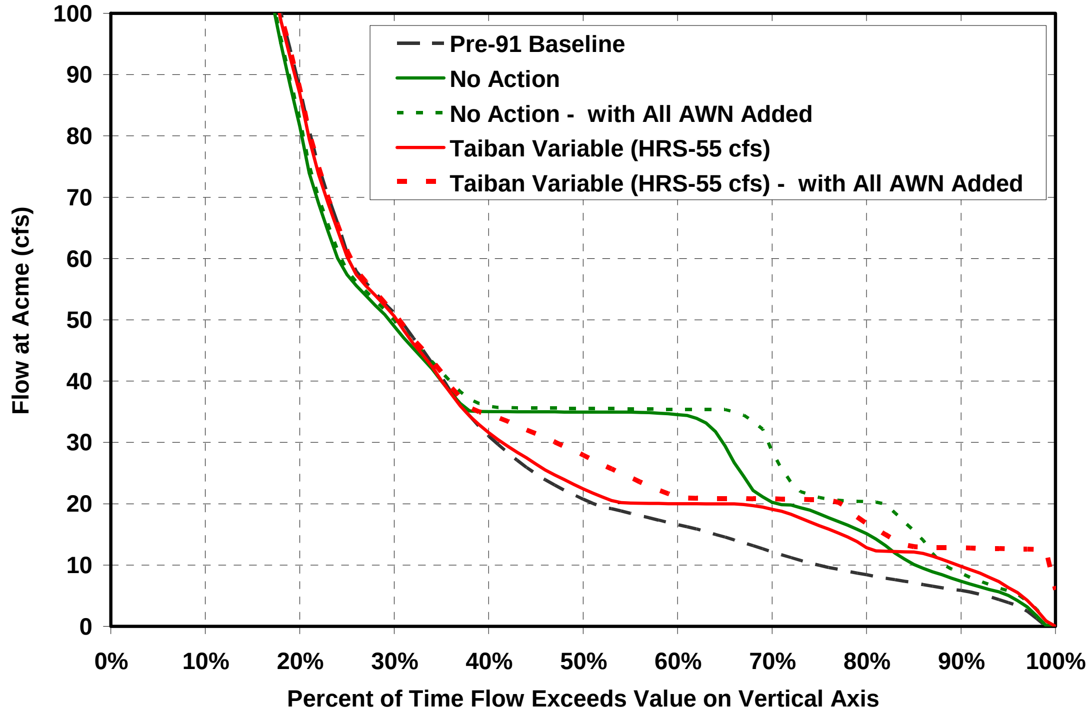


Figure 4.11 Impact of Taiban Variable Alternative (55 cfs) on flows at the Near Acme gage.

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. Table 4.5 presents values for water resources indicators under the Acme Constant and No Action Alternatives and the pre-1991 baseline. Model results show 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 period (0.67 percent of the time). 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 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. 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 maximum annual transmission loss in the reach from Sumner Lake to Brantley Reservoir (6,900 acre-feet per year) and maximum net depletions to State-line flows (5,400 acre-feet per year) are also greater than under any other alternative. This alternative increases the average annual Compact Obligation by 1,200 acre-feet.

Figure 4.12 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)	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

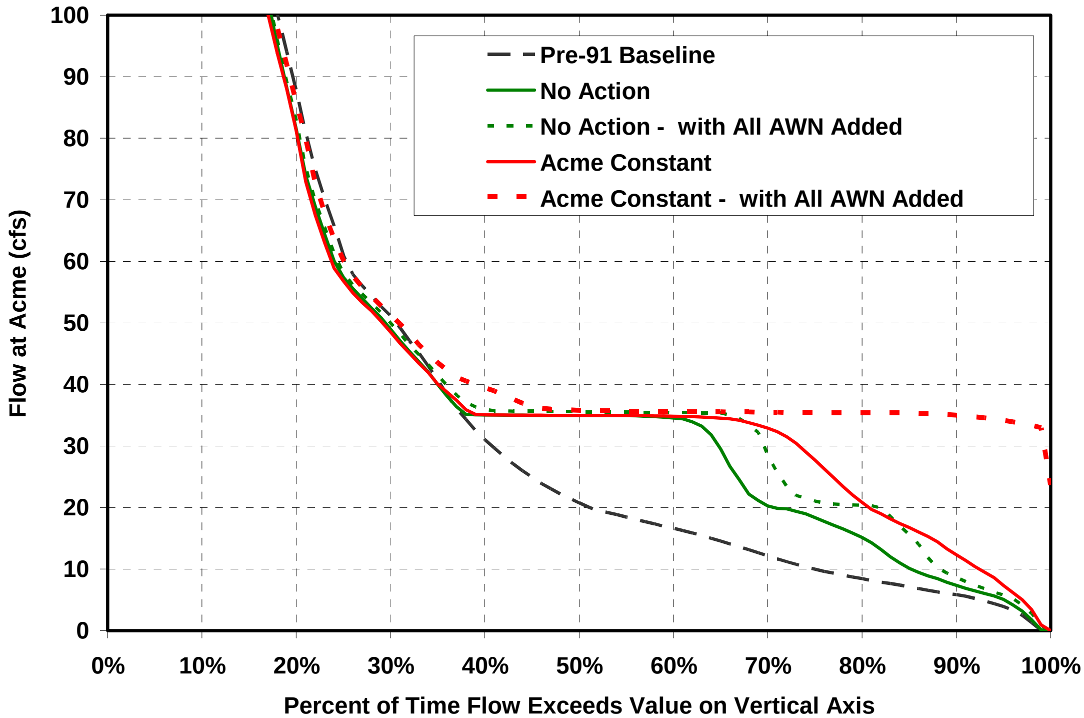


Figure 4.12 Impact of Acme Constant Alternative on flows at the Near Acme gage.

3.3.5 Acme Variable Alternative

The Acme Variable Alternative includes different target flows depending on hydrologic condition (wet, average, or dry). Table 4.6 presents modeled values for water resources indicators under the Acme Variable and No Action Alternatives and the pre-1991 baseline. Model results show that compared to the pre-1991 baseline and No Action Alternative, intermittency occurs less frequently under the Acme Variable Alternative (150 days for the 60-year 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. 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 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. 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 in the reach from Sumner Lake to Brantley Reservoir is 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 Compact obligation is 900 acre-feet greater under this alternative.

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)	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 4.13 presents flow exceedance curves. The distinct “stair-steps” evident in these flow exceedance curves illustrate the effect of the different target flows.

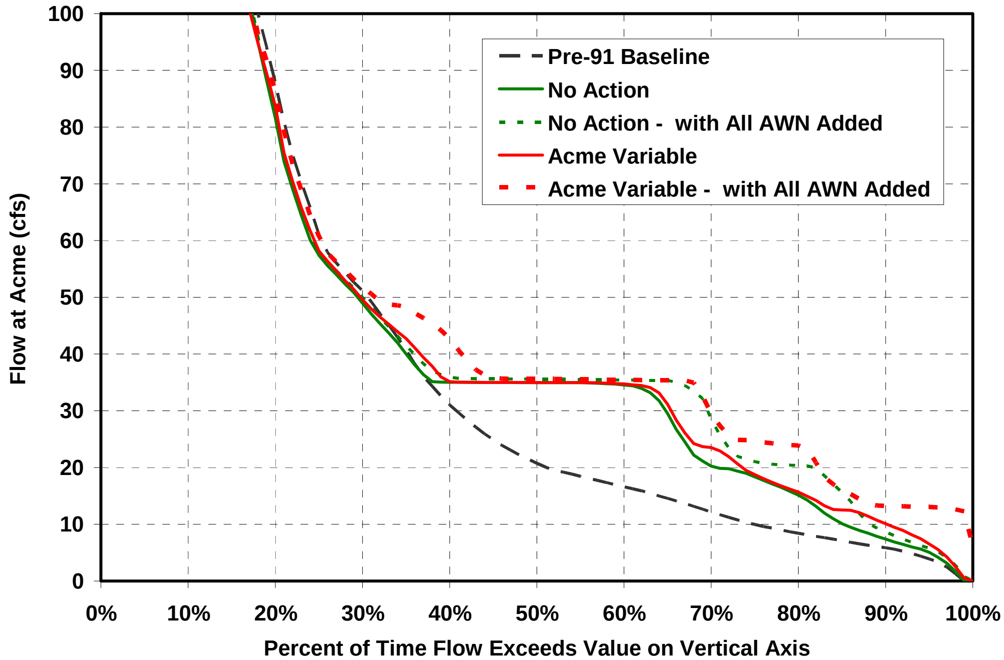


Figure 4.13 Impact of Acme Variable Alternative on flows at the Near Acme gage.

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. Table 4.7 presents values for water resources indicators under the Critical Habitat and No Action Alternatives and the pre-1991 baseline. Model results show that intermittency occurs more frequently under the Critical Habitat Alternative than under any other alternative (234 days for the 60-year period, or 1.00 percent of the time). The Critical Habitat Alternative shows the largest modeled intermittency of all the alternatives for two reasons: (1) 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 (2) 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. The average annual bypass volume for critical habitat 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 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 loss in the reach from Sumner Lake to Brantley Reservoir and the maximum annual depletions to State-line flows are 1,400 acre-feet and 4,000 acre-feet per year, respectively. This alternative has no long-term average effect on Compact obligations.

Figure 4.14 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 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
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

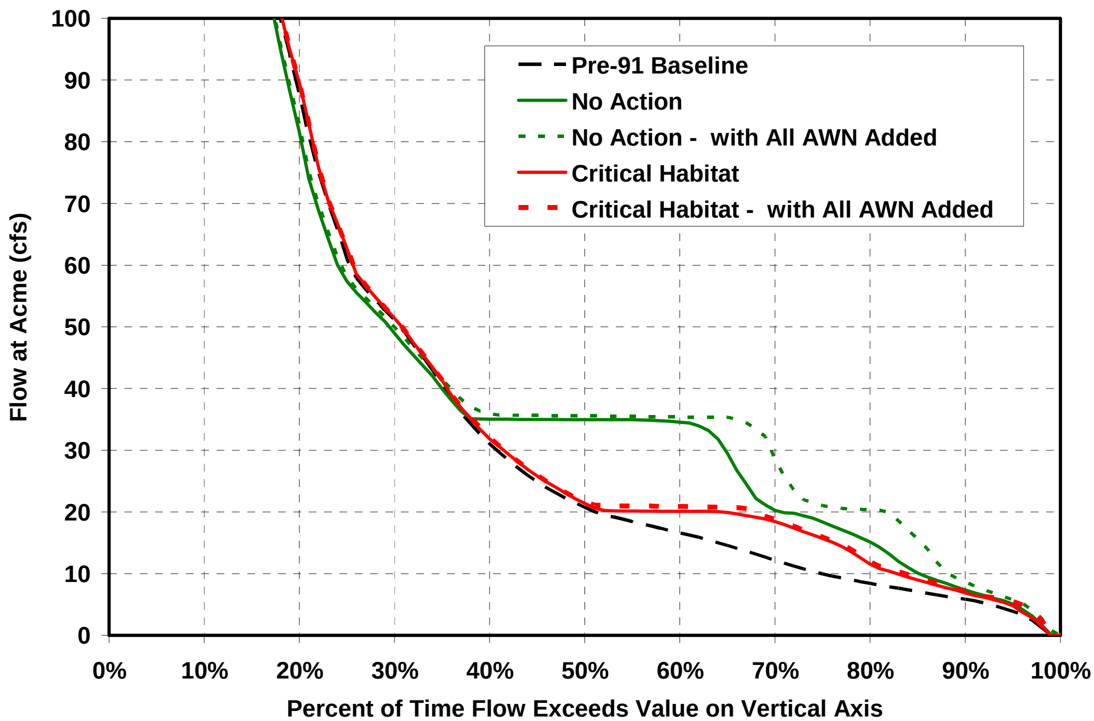


Figure 4.14 Impact of Critical Habitat Alternative on flows at the Near Acme gage.

3.4 Impacts of CPWA Options

This section presents efficiencies for CPWA options and a limited discussion about 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

CPWA Efficiencies

The effectiveness of Carlsbad Project water acquisition (CPWA) options is 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 the river until it reaches 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.

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 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. Also, note that CPWA options would decrease the amount of outflow from Sumner Dam (from the original alternative) and, subsequently, would decrease the Pecos River Compact delivery obligation resource indicator summarized for all the alternatives in figure 4.4. In some cases, such as for CPWA options combined with Taiban Constant, it may decrease the Compact delivery obligation below pre-1991 baseline levels.

Each water acquisition option had predetermined CPWA “available amounts” (chapter 2, section 7; appendix 2). 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 mitigate 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.

An average efficiency from all the alternative-CPWA option combinations for each CPWA option was used to calculate the amount of CPWA needed for each alternative. This average efficiency was used because it was the best general representation of the CPWA option’s performance with respect to all the alternatives, even though CPWA option modeling was confined to combinations with the Acme Constant and Taiban Constant Alternatives.

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. On the basis of the FSID return flow method developed for the RiverWare model, 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 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 because of 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. CPWA options from CID would be implemented by: (1) leasing or purchasing acreage or (2) replacing a portion of the crop consumptive use in CID equal to the amount of net depletions created by an alternative. (See section 3.4.6.) 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 because of 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 practices 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. Table 4.10 shows that for CID retirement, if net depletions to the Carlsbad Project were eliminated with a lease/purchase of CID water rights, then the net depletions to flows at the State line would be eliminated. The contrary is true for some 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. However, if cropping patterns were switched to very low use crops (approximately 0.7 acre-foot per acre), table 4.11 shows that State-line deliveries would benefit from using a very low water use alternative crop as a CPWA option to keep CID 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 table 4.11.

Table 4.11 CPWA analysis summary for changes to CID cropping patterns

<table>
<tr><th colspan="2">Estimate for available CPWA at source[1]</th><th colspan="4">6,000 to 10,500 acre-feet per year</th></tr>
<tr><td colspan="6">Modeled alternatives, reduced diversions and transit efficiencies to Brantley Reservoir from source (all alternative and forbearance volume permutations - acre-feet per year unless noted otherwise)</td></tr>
<tr><th colspan="2">CPWA parameter</th><th>Taiban Constant Alternative – very low water use replacement crop</th><th>Taiban Constant Alternative - medium water use replacement crop</th><th>Acme Constant Alternative - very low water use replacement crop</th><th>Acme Constant Alternative - medium water use replacement crop</th></tr>
<tr><td colspan="2">Curbed diversion compared to pre-1991 baseline[2]</td><td>14,000</td><td>5,200</td><td>14,000</td><td>5,200</td></tr>
<tr><td colspan="2">Transmission efficiency</td><td>100 percent</td><td>100 percent</td><td>100 percent</td><td>100 percent</td></tr>
<tr><td colspan="6">Average transmission efficiency to Brantley Reservoir from CPWA source: 100 percent</td></tr>
<tr><td colspan="6">Estimated CID source volume of CPWA required[3] (acre-feet)</td></tr>
<tr><th>No Action Alternative</th><th>Taiban Constant Alternative</th><th>Taiban Variable Alternative</th><th>Acme Constant Alternative</th><th>Acme Variable Alternative</th><th>Critical Habitat Alternative</th></tr>
<tr><td>1,600</td><td>1,200</td><td>1,200 to 1,700</td><td>3,900</td><td>3,000</td><td>1,200</td></tr>
</table>

Table 4.11 CPWA analysis summary for changes to CID cropping patterns

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 because of 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. In other words, the estimated available identified amount (20,000 acre-feet per year; appendix 2) was much greater than the amount needed to keep the Carlsbad Project whole (10,000 acre-feet per year or less) for any of the alternatives, so the option was scaled down to a more appropriate level (10,000 acre-feet per year) considering the net depletions to the Carlsbad Project water supply caused by the alternatives. The augmentation pumping schedule was determined on the basis of 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 is retired (uniformly from the entire basin), but the amount pumped to the river is lower (because of the lower bypass volume). As a result, the level of the water table rises, and a portion of the CPWA water is 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
CPWA parameter	**Taiban Constant Alternative: Seven Rivers**	**Taiban Constant Alternative: Buffalo Valley**	**Acme Constant Alternative: Seven Rivers**	**Acme Constant Alternative: Buffalo Valley**
Base inflow gain	3,700	3,400	3,400	1,700
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 because of 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

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
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 a well field developed near Fort Sumner
- 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 also were 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. 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 conveyed more efficiently 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. This AWA option may affect New Mexico's Compact obligation as it involves changes in the release pattern from Sumner Dam.

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

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 as shown in table 4.20 in columns 3 and 5. Model results indicate that the addition of 1,300 acre-feet more AWA water (i.e., from 3,000 to 4,300 acre-feet) slightly increases the Carlsbad Project water supply (to the nearest 100 acre-feet) under the Acme Constant Alternative and does not increase it under the Taiban Constant Alternative. These results are consistent with (1) the small amounts of added AWA and (2) the manner in which the water is conveyed (i.e., it is not conveyed in block releases, which is the most efficient manner). Table 4.20 summarizes the impacts for the Taiban Constant and Acme Constant Alternatives on net depletions to the Carlsbad Project water supply.

Table 4.19 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

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 Well Field Pumping

Model runs were conducted to evaluate whether flows in critical habitat for the shiner could be augmented further by pumping 1,800 acre-feet per year from a well field developed near Fort Sumner. (See chapter 2, section 10, "AWA Options," and section 11, "Detailed Description of AWA Options" for additional details.) 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 this AWA option on 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 300 acre-feet per year to augment riverflows, but this source would yield little water to the river. (See chapter 2, section 10, “AWA Options,” and section 11, “Detailed Description of AWA Options” for additional details concerning this option.) Tables 4.24 and 4.25 summarize the impacts of the AWA option on flow frequency and intermittency. 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 negligible 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. In addition, pumping from the pit would reduce local ground water storage in the FSID area because water accumulates in the pit from the local ground water system. Subsequently, local ground water levels and return flows from FSID also would be reduced (Duke Engineering and Services, 2000). 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 day)	4,100	200	1,100	-100
FSID gravel pit pumping (20 acre-feet per day)	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 evaluate specifically 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., 2003a). As shown on figure 4.15, 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 it would be with no limit. In other words, a 15-day limit on block releases only allows for filling Brantley Reservoir by approximately 30,000 acre-feet in a single block release. Conversely, the reservoir can be filled to the conservation limit of 40,000 acre-feet in a single block release with no limit on its duration. 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 4.16; 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 illustrated by the results shown in figure 4.17. The higher reservoir water 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.

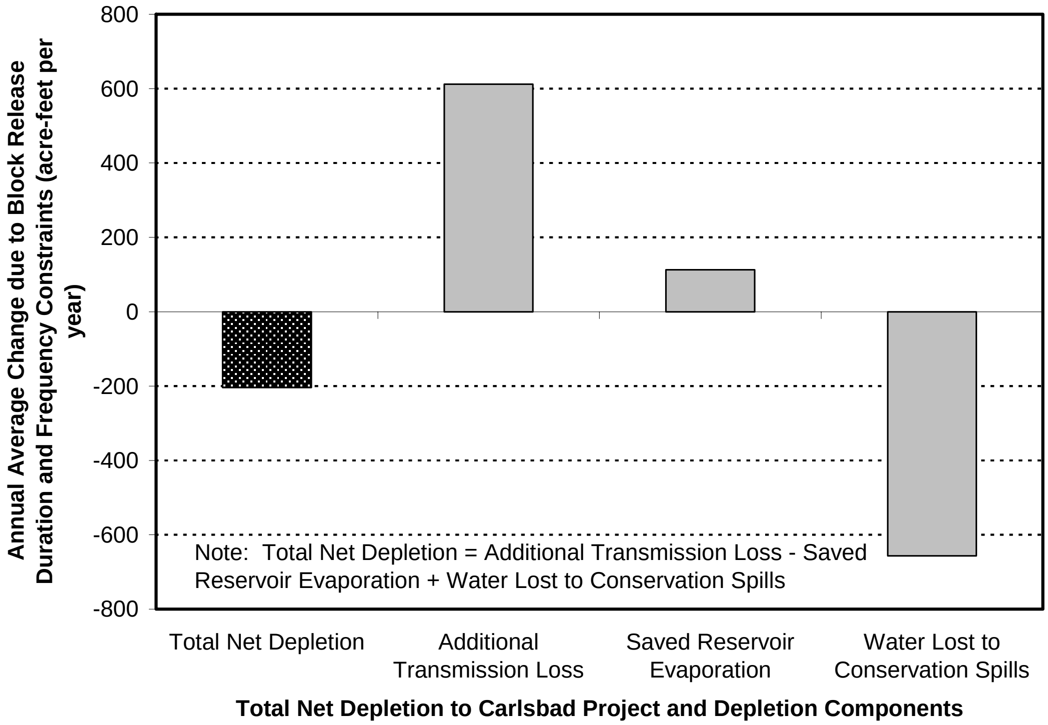


Figure 4.15 Effect of block release constraints (15-day limit on duration of block releases, 14 days in between block releases) on the Carlsbad Project water supply with pre-1991 baseline no bypass target operations (total net depletions and net depletion components).

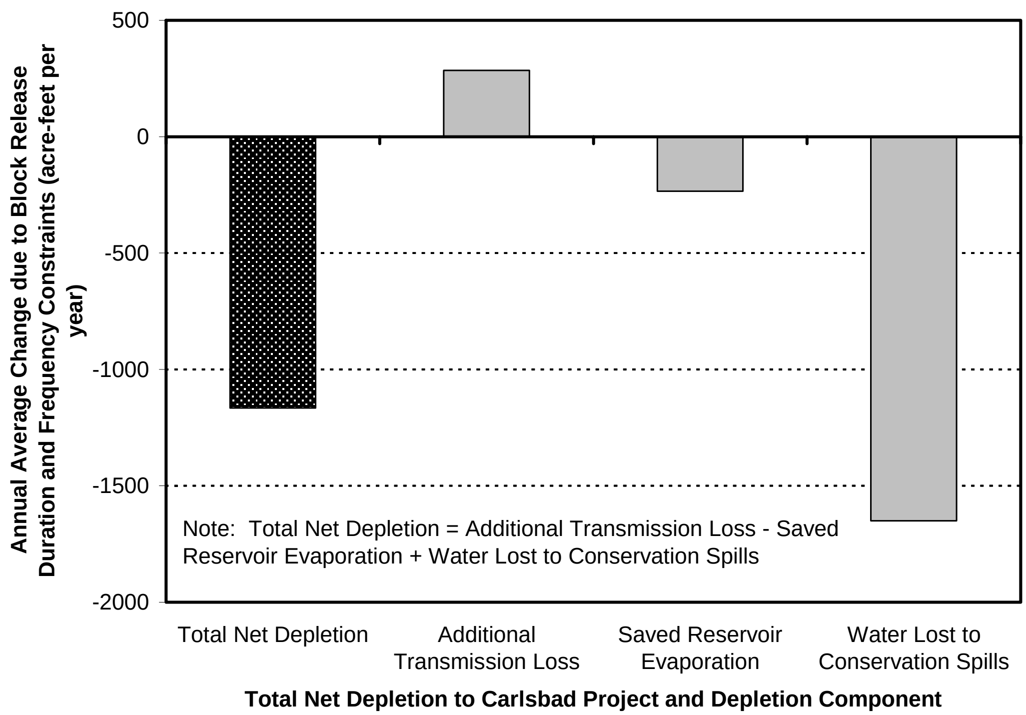


Figure 4.16 Effect of block release constraints (15-day limit on duration of block releases, 14 days in between block releases) on the Carlsbad Project water supply with No Action Alternative bypass target operations (total net depletions and net depletion components).

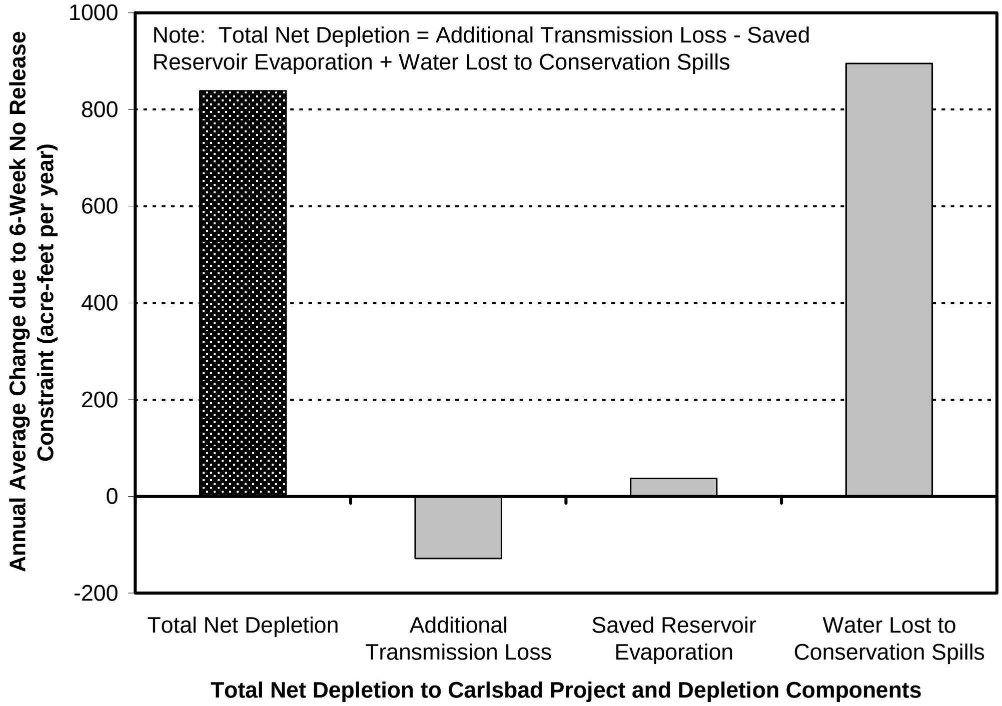


Figure 4.17 Effect of 6-week, no-release constraint centered on August 1 on the Carlsbad Project water supply with alternative bypass target operations (total net depletions and net depletion components).

In addition to impacts on the Carlsbad Project water supply, impacts of modifications to block releases also were examined in terms of their effect on geomorphology. (See the Geomorphology Memorandum in Appendix 3, "Hydrologic and Water Resources.") These impacts were examined in response to concerns that diminishing block release frequencies and volumes (from bypassing) would result in channel narrowing. Both the original bypass volumes as well the extreme case of taking all of the AWN from the block release flow frequency range were examined; the investigation showed minimal change to modeled channel width in the vicinity of the Near Acme gage for both cases. Because the total volume of block releases was not considerably reduced 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 EIS would be negligible.

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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, 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 microSiemens per centimeter (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 4.18 shows the effect of higher EC on the yield of alfalfa. The data to construct figure 4.18 were taken from Ayers and Westcot (1985). As shown on figure 4.18, 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 4.18 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.

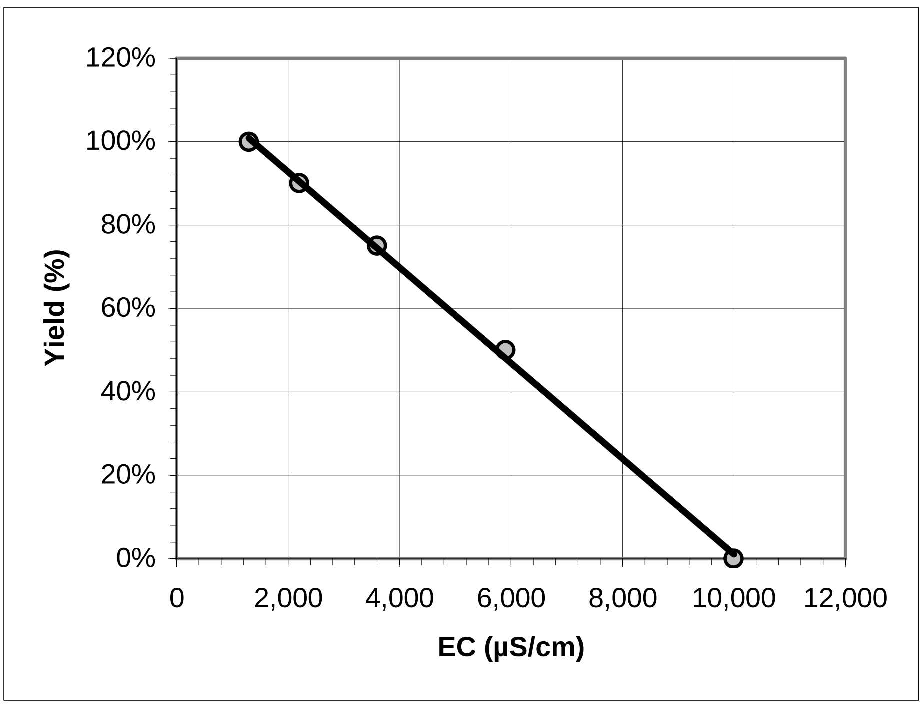

Figure 4.18 Effect of higher EC on alfalfa.

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 4.19.

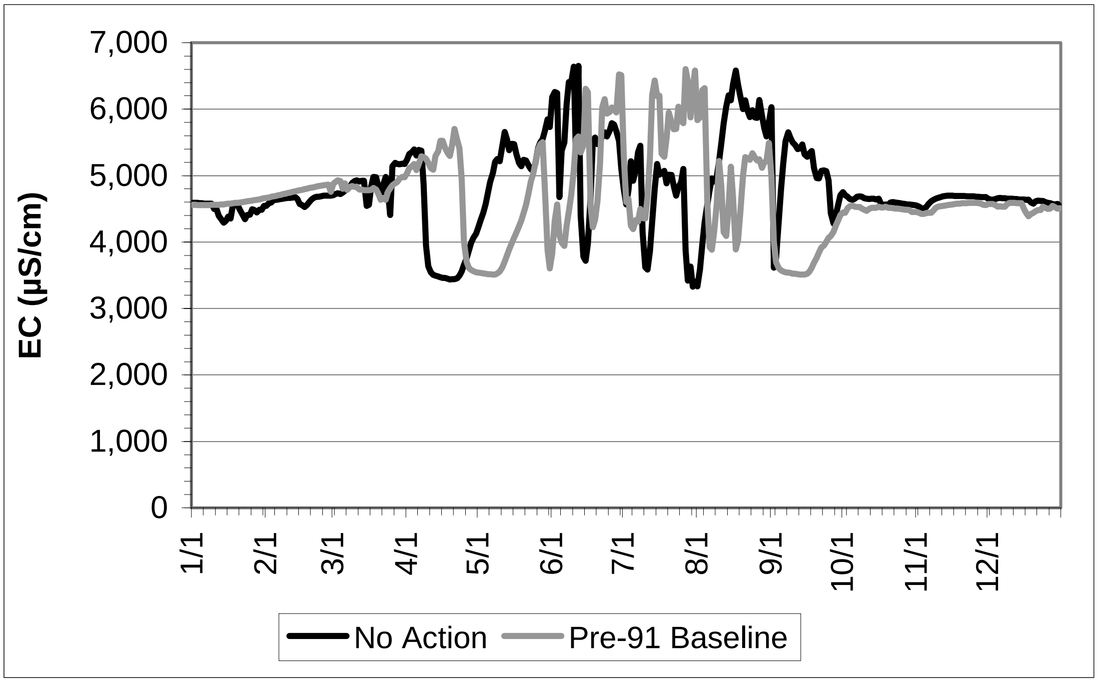

Figure 4.19 Daily EC at the Artesia gage in a normal year under the pre-1991 baseline and No Action Alternative.

As shown on figure 4.19, 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 4.19, 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 4.18 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 4.20 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.

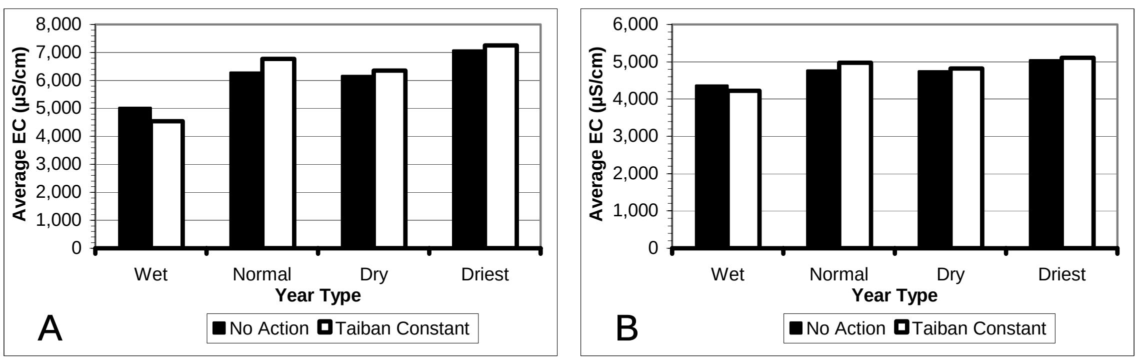

Figure 4.20 Comparison of EC under No Action Alternative and Taiban Constant Alternative: A = Near Artesia gage and B = Below Brantley Dam gage.

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 4.21 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.

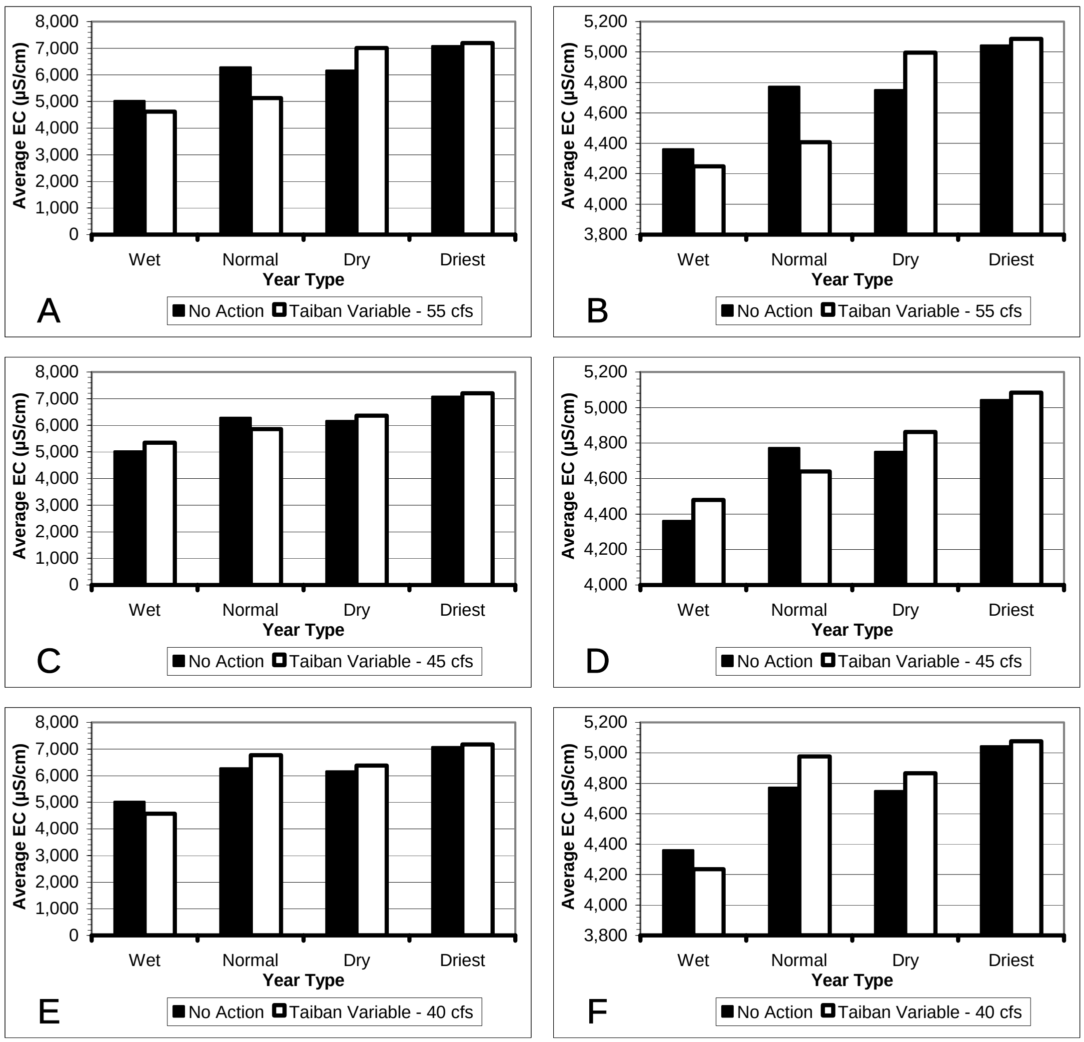

Figure 4.21 Comparison of EC under the No Action Alternative and the Taiban Variable Alternative: A, C, E = Near Artesia gage and B, D, F = Below Brantley Dam gage.

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 4.22 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.

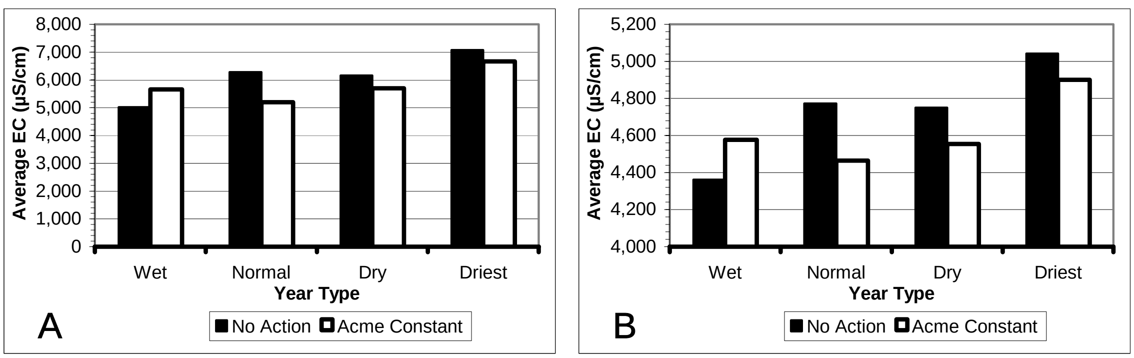

Figure 4.22 Comparison of EC under the Acme Constant Alternative and No Action Alternative: A = Near Artesia gage and B = Below Brantley Dam gage.

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 4.23 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.

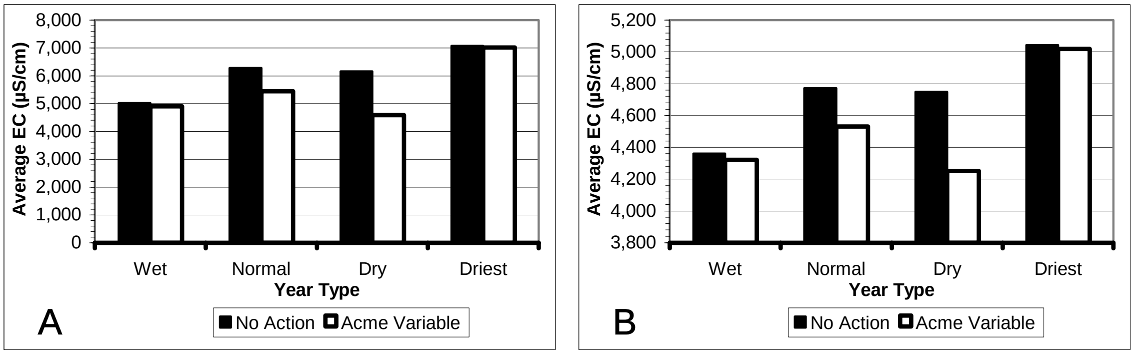

Figure 4.23 Comparison of EC under the Acme Variable Alternative and No Action Alternative:
A = Near Artesia gage and B = Below Brantley Dam gage.

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 4.24 compares the projected annual average EC under the Critical Habitat Alternative and No Action Alternative at the two sites for the four year types.

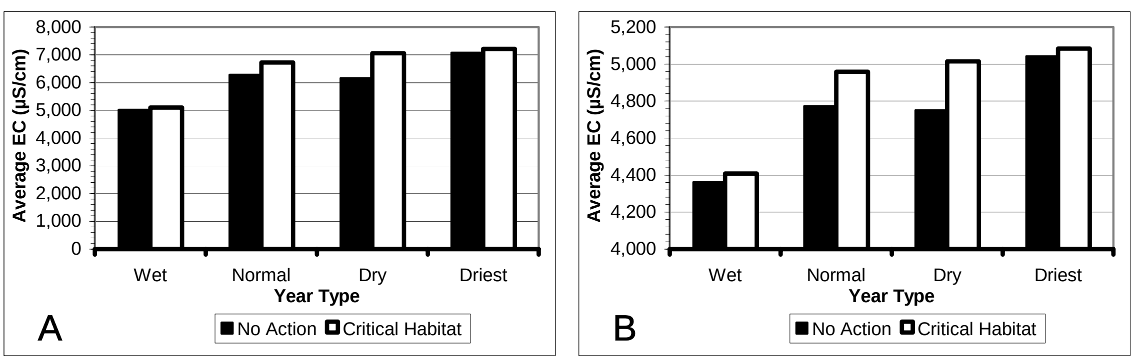

Figure 4.24 Comparison of EC under Critical Habitat Alternative with No Action Alternative:
A = Near Artesia gage and B = Below Brantley Dam gage.

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 4.20 through 4.24 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 4.25 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.

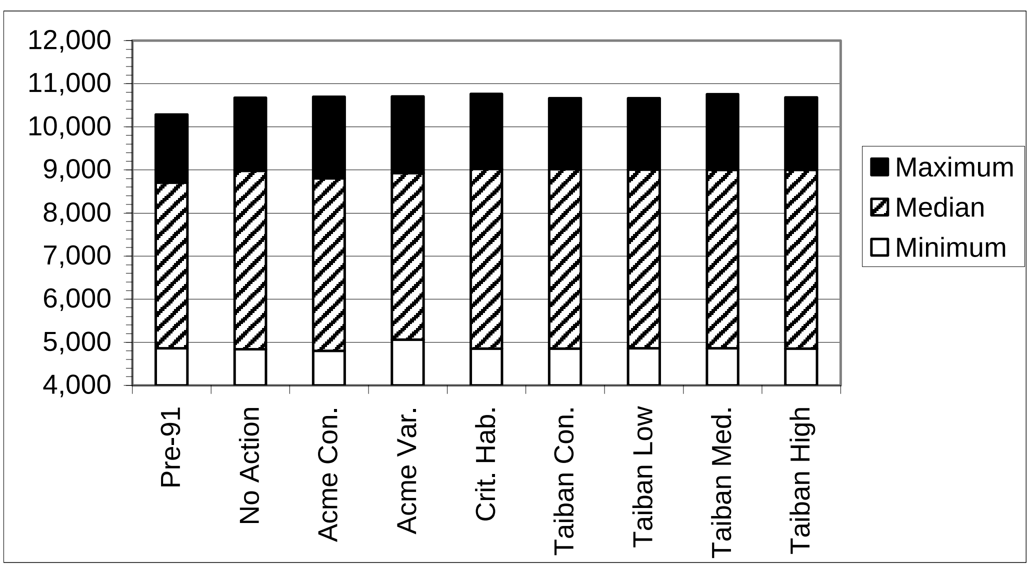

Figure 4.25 Minimum, median, and maximum ground water EC (µS/cm) under the pre-1991 baseline and alternatives.

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.

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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 farmland 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 because of 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 Web sites (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 because of 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.

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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 4.26, 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

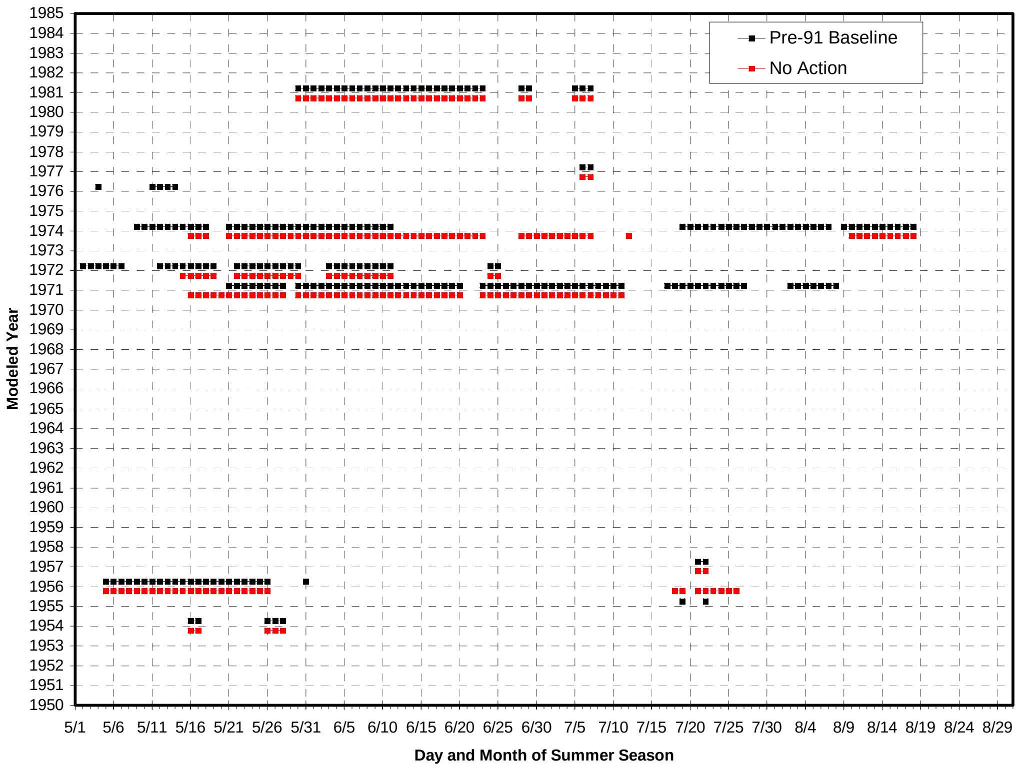

Figure 4.26 Comparison of intermittency under the No Action Alternative and pre-1991 baseline. Two extended period of intermittency during the nonirrigation season (2/10/1940-3/5/1940 and 2/27/1979-3/4/1979) were not plotted in this figure. Years with intermittency are consistent under all alternatives.

Because intermittency does not occur during the nonirrigation season with bypass flows or during the irrigation season in wet hydrologic conditions under any alternative (table 4.39), 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 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 4.40) 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 4.40 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). Reclamation has consulted with the Service and received a BO which will take effect on or about August 1, 2006, or 30 days after the Record of Decision (ROD) has been signed. The BO is provided in appendix 1.

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 in 2004. In 2005, terns were observed, but no evidence of nesting was found during the summer months. (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 4.41 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 4.41 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

Table 4.41 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)			
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 4.42.

6.3.4.2 Interior Least Tern

Potential impacts on the interior least tern are described in table 4.43.

6.3.4.3 Other Special Status Species

Potential impacts on other special status species other than the Pecos bluntnose shiner and interior least tern are described in table 4.44.

Table 4.42 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 4.40). 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 4.40). 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.

Table 4.43 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 4.41). 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 4.41). 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

Table 4.43 Summary of potential impacts on interior least tern

Alternative	Potential impacts
	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 4.41). 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 4.41). 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 4.41). 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 4.44 Summary of potential impacts on special status species other than the Pecos bluntnose shiner and interior least tern

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

Table 4.44 Summary of potential impacts on special status species other than the Pecos bluntnose shiner and interior least tern

Species	No Action Alternative	Taiban Constant Alternative	Taiban Variable Alternative	Acme Constant Alternative	Acme Variable Alternative	Critical Habitat Alternative
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

6.3.4.4 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.

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 4.26 and 4.27). When compared to the pre-1991 baseline, the No Action Alternative provides greater protection from intermittency.

When flows are intermittent at the Near Acme gage, flow exceedance values at the Near Dunlap gage[1] vary little among the alternatives (figure 4.28), 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.

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 4.39), with flows at the Near Acme gage greater than 3

[1] When intermittency occurred at the Near Acme gage, the Near Dunlap Gage was the next closest upstream gage that remained flowing.

to 5 cfs most of the time (table 4.40). These flows would still provide river connectivity and aquatic habitat and movement corridors necessary for aquatic organisms.

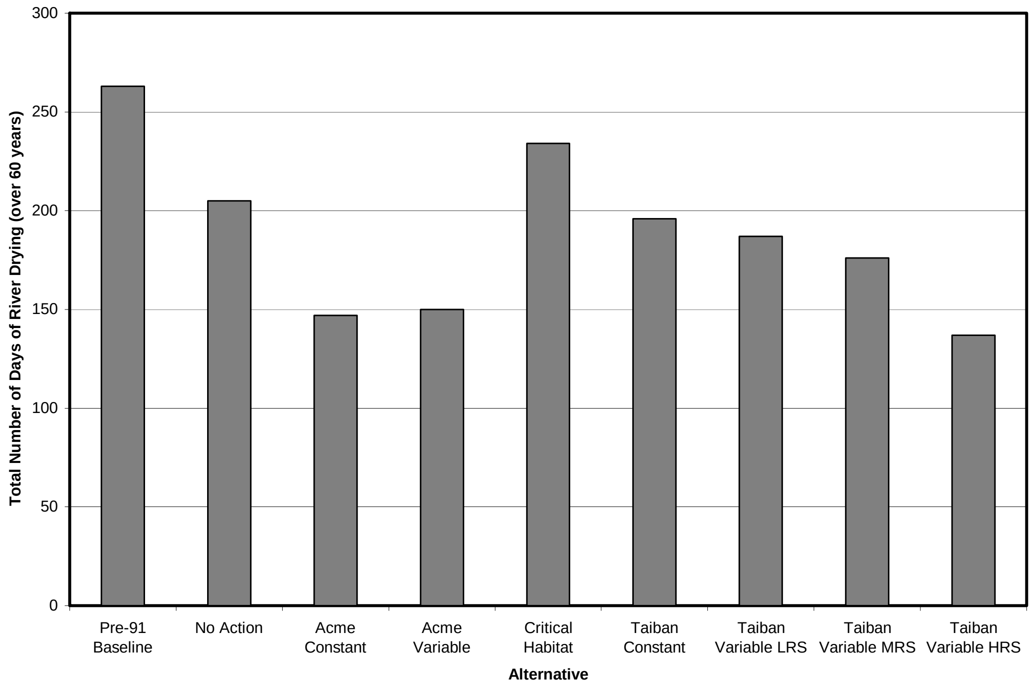

Figure 4.27. Number of days with intermittency at the Near Acme gage under the pre-1991 baseline and the alternatives.

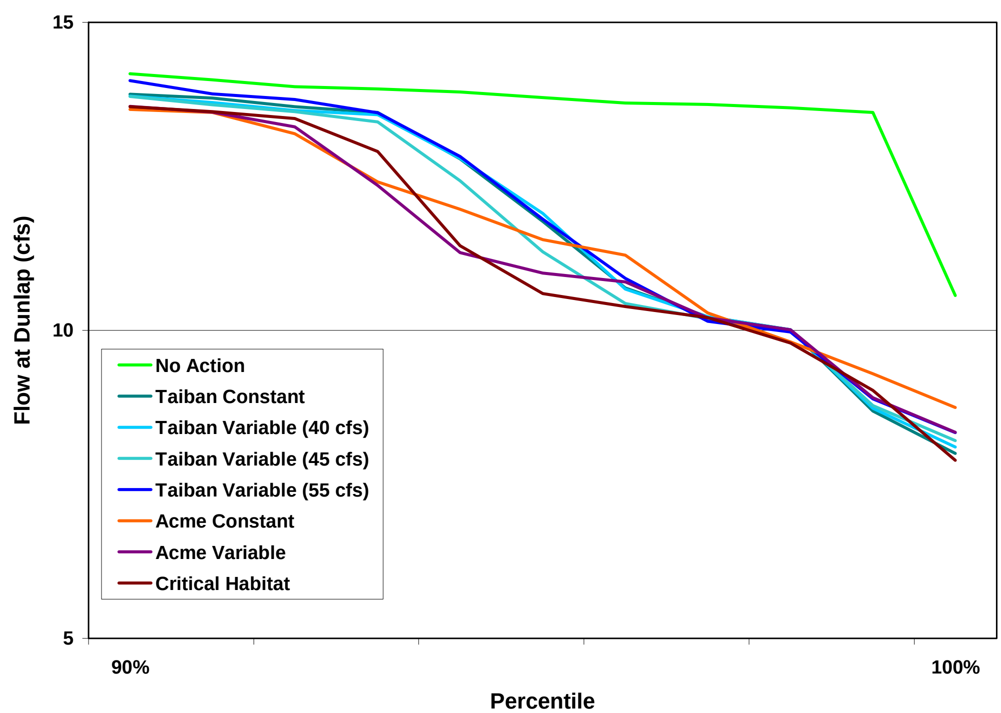

Figure 4.28 90%-100% exceedence plot of riverflow at the Near Dunlap gage when intermittency occurs at the Near Acme gage.

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 4.39). 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 4.40). 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 4.39). 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 4.40). 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, although the timing and duration of these events varies (figure 4.29) and fewer dry days occur (figure 4.27). 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.

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 4.28).

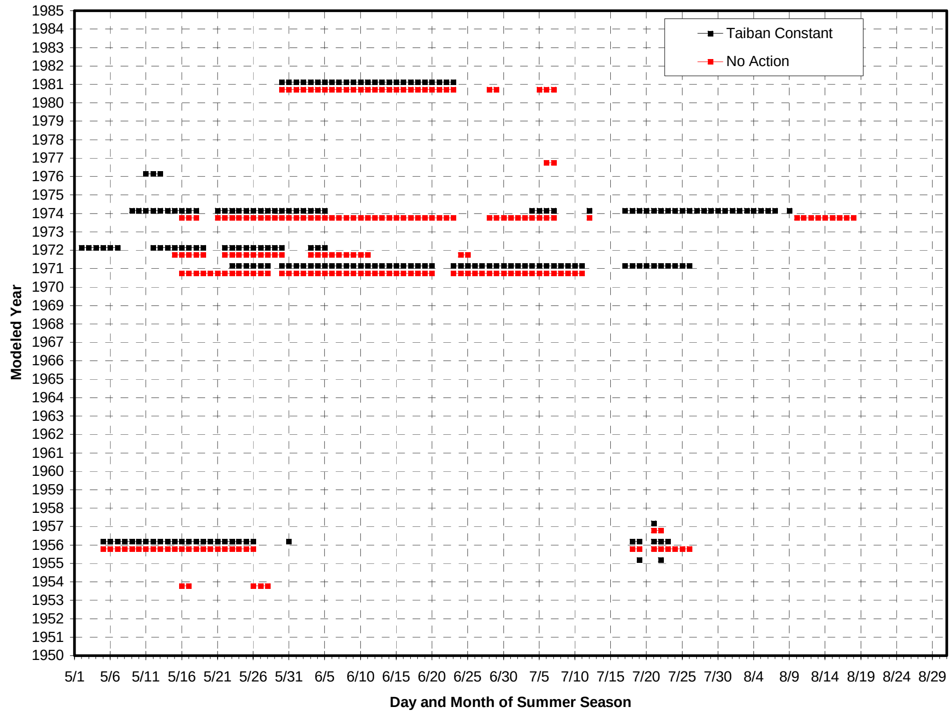

Figure 4.29 Comparison of intermittency under the No Action and Taiban Constant Alternatives.

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 4.39). 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 4.40) 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 4.40). 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 4.39). 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 4.40).

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 4.39). 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 4.30, 4.31, and 4.32). 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. 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 4.27).

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.

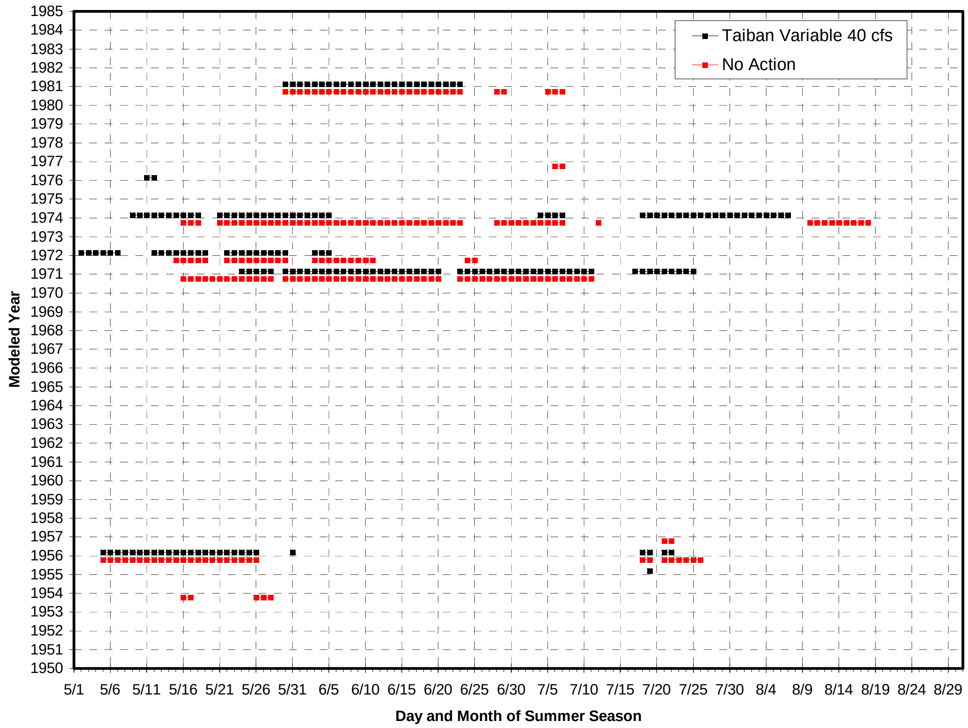

Figure 4.30 Comparison of intermittency under the No Action and the Taiban Variable Alternatives with target flows of 40 cfs at the Taiban gage.

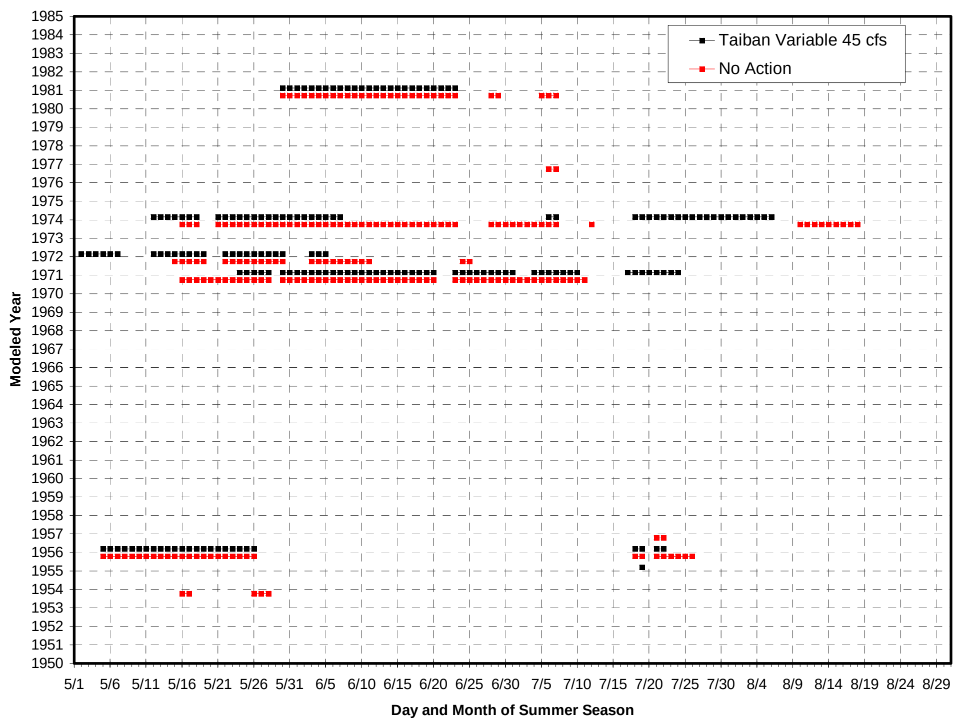

Figure 4.31 Comparison of intermittency under the No Action and Taiban Variable Alternatives with target flows of 45 cfs at the Taiban gage.

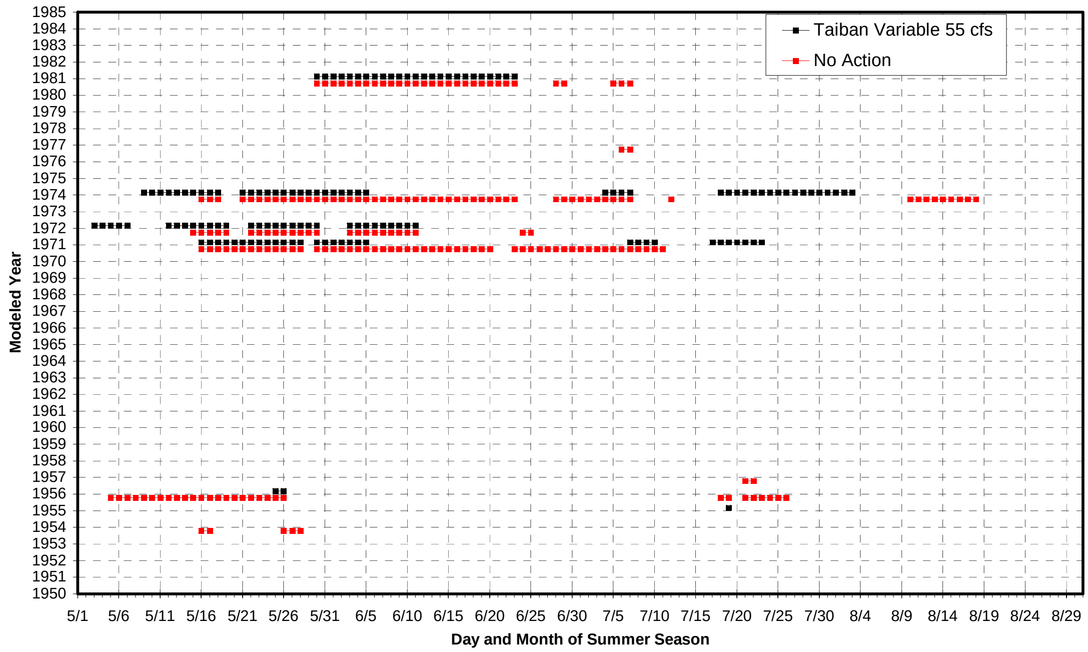

Figure 4.32. Comparison of intermittency under the No Action and the Taiban Variable Alternatives with target flows of 55 cfs at the Taiban gage.

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 4.39). 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 4.40). 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 (figure 4.33). Additionally, 50 fewer days with channel drying occur than under the No Action Alternative (figure 4.27). 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.

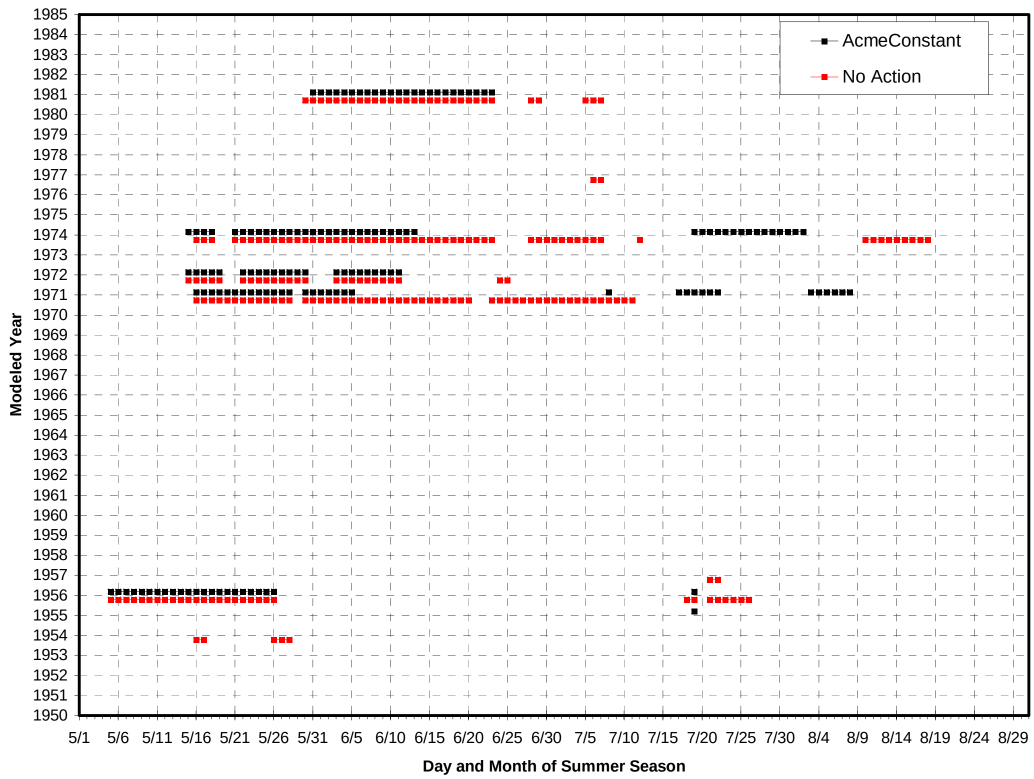

Figure 4.33 Comparison of intermittency under the No Action and Acme Constant Alternatives.

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 4.28). 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.

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 4.39) and that flows at the Near Acme gage are higher than 3 to 5 cfs most of the time (table 4.40). 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 (figure 4.34) with fewer total days of intermittency over the 60-year modeling period (figure 4.27). 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.

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.

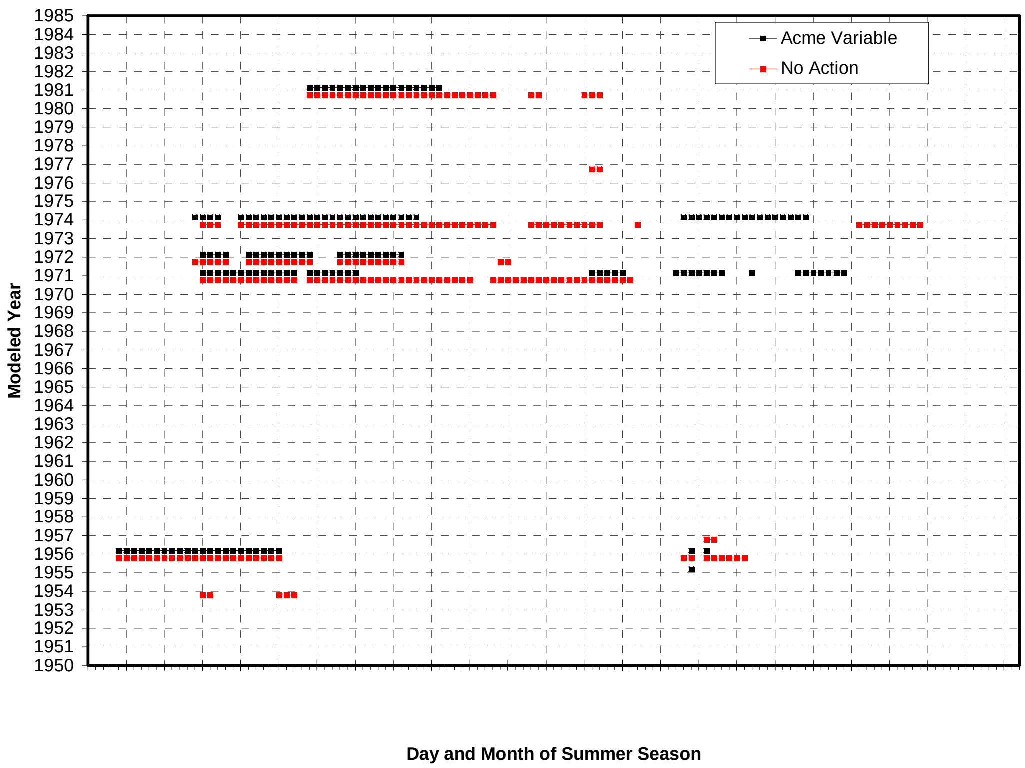

Figure 4.34 Comparison of intermittency under the No Action and the Acme Variable Alternatives.

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 (figure 4.35). 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.

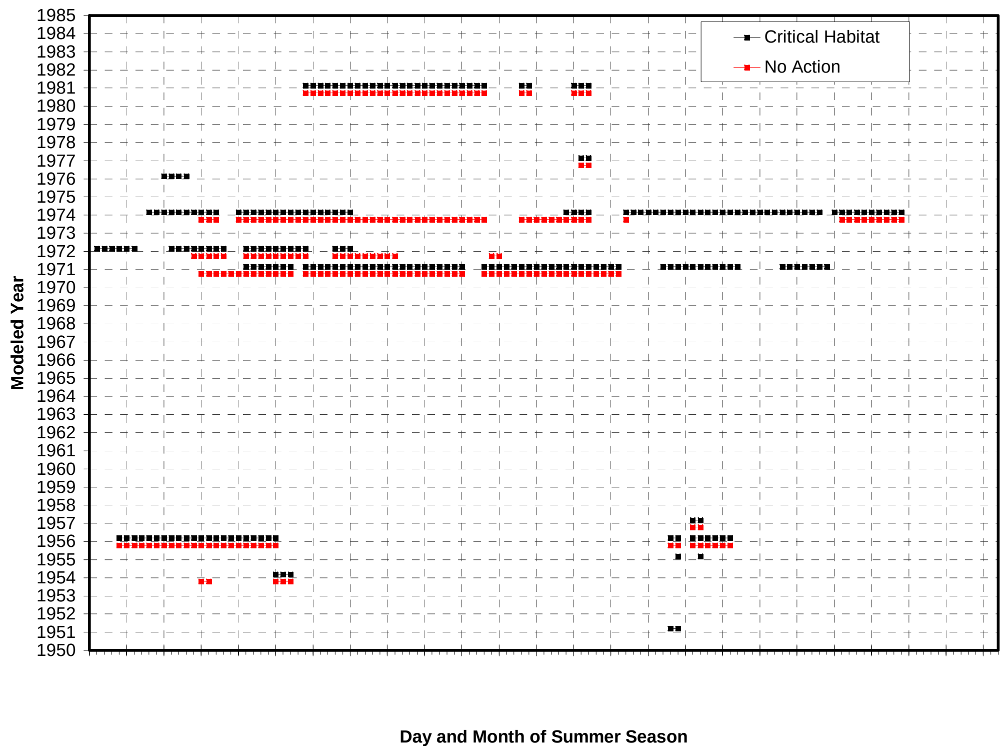

Figure 4.35 Comparison of intermittency under the No Action and the Critical Habitat Alternatives.

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.

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 4.45 presents a brief summary of impacts of CPWA options on biological resources, and table 4.46 presents a brief summary of the impacts of AWA options.

Table 4.45 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

Table 4.45 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
				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 4.46 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 because of their uncertain duration.

Table 4.46 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
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 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.

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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 4.47 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 4.48 summarizes the impacts of the action alternatives compared to the No Action Alternative. A narrative summary discussion follows.

Table 4.47 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

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.

Table 4.48 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

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 4.49. A range of impacts are estimated based on the equivalent acreage requirements shown in table 4.49.

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 4.49 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 seven 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 4.50 summarizes these one-time impacts.

Table 4.50 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
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 positive regional economic 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 area.

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 because of 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 because of 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 4.51. The results indicate alfalfa is the primary generator of agricultural income in the region.

Table 4.51 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 4.52 shows representative costs and returns for retired and fallowed land and land that experiences changes to cropping patterns.

Table 4.52 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 4.52 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 4.53 on a per acre basis, except for employment, which is presented as an impact per 1,000 acres.

Table 4.53 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 4.54 through 4.59. Narrative discussions of the impacts follow.

Table 4.54 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 4.55 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 4.56 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 4.57 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 4.58 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 4.59 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 4.60 summarizes the impacts of the alternatives on recreation. A narrative summary discussion follows.

Table 4.60 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 attributable 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 4.61 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 4.61 Percentage difference in maximum, average, and minimum flows between action alternatives and the No Action Alternative[1]

Alternative	Flow measure (cfs)	Near Acme gage	Near Artesia gage
No Action	Maximum	20,606.0	41,219.5
	Average	142.0	197.7
	Minimum	0.0	5.5
Taiban Constant	Maximum	0.0%	0.0%
	Average	1.2%	0.8%
	Minimum	[2]	0.0%
Taiban Variable (45 cfs)	Maximum	0.0%	0.0%
	Average	0.6%	0.4%
	Minimum	[2]	0.0%
Acme Constant	Maximum	0.0%	0.0%
	Average	-0.7%	-0.7%
	Minimum	[2]	4.7%
Acme Variable	Maximum	0.0%	0.0%
	Average	0.0%	-0.1%
	Minimum	[2]	0.0%
Critical Habitat	Maximum	0.0%	0.0%
	Average	1.0%	0.7%
	Minimum	[2]	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, 2003c.

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 4.62 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 4.62 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	4,729	4,252	3,247
	Storage	56,953	24,472	24,330
Taiban Constant	Elevation	0.0	0.0	0.0
	Storage	0.4	-2.5	0.5
Taiban Variable (45 cfs)	Elevation	0.0	0.0	0.0
	Storage	1.1	0.3	-0.3
Acme Constant	Elevation	0.0	0.0	0.0
	Storage	5.3	11.2	-3.2
Acme Variable	Elevation	0.0	0.0	0.0
	Storage	3.9	8.8	-4.4
Critical Habitat	Elevation	0.0	0.0	0.0
	Storage	0.6	-3.5	0.7

Source: HRC, 2003c.

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 4.63 summarizes the impacts of both CPWA and AWA options on recreation use.

Table 4.63 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 purchase	Moderate	Localized	Long-term	A permanent acquisition of additional water to remain in the river helps provide additional water for recreational uses.
Water right lease	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 4.64 summarizes the impacts of the alternatives on cultural resources. A narrative summary discussion follows.

Table 4.64 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. Low 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. Least amount of 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 EIS 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 2003-2006 BO (Service, 2003). Reclamation also would continue to acquire water to conserve the Carlsbad Project water supply. Operations under the Interim BO are unlikely to 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, except the Critical Habitat 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. 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 State Historic Preservation Office (SHPO) and tribal groups.

Table 4.65 presents a brief summary of the impacts of CPWA options on cultural resources, and table 4.66 presents a brief summary of the impacts of AWA options.

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 (AMP). No direct impacts on cultural resources are anticipated from these actions.

Table 4.65 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 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.
D-1B, D1BX	Surface water right purchase: Roswell area	
D-1C, D-1CX	Surface water right purchase: CID	
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 4.66 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.
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)	

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 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.

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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 EIS, 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 EIS 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 the Acme Constant and Acme Variable 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 because of 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.

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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 farmland because of 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.

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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.

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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. Further environmental compliance actions and permitting will be completed as required.

***Adaptive management plan*:** Implementation of an AMP 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. The core components of the Adaptive Management Plan are criteria, triggers, monitoring, and responses. The AMP provides guidance for addressing changing conditions in the future management of river operations by modifying operations within established parameters. It also 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. Attachment 2 is the AMP based on the Taiban Constant Alternative.

Section 7 consultation measures: Reclamation will implement measures from the BO (appendix 1) to offset take and to avoid or reduce any adverse effects. The specific Reasonable and Prudent Measures and other actions outlined in the BO that Reclamation will implement will be included in the ROD.

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.