Chapter II

Development of Action Alternatives

2.1 Planning for Positive Benefits

To address highly variable water supply and competing demands along the Rio Grande, the water managers realized that they needed two tools: a common computer model to facilitate the sharing of daily water operations data; and a clear, written description of existing procedures by which the river has come to be managed. A long-term planning version of the Upper Rio Grande Water Operations Model (URGWOM) and a specific set of written operating rules and coordination procedures for the alternative selected in the Record(s) of Decision are the outcomes of this project.

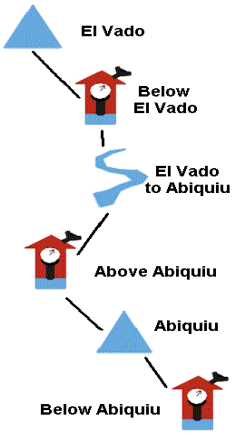
The Action Alternatives developed in the Water Operations Review (Review) and Environmental Impact Statement (EIS) are integrated water operations plans for federally-operated facilities in the upper Rio Grande basin. In the past, these facilities operated with limited coordination and consideration of the long-term cumulative impacts to natural and human resources. Each alternative presents a specific set of limits for operations developed from a study of flexibilities within existing authorities for federal facilities in the upper Rio Grande basin, as well as consideration of public comments during scoping. The Preferred Alternative was selected on the basis of the combined positive benefits it would afford for the affected resources in the basin. Operations that could potentially provide positive benefits, but were not evaluated because they are outside the existing authorities of the joint lead agencies (JLA), are discussed in Chapter 6, Section 6.2.

This project is a cooperative process involving multidisciplinary and multi-agency teams who did the work, shared resources to collect new data, shared data collected by others, provided multi-agency project management, collaborated in multi-agency tool development and use, and cooperated in many other ways. The JLA worked to disclose and describe how water management agencies operate, to improve communication between agencies, to foster better coordination with the tribes, and to increase interaction with the public with respect to water operations in the upper Rio Grande basin.

In addition, the Review and EIS stand as a foundation for future research, planning, and management (see Chapter 6). This project documents what we know about the upper Rio Grande basin, points out much of what we do not know, and identifies areas where more work needs to be done.

2.2 Key Tools

Given the complexity of the Review, numerous tools were refined and developed for use in the evaluation of alternatives. These key tools are briefly described in this section. More detailed descriptions are available in the specified referenced appendices. These tools include URGWOM, FLO-2D model, RMA-2/Aquatic Habitat Model, the San Acacia Surface Water/Groundwater Model, GIS spatial analysis and data, described individually below. The 40-year hydrologic modeling sequence represents the range of climatic conditions used to evaluate the effects of alternatives. In addition, a decision support model was used to aid in comparing and contrasting results of the alternatives. This suite of tools provides the best available information concerning the Rio Grande system.



2.2.1 URGWOM Planning Version

The URGWOM planning version represents the framework of the institutionally and physically complex upper Rio Grande system. URGWOM is a set of daily time-step, river-reservoir models for the basin using RiverWare® software. The model was used to simulate river hydrographs and reservoir contents for the No Action Alternative and the Action Alternatives to compare their effects on river and reservoir conditions over a range of hydrologic conditions, from drought to wet periods. The cartoon to the left shows an example of the URGWOM workspace reservoir, reach, and gage objects. Additional information on the use of the URGWOM planning version is presented in Appendix I. Complete draft documentation of all URGWOM versions is available on the website at http://www.spa.usace.army.mil/urgwom/default.asp and is also available upon request from the JLA.

2.2.2 Stochastic 40-Year Hydrologic Sequence

In order to compare alternatives, a hypothetical 40-year hydrologic period was developed. Annual water data were analyzed for the years 1975–2000 and selectively sampled to generate the hypothetical 40-year dataset used in the URGWOM modeling. In order to simulate a full range of possible hydrologic conditions, the 40-year sequence includes a wet period, a drier than average period, and a period of extreme drought (see Appendix I for details). Data presented in **Figure 2-1** provided the basis for climatic inputs to URGWOM.

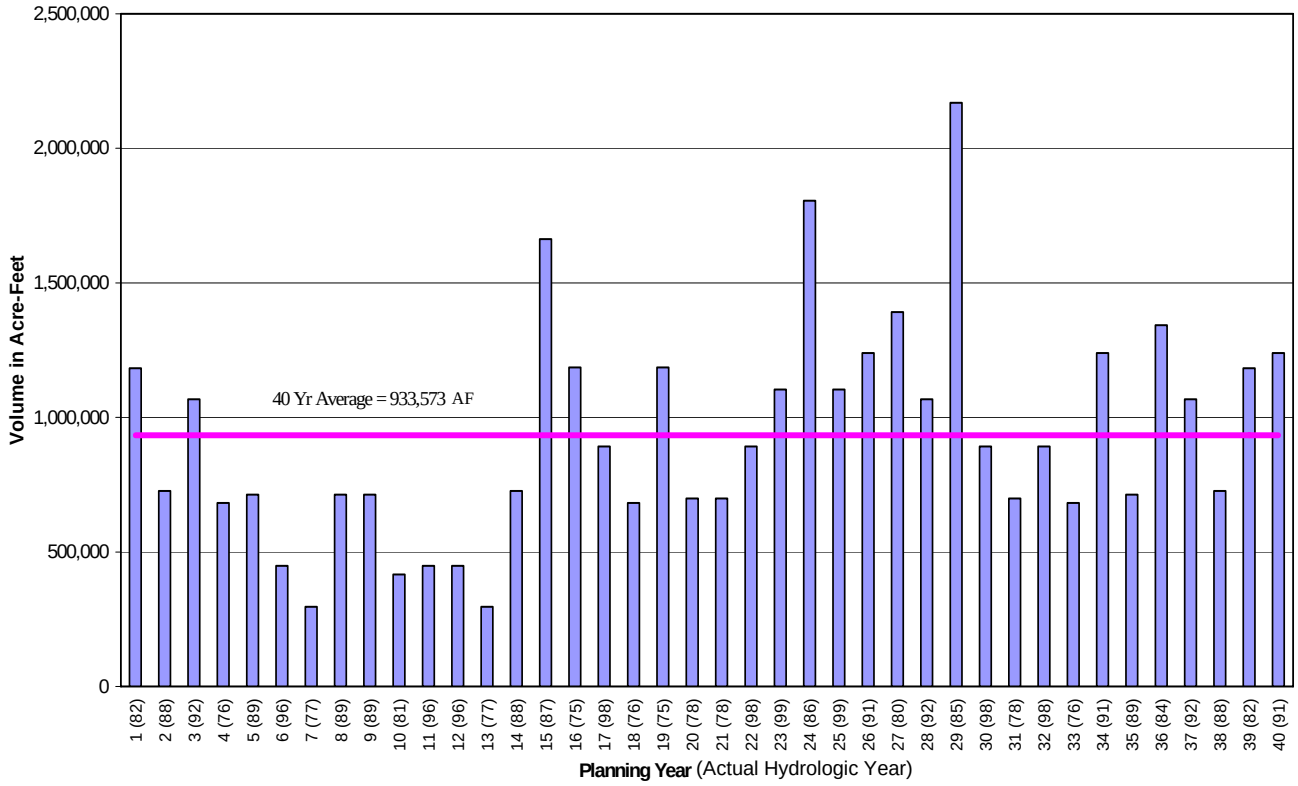
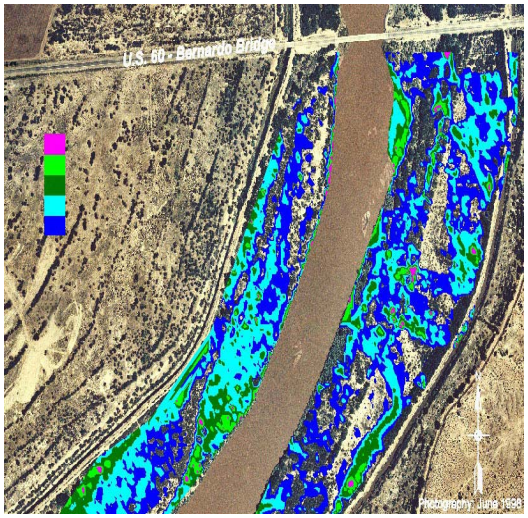


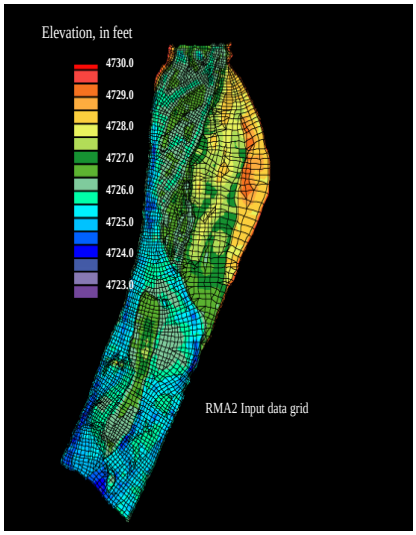
Figure 2-1. 40-Year Synthetic Hydrographic Sequence at Otowi

2.2.3 FLO-2D Hydraulic Models



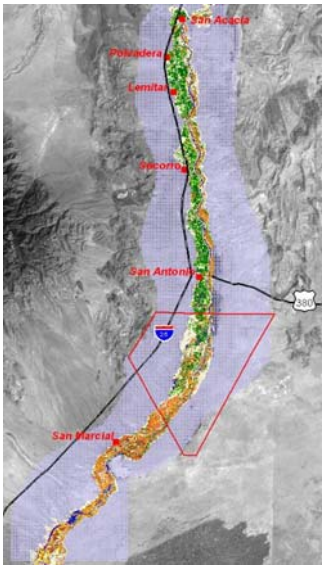
The FLO-2D model (Appendix J) is a simple volume conservation model that distributes a flood hydrograph over a system of square grid elements. It is a two-dimensional model that numerically routes a flood over a grid of surface points while predicting the area of flooding and how much the flood wave is slowed by the floodplain. The flood routing models for Reaches 7–14 (Appendix J) were developed in cooperation with many agencies in the upper Rio Grande basin to provide a basis for determining overbank flooding. The Review and EIS used these models to assist in understanding the differences in hydraulic effects between action alternatives. These models helped translate the flows from URGWOM into depths, velocities, and the extent and duration of inundation and helped to estimate sediment transport. An example of overbank flooding areas generated by FLO-2D is shown to the right.

2.2.4 RMA-2 Hydraulic Model/Aquatic Habitat Model



RMA-2 is a two-dimensional module for a surface modeling system developed at Brigham Young University in cooperation with the Corps Waterways Experiment Station. RMA-2 was used to develop the hydraulic framework for each of eight representative aquatic habitat sites that provided depth and velocity information at various flows to a spreadsheet called the aquatic habitat model. This hydraulic information, combined with flow information from the URGWOM model and habitat suitability relationships developed for five fish species, comprised the Aquatic Habitat Model used to evaluate alternatives. The Hydraulic Model/Aquatic Habitat Model Development Report is included in Appendix K. A summary report on the evaluation of the alternatives with the Aquatic Habitat Model is included in Appendix K. Sample model output is shown to the right.

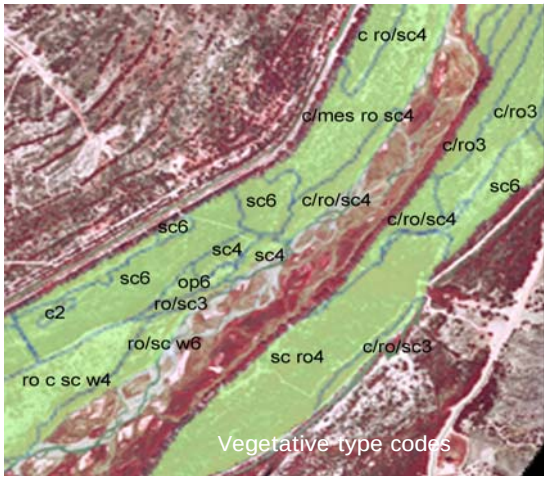
2.2.5 San Acacia Reach Surface Water/Ground Water Model



The NMISC developed a surface water/groundwater model of the Rio Grande reach from San Acacia to Elephant Butte reservoir (Appendix J). The purpose of the model is to evaluate potential system-wide depletions that may result from changes in operation of the Low Flow Conveyance Channel (LFCC), riparian vegetation restoration projects, and riverbed aggradation. The model simulates the Rio Grande channel, the LFCC, and the main irrigation canals and drains as well as the alluvial and the Santa Fe group aquifers. The U.S. Geological Survey program MODBRANCH is used to represent the surface water/groundwater system. The surface water component is represented by solving the one-dimensional form of the continuity and momentum equations, known as Saint-Venant equation. The groundwater component is dynamically linked to the surface water

component. The physical processes represented in the model are surface water routing, surface water/ groundwater interaction, discharge from springs, riparian and crop depletions, groundwater withdrawals and groundwater levels. The model provides groundwater elevation, surface water flow and riparian and crop depletion. The area shown to the right is the extent of this model.

2.2.6 Geographic Information System (GIS) Spatial Analysis



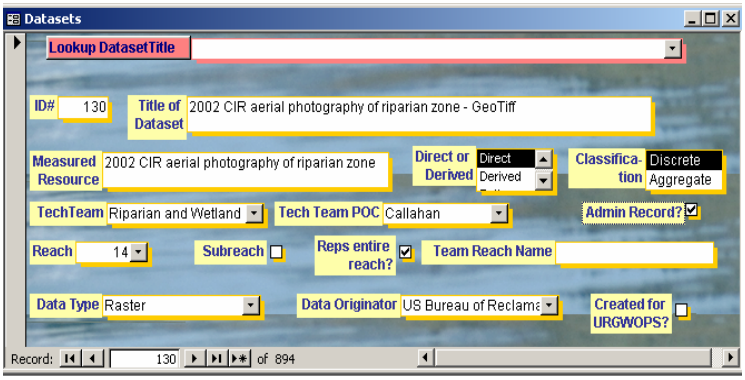
A basin-wide system was developed for geospatial analysis, data integration across resources, and referencing data points to specific geographic locations. Geographic Information System (GIS) software was used in the project as the basis for managing and sharing data throughout the lifecycle of this EIS for data collection, organization, evaluation, analysis, and synthesis. GIS analysis was used to process spatial outputs from the key tools, associated databases, and other sources in order to characterize the affected environment and analyze impacts of the EIS alternatives. Data generated from GIS were tabular, spatial, or a combination. An example of vegetation mapping developed for this project is shown to the left.

2.2.7 Decision Support System

Criterium Decision Plus™ (InfoHarvest 2001) is used to document a multicriteria decision-making process leading to the selection of a preferred alternative that best meets weighted decision criteria. The model uses decision criteria, weights assigned by decision-makers and stakeholders, and alternative performance rankings to identify the highest ranking alternative. The model also helps decision makers understand the values, uncertainties, and trade-offs involved in selecting a preferred alternative. See Appendix P for more details.

2.2.8 Data Quality Database

The data quality database organizes the information for each data set used in evaluation of alternatives so that it can be sorted, grouped and selected, as needed. Based on Data Query Forms filled out by each technical team, the database summarizes the data quality by reach, subject, and team. It documents, summarizes, and references data used and generated during this project. A screen print of part of the data entry form is shown to the right. Details are provided in Appendix P.



2.3 Description of No Action

2.3.1 The No Action Alternative and How It Was Derived

The No Action Alternative is the water operations alternative that depicts current storage and water delivery operations of federal facilities, including those changes in the system that are already published in the public record and will occur in the foreseeable future. It is also called the “future condition without project.” For this project, it specifically means current operation of the ten water operations facilities in

the basin, without integrating any of the flexibilities identified at Heron and Abiquiu Dams, Cochiti Lake, or the LFCC into a water operation plan (see Map 1-1). It does include the City of Albuquerque Drinking Water Project, assumed to be operating by year 4 of the 40-year planning period. A detailed description of the No Action Alternative is presented in Appendix I. The authorized function and current operation of each facility in the No Action Alternative is described briefly below:

- **Closed Basin Project—**Located near Alamosa, Colorado, the Reclamation's Closed Basin Project uses wells to salvage groundwater from high water table conditions to assist Colorado in meeting its Rio Grande Compact delivery obligations. Some of the salvaged water is also used to support the Alamosa National Wildlife Refuge, the Blanca Wildlife Habitat Area, and support wildlife and recreational facilities at San Luis Lake. Salvaged groundwater varies in quality and is therefore blended to meet quality requirements of the Rio Grande Compact and the Clean Water Act. A network of observation wells monitors water levels in the underlying confined and unconfined aquifers to ensure that operations are within drawdown limits prescribed by the authorizing legislation. Well degradation and fouling is now limiting production. A well rehabilitation and replacement program is in progress. *There would be no changes in the current operation of the Closed Basin Project under the No Action Alternative nor under any of the Action Alternatives.*
- **Platoro Dam—**Also in Colorado, Platoro Dam on the Conejos River is a Reclamation facility operated by the Conejos Water Conservancy District. A joint-use pool is used for both flood space and conservation; if flood space is needed, water in conservation storage is released to make room. A small permanent pool is maintained for recreation, fish, and wildlife, and Platoro is managed to preserve fish and wildlife downstream. Flood control operation is the responsibility of the U.S. Army Corps of Engineers (Corps) and is the only function under review under the scope of this project. Because Platoro is a post-1929 reservoir, its operations are subject to Compact requirements. *There would be no changes in the operation of Platoro under the No Action Alternative nor under any of the Action Alternatives.*
- **Heron Dam**—Heron Dam on Willow Creek in northern New Mexico stores no native Rio Grande water, therefore, this reservoir is not subject to Compact requirements. It was built by Reclamation in the late 1960s to store water from the upper Colorado River system and to import it to the Rio Grande through the San Juan-Chama (SJC) Project. There are maximum limits on transbasin deliveries in any one year and in any ten-year period. Reclamation stores water in Heron Reservoir to meet the demands of its SJC Project water contractors who are required to take delivery of their annual allotment by December 31 of the irrigation year. Carryover storage is not permitted, except by waiver. *The No Action Alternative waiver delivery date would be April 30.*
- **El Vado Dam—**Next in the sequence of facilities on the upper Rio Grande is El Vado Dam on the Rio Chama. This reservoir was not part of the Review due to active litigation and changes to its operations were not considered. *Historic operation of the facility was modeled in evaluating the No Action and all of the Action Alternatives.*
- **Abiquiu Dam—**Abiquiu Dam, also on the Rio Chama, is operated as a flood control facility by the Corps. During flood control operations, water is released at a rate of up to 1,800 cubic feet per second (cfs) to evacuate the reservoir and maintain safe channel capacity downstream. The reservoir can also be used to store SJC Project water up to an elevation of 6,220 feet. The City of Albuquerque owns storage easements up to this elevation and has a current contract with the Corps to store SJC Project water in this incidental pool. The reservoir is also authorized to store native Rio Grande water in the authorized SJC Project water space when such space is not needed. The Corps has specific requirements for holding and releasing carryover native Rio Grande water in the facility. Such storage is subject to other requirements such as a state engineer

permit, a Corps deviation from normal operations, and unanimous concurrence of the deviation by the Compact Commission. *The No Action Alternative would maintain a channel capacity downstream of Abiquiu Dam of 1,800 cfs and would not store native Rio Grande water in the reservoir.*

- **Cochiti Dam—**Cochiti Dam, operated by the Corps, is a sediment and flood control structure located primarily on Pueblo of Cochiti lands. Pueblo of Cochiti has provided most of the lands, easements and rights-of-way for the facility and the Corps coordinates with Pueblo of Cochiti on actions involving this reservoir. Cochiti Dam spans the main stem of the Rio Grande and the Santa Fe River tributary to the Rio Grande, south of Santa Fe, New Mexico, on the Pueblo of Cochiti. The Corps has specific requirements for holding and releasing carry-over native Rio Grande floodwater in the facility. A permanent pool of SJC Project water is maintained in Cochiti Lake for recreation, fish, and wildlife. There is no authorization to store native Rio Grande water in Cochiti Lake. *The No Action Alternative would maintain a downstream channel capacity for flood control releases of 7,000 cfs, as measured at the Albuquerque gage.*
- **Jemez Canyon Dam—**A sediment and flood control structure on the Rio Jemez, Jemez Canyon Dam is operated as a dry reservoir by the Corps. The dam and reservoir area are on Pueblo of Santa Ana lands and the Corps coordinates with the Pueblo on actions involving this reservoir. There are no water contracts in place or proposed for re-establishing a sediment pool. *The No Action Alternative would continue to operate Jemez Canyon Dam as a dry reservoir.*
- **Low Flow Conveyance Channel—**The LFCC was constructed by Reclamation in the 1950s to aid delivery of Compact waters to Elephant Butte Reservoir. It also served to improve drainage and supplement irrigation water supply. The riprap-lined channel parallels an approximately 60-mile reach in the San Acacia Section of the Rio Grande from San Acacia to San Marcial, New Mexico. The LFCC collects river seepage and irrigation surface and subsurface return flows; transport via the LFCC reduces evaporation, as shown in **Figure 2-2**. The usefulness of the LFCC is somewhat determined by the water level of Elephant Butte Reservoir. When outfall conditions allow, up to 2,000 cfs can be diverted into the LFCC at San Acacia. The facility also provides water to both Bosque del Apache National Wildlife Refuge and to irrigators in the Middle Rio Grande Conservancy District. *This alternative preserves the authorization and flexibility to divert up to 2,000 cfs, if necessary to meet downstream obligations. However, the current physical condition of the LFCC precludes active diversion since high water levels in Elephant Butte buried the last 15 miles of the channel and outfall in the late 1980s.*
- **Elephant Butte Dam—**Elephant Butte Reservoir is owned and operated by Reclamation, and is the primary water storage facility for Rio Grande Project water. Rio Grande Project water is delivered primarily to New Mexican, Texan, and Mexican irrigators living downstream of Caballo Reservoir. Release of water for delivery to the downstream entities was not addressed in the Review and EIS. Operation of the facilities for "prudent flood space" was included in the scope of this Review and EIS. A 50,000 acre-foot (AF) flood space is maintained from April 1 to September 30; 25,000 AF of flood space is reserved between October 1 and March 31. Flood release is required when the reservoir level is within the prudent flood space. Generation of hydropower is a secondary purpose of the facility. *The No Action Alternative and all of the Action Alternatives would include the same written coordinated procedures and protocol on how Reclamation and the Corps will work together when circumstances warrant use of the "prudent flood space."* Elephant Butte Dam and Caballo flood control protocol are documented in Appendix I.

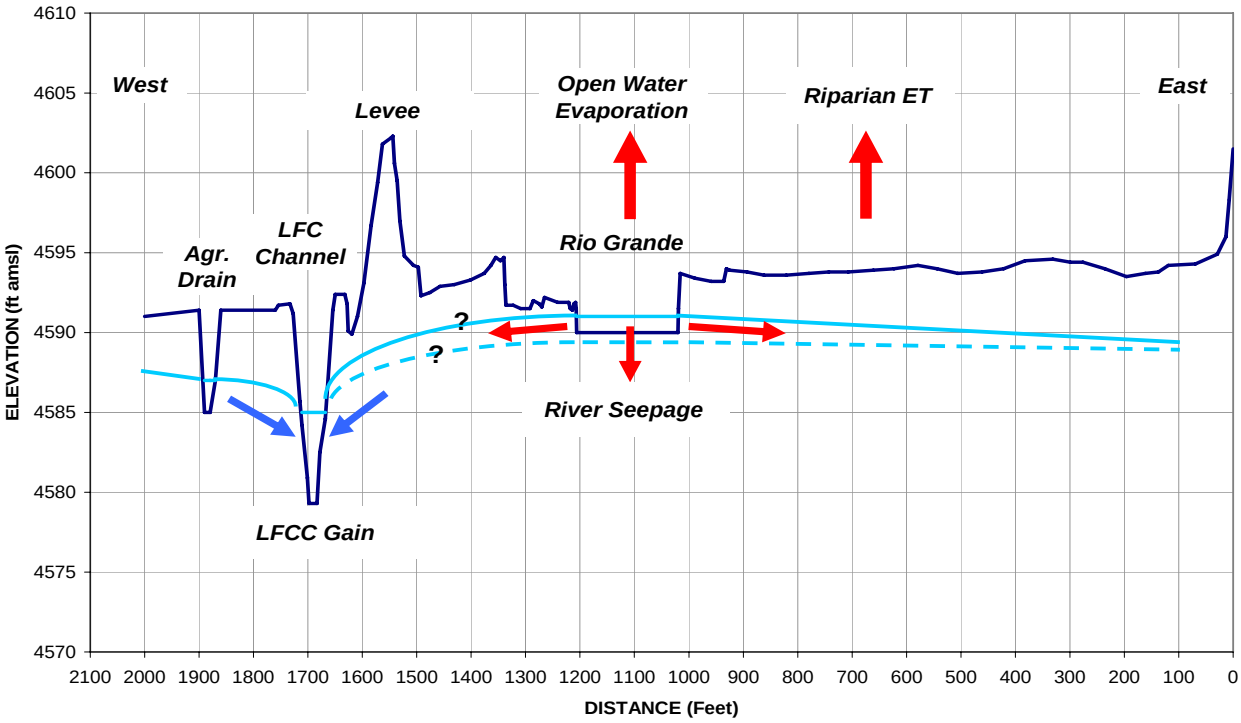


Figure 2-2. Floodplain Cross-Section of Rio Grande and Low Flow Conveyance Channel near Socorro

- **Caballo Dam—**Caballo Dam is similar to Elephant Butte, and only flood control activities were part of the Review and Water Operations EIS. Reclamation constructed Caballo and coordinates flood control operations with the U.S. Section of the International Boundary and Water Commission (USIBWC). Protocol for flood operations involving the Corps operation of Cochiti Dam for certain flooding conditions downstream of Caballo was developed and coordinated among the USIBWC, Reclamation, and the Corps as part of the Review. *The No Action Alternative and all of the Action Alternatives would include the documentation of the circumstances and protocol for how the USIBWC, Reclamation, and the Corps will work together when it is necessary to hold back floodwaters in Cochiti to prevent flooding below Caballo.* Elephant Butte and Caballo flood control protocol are documented in Appendix I.

2.4 Description of Action Alternatives

The development and description of the alternatives are described in CEQ Regulations for Implementing NEPA, Section 1502.14, as "the heart of the environmental impact statement." Alternatives other than the No Action Alternative may be developed to meet the purpose and need and in response to substantive scoping comments, in order to evaluate a range of reasonable alternatives. This section identifies the issues and process used to develop the alternatives analyzed in detail in this EIS, as well as those alternatives eliminated from detailed study.

2.4.1 Significant Issues Identified During Scoping

General actions to coordinate and improve facility operations were published in the March 2000 Notice of Intent to conduct the EIS (FR 2000). The JLA held nine scoping meetings in 2000 in Colorado, New Mexico, and Texas to identify issues of concern and to further define the range of flexibilities to be considered in this EIS. Meeting attendees expressed an interest in learning more about the alternatives before they were finalized and analyzed. In response, the JLA held an additional 10 meetings in 2002 to present draft alternatives and proposed operational changes, and to clarify issues of importance to the

public that needed to be addressed in the action alternatives. The comments from the second round of public meetings can be considered an extension of scoping. Full comment text from the draft alternatives public meetings is provided in Appendix E. Possible operational flexibilities presented by the JLA at the meetings identified ranges to be considered for reservoir storage and channel capacity, flow bypasses, and timing of waivers. Also discussed for background information were uncertainties in weather, variability in runoff, and unplanned issues affecting water management. Significant comments identified by the public in the alternatives development meetings that were determined to be relevant for developing the Action Alternatives are summarized briefly below under primary categories. Many comments submitted were appropriate to be considered in the effects analyses for specific resources. Although they do not appear below, they are addressed in Chapter 4, Environmental Consequences.

1. Water Operations/Reservoirs/River Flows
   a. Consider lower than current Rio Chama channel flows below Abiquiu Dam.
   b. Identification of additional upstream storage capacity to minimize evaporation losses.
   c. Store water upstream as long as possible by changing the timing of releases.
2. Threatened and Endangered Species: Examine the flexibility in the system related to timing releases to manage for threatened and endangered species.
3. Agriculture: Consider lower flows than currently in the channel below Abiquiu Dam in order to protect Rio Chama acequia headgates and diversion structures.

After the public meetings and input from the JLA, water managers, Cooperating Agencies, and other stakeholders, seven combinations of water operations were developed. These operational variations included: varying waiver dates at Heron Reservoir; varying native storage at Abiquiu Reservoir; varying channel capacities below Abiquiu and Cochiti Dams; a range in diversion to the LFCC; and improved flood control protocols and coordination at Elephant Butte and Caballo Dams. Additional information concerning the public scoping process and input received is included in Chapter 5 and Appendix E.

2.4.2 Description of Alternatives for Detailed Analysis

Based on public scoping, review of historic hydrologic extremes, and considering the breadth of possible events that could occur within a 40-year planning period, draft operational plans (designated by letters) were developed using combinations of facility-specific actions. These plans were further differentiated (modified by numbers) recognizing natural limitations and operational feasibilities under a range of climatic conditions. Some draft alternatives necessarily fell out in the initial screening process through application of the three preliminary screening criteria presented in the public scoping meetings: (1) the alternative is physically possible; (2) the alternative meets the Memorandum of Agreement purpose and need statement; and (3) the alternative is within the existing authorities of the agencies involved.

Alternatives considered for detailed analysis were selected based on a review of preliminary URGWOM planning version results using three threshold screening criteria identified by the JLA and Steering Committee, together with detailed water operations performance measures developed by the Water Operations Support Team and consideration of significant issues identified by the public in the draft alternatives meetings. Threshold criteria included dam safety and flood control operations, Compact compliance, and meeting contractual water supply obligations. The final alternatives that were analyzed in this EIS are listed in **Table 2-1** with the primary operational components at each facility that were identified as having flexibility.

Table 2-1. Summary of No Action and Action Alternatives Retained for Detailed Analysis

Alternatives	Operation/Facility						
	Heron Waivers	Abiquiu Storage Capacity	Abiquiu Channel Capacity	Cochiti Channel Capacity	Diversions to LFCC	Elephant Butte and Caballo	Basin-wide
No Action [1] (G-3)	April 30	0 AF	1,800 cfs	7,000 cfs	0–2,000 cfs	Informal coordination	Informal communication
B-3	Sept. 30	0–180,000 AF	1,500 cfs	8,500 cfs	No Change	Protocol/ coordination	Improved communications
D-3	Aug. 31	0–180,000 AF	2,000 cfs	No Change	No Change	Protocol/ coordination	Improved communications
E-3 [2]	Sept. 30	0–180,000 AF	No Change	10,000 cfs	No Change	Protocol/ coordination	Improved communications
I-1	No Change	0–20,000 AF	No Change	No Change	0–500 cfs	Protocol/ coordination	Improved communications
I-2	No Change	0–75,000 AF	No Change	No Change	0–1,000 cfs	Protocol/ coordination	Improved communications
I-3	No Change	0–180,000 AF	No Change	No Change	No Change	Protocol/ coordination	Improved communications

Note: No Change means no difference from No Action alternative. Modeled diversions to the LFCC begin only when there is at least 250 cfs in the river.

[1] Least flexible alternative. [2] Most flexible alternative.

A brief description of how the Action Alternatives are different from the No Action is included below, associated with the numbers of the significant issues to which they respond. Several of the alternatives address the same public comments, but vary in a few parameters in order to facilitate the evaluation of resource impacts from combinations of differences throughout the system. Alternatives were modeled to maximize available storage and diversion capacities.

2.4.2.1 Alternative B-3

Alternative B-3 was defined as an Action Alternative in order to evaluate the impacts of later water delivery from Heron Dam, to take advantage of the flexibility available to store native Rio Grande water in Abiquiu Reservoir, consider lower flows below Abiquiu Dam, and higher flows below Cochiti Dam. These variations from No Action were included in an alternative to address the following issues identified in Section 2.4.1 above: 1a, 1b, 1c, 2, and 3.

2.4.2.2 Alternative D-3

The primary differences between Alternative D-3 and the No Action Alternative are a later Heron waiver date, storage of native Rio Grande water in Abiquiu Reservoir, and a higher maximum flow below Abiquiu Dam. These variations from No Action were included in an alternative to address the following issues identified in Section 2.4.1 above: 1b, 1c, 2.

2.4.2.3 Alternative E-3

The primary differences between Alternative E-3 and the No Action Alternative are a later Heron waiver date, storage of native Rio Grande water in Abiquiu Reservoir, and a higher maximum flow in the

channels below Abiquiu Dam and Cochiti Dam. These variations from No Action were included in an alternative to address the following issues identified in Section 2.4.1 above: 1b, 1c, 2.

2.4.2.4 Alternative I-1

The primary differences between Alternative I-1 and the No Action Alternative are storage of native Rio Grande water in Abiquiu Reservoir and a lower maximum diversion into the LFCC. These variations from No Action were included in an alternative to address concerns from the Interdisciplinary NEPA Team that a greater range of upstream storage and LFCC diversions should be analyzed in order to better understand the impacts to resources along the Rio Chama and the Rio Grande. It was also developed to increase the variation between alternatives in compliance with NEPA requirements.

2.4.2.5 Alternative I-2

The primary differences between Alternative I-2 and the No Action Alternative are storage of native Rio Grande water in Abiquiu Reservoir and a lower maximum diversion into the LFCC. These variations from No Action were included in an alternative to address concerns from the Interdisciplinary NEPA Team that a greater range of upstream storage and LFCC diversions should be analyzed in order to better understand the impacts on resources along the Rio Chama and the Rio Grande. It was also developed to increase the variation between alternatives in compliance with NEPA requirements.

2.4.2.6 Alternative I-3

The primary differences between Alternative I-3 and the No Action Alternative are high amounts of storage of native Rio Grande water in Abiquiu Reservoir and the maximum authorized diversion into the LFCC. These variations from No Action were included in an alternative to analyze the impacts to the system through exercising maximum flexibility in upstream storage and LFCC diversions in order to better understand the impacts on resources along the Rio Chama and the Rio Grande.

2.4.3 Description of Operational Flexibilities and Preliminary Screening

The scope of this Review and EIS was limited to evaluating operational flexibilities in ten water operations facilities under existing JLA authorities. Of the ten facilities, only El Vado Dam was determined to be outside the scope of this Review and EIS. The nine remaining facilities can be manipulated individually or in concert by the lead federal agencies to address various situations. First, general areas of flexibility were identified:

- **Heron Reservoir Waivers—**A waiver provides an extension for water contractors required to take delivery of their current-year SJC water allocation from Heron Reservoir before December 31. Waivers are typically not provided unless they would benefit the federal government and would not interfere with other water users. Contractors take delivery upon release by the use, sale, or movement of water to downstream storage reservoirs. Extending waiver dates can allow for additional storage of native water downstream. Temporary waivers allowing extended storage and later delivery were historically used to enhance winter flows and fisheries management on the Rio Chama. Waivers provide additional capacity to store snowmelt runoff and SJC waters in other downstream reservoirs, as long as Compact compliance is maintained. Waivers are only permitted for SJC water stored in Heron Reservoir.
- **Abiquiu Reservoir Native Storage—**Currently, Abiquiu Reservoir is the only facility above San Marcial (approximately 237 river miles upstream) authorized for native storage. Opportunities for native water storage in Abiquiu Reservoir occur, subject to a State Engineer permit, when all of the following are true.
    1. Native water flow on the mainstem of the Rio Grande is sufficient to meet downstream demand in the Española and middle Rio Grande valleys.

2. Native water inflow to the reservoir exceeds downstream demand on the Rio Chama.
3. Rio Grande Compact does not limit native water storage operations.
4. New Mexico is in an accrued Compact credit status.
5. Space exists in the authorized pool within the reservoir.

- **Channel Capacity—**Ranges in channel capacity downstream of Abiquiu and Cochiti Dams offer options to decrease or increase release rates in accordance with needs for flood management, water delivery demands, and Compact compliance.
- **LFCC Operations—**Historically, the LFCC conveyed water from San Acacia to Elephant Butte Reservoir, reducing evaporation, transpiration, and infiltration losses, resulting in improved Compact compliance. While the LFCC is not currently operational, as designed, Reclamation is evaluating a full range of operations including realigning and restoring this conveyance and diversion at original design diversion rates, diversion at limited rates, and zero diversions. This EIS considers the full range of diversion options for the LFCC.

No substantive operational flexibilities were identified for the Closed Basin Project and Platoro Dam. Only limited changes were identified for Elephant Butte and Caballo Reservoirs because only flood control operations were included for consideration in this Review and EIS.

2.4.4 Considered but Eliminated from Detailed Analysis

A complete list of all of the draft alternatives developed for preliminary analysis, including those selected to be analyzed in detail, appears in **Table 2-2**. Appendix I documents the actions considered at each facility and the water operations attributes used to evaluate each action. The rationale for selecting or not selecting an action is also presented in detail. Plans A through F were developed considering the ranges of operating flexibility at each facility, together with scoping issues. Plan G represents present operating conditions with improved coordination and communication and was identified as the No Action Alternative. Plan H represents historic independent facility operations by various federal agencies. Plan I Alternatives were added based on additional constraints requested for further consideration by the Interdisciplinary (ID) National Environmental Policy Act (NEPA) Team in order to ensure that a full range of alternatives would be considered. Actions determined to be outside the scope of this Review and EIS are discussed in Chapter 6 for possible future consideration.

To assist in the selection of the Action Alternatives and the elimination of some of the draft alternatives, ten qualitative performance criteria were established and weighed in importance, as shown in **Table 2-3**. The Water Operations Team evaluated the relative magnitude of flood control protection, Compact delivery, native storage, carryover storage, reservoir drawdown, peak flow, sediment transport, and water supply delivery. Alternative performance against the ten performance measures was assessed and ranked. Action alternatives were selected for further analysis. The alternatives selected provided a high level of flexibility and maintained the ability to balance variable water supply conditions with multiple demands. The highest-ranking alternatives included Plans B-3, C-3, D-3, E-3, and I-3. The ID NEPA Team also requested the inclusion of two alternatives. To limit the number of alternatives analyzed in detail, Action Alternatives C-3 and E-3 were combined due to similarities in proposed actions. Although Alternatives I-1 and I-2 do not necessarily meet the Rio Grande Compact compliance threshold criterion, they were retained at the request of the Interdisciplinary NEPA Team to broaden the spectrum of alternatives analyzed to include limiting LFCC diversions and restrictions on Abiquiu native water storage. Alternatives retained for detailed analysis are highlighted in Table 2-2. Alternative scores relative to performance measures evaluated by the Water Operations team are presented in Table 2-3.

Table 2-2. Alternative Plans Considered for Analysis

Plan	A	B	C	D	E	F	G	H	I
Feature or Action	**A-1**	**B-1**	**C-1**	**D-1**	**E-1**	**F-1**	**G-1**		**I-1**
Heron Reservoir Waivers	Waivers - 4/30	Waivers - 4/30	Waivers - 4/30	Waivers - 4/30	Waivers - 4/30	Waivers - 4/30	NC	NC	Waivers - 4/30
Abiquiu Native Storage	0-20,000 AF	0-20,000 AF	0-20,000 AF	0-20,000 AF	0-20,000 AF	0 AF	NC	NC	0-20,000 AF
Abiquiu Channel Capacity	1,200 cfs	1,500 cfs	1,800 cfs	2,000 cfs	1,800 cfs	1,800 cfs	NC	NC	1,800 cfs
Cochiti Channel Capacity	7,000 cfs	7,000 cfs	7,000 cfs	7,000 cfs	10,000 cfs	10,000 cfs	NC	NC	7,000 cfs
Low Flow Conveyance Channel	0 - 2,000 cfs	0 - 2,000 cfs	0 - 2,000 cfs	0 - 2,000 cfs	0 - 2,000 cfs	Limited Diversion	NC	NC	0 - 500 cfs
Elephant Butte/Caballo Coordination	I	I	I	I	I	I	I	NC	I
Communications	I	I	I	I	I	I	I	NC	I
Feature or Action	**A-2**	**B-2**	**C-2**	**D-2**	**E-2**	**F-2**	**G-2**		**I-2**
Heron Reservoir Waivers	Waivers - 9/30	Waivers - 9/30	Waivers - 9/30	Waivers - 8/31	Waivers - 4/30	Waivers - 4/30	NC	NC	Waivers - 4/30
Abiquiu Native Storage	20,000-75,000 AF	20,000-75,000 AF	20,000-75,000 AF	20,000-75,000 AF	20,000-75,000 AF	0 AF	NC	NC	0-75,000 AF
Abiquiu Channel Capacity	1,200 cfs	1,500 cfs	1,800 cfs	2,000 cfs	1,800 cfs	1,800 cfs	NC	NC	1,800 cfs
Cochiti Channel Capacity	7,000 cfs	7,000 cfs	7,000 - 10,000 cfs	7,000 cfs	10,000 cfs	10,000 cfs	NC	NC	7,000 cfs
Low Flow Conveyance Channel	0 - 2,000 cfs	0 - 2,000 cfs	0 - 2,000 cfs	0 - 2,000 cfs	0 - 2,000 cfs	Coordination & Protocol	NC	NC	0 - 1,000 cfs
Elephant Butte/Caballo Coordination	I	I	I	I	I	I	I	NC	I
Communications	I	I	I	I	I	I	I	NC	I

Plan	A	B	C	D	E	F	G	H	I
Feature or Action	**A-3**	**B-3**	**C-3*** **	**D-3**	**E-3**	**F-3**	**G-3 (No Action)**		**I-3**
Heron Reservoir Waivers	Waivers - 9/30	Waivers - 9/30	Waivers - 9/30	Waivers - 8/31	Waivers - 4/30	Waivers - 4/30	NC	NC	Waivers - 4/30
Abiquiu Native Storage	75,000-180,000 AF	0-180,000 AF	75,000-180,000 AF	0-180,000 AF	0-180,000 AF	0 AF	NC	NC	0-180,000 AF
Abiquiu Channel Capacity	1,200 cfs	1,500 cfs	1,800 cfs	2,000 cfs	1,800 cfs	1,800 cfs	NC	NC	1,800 cfs
Cochiti Channel Capacity	7,000 - 8,500 cfs	8,500 cfs	8,000 - 10,000 cfs	7,000 cfs	10,000 cfs	10,000 cfs	NC	NC	7,000 cfs
Low Flow Conveyance Channel	0 - 2,000 cfs	0 - 2,000 cfs	0 - 2,000 cfs	0 - 2,000 cfs	0 - 2,000 cfs	Coordination & Protocol	NC	NC	0 - 2,000 cfs
Elephant Butte/Caballo Coordination	I	I	I	I	I	I	I	NC	I
Communications	I	I	I	I	I	I	I	NC	I

NOTES:

Denotes alternative retained for detailed analysis

NC No change from current operations

I Improved communications

AF = acre-feet

cfs = cubic feet per second

Waivers - #/# = Waivers - month/day

C-3*** = Alternative combined with E-3 for detailed analysis

Table 2-3. Decision Support: Alternative Performance vs. Water Operations Performance Measures

	Performance Measure	Compatible w/Flood Control Operations	Compatible w/Rio Grande Compact	Improves System Operational Flexibility	Supports Water Delivery	Maximizes Conservation Storage Opportunities	Maximizes Peak Discharge Opportunities	Maximizes Sediment Transport Opportunities	Supports Desirable Winter Flows	Supports Recreational Uses	Supports Stable Reservoir Levels	Wtd. Avg. % Met	Rank
	Threshold Criterion	X	X		X								
	ALTERNATIVE / Weight	0.20	0.20	0.15	0.15	0.10	0.08	0.05	0.04	0.02	0.01		
1	**Plan G - No Action (Baseline)**	**7**	**4**	**5**	**8**	**0**	**6**	**6**	**5**	**5**	**5**	**52.80%**	**19**
2	Plan A-1	4	5	3	2	3	2	2	3	3	3	33.20%	22
3	Plan A-2	4	5	4	2	7	2	2	1	1	1	37.30%	21
4	Plan A-3	4	5	5	2	10	2	2	1	1	1	41.80%	20
5	Plan B-1	6	7	6	7	3	5	5	4	4	4	57.80%	18
6	Plan B-2	7	7	8	8	7	7	7	5	5	5	71.60%	16
7*	**Plan B-3**	**9**	**9**	**10**	**8**	**10**	**8**	**9**	**5**	**5**	**5**	**87.40%**	**6**
8	Plan C-1	7	8	6	8	3	6	6	5	5	5	65.30%	17
9	Plan C-2	10	10	8	9	7	9	8	6	5	5	87.60%	5
10***	**Plan C-3**	**10**	**10**	**10**	**10**	**10**	**9**	**9**	**6**	**5**	**5**	**95.60%**	**1**
11	Plan D-1	10	8	7	10	3	8	8	5	5	5	78.40%	11
12	Plan D-2	10	8	8	10	7	8	8	5	5	5	83.90%	8
2*	**Plan D-3**	**10**	**10**	**10**	**10**	**10**	**8**	**8**	**5**	**5**	**5**	**93.90%**	**3**
14	Plan E-1	10	10	6	8	3	9	9	5	6	5	79.40%	10
15	Plan E-2	10	10	7	9	7	9	9	6	6	5	86.80%	7
16*	**Plan E-3**	**10**	**10**	**9**	**10**	**10**	**9**	**9**	**6**	**6**	**5**	**94.30%**	**2**
17	Plan F-1	10	8	5	10	0	9	9	6	6	6	74.40%	13
18	Plan F-2	10	8	5	10	0	9	9	6	6	6	74.40%	13
19	Plan F-3	10	8	5	10	0	9	9	6	6	6	74.40%	13
20**	**Plan I-1**	**10**	**6**	**6**	**10**	**3**	**7**	**7**	**6**	**6**	**6**	**72.30%**	**15**
21**	**Plan I-2**	**10**	**8**	**8**	**10**	**7**	**7**	**7**	**6**	**6**	**6**	**83.30%**	**9**
22*	**Plan I-3**	**10**	**10**	**10**	**10**	**10**	**7**	**7**	**6**	**6**	**6**	**93.30%**	**4**

NOTES: 1. Performance Measure weights sum to 100 points total
2. Weighted Average Percent Met multiplies sums (scores * weights) for all measures
3. Alternatives are ranked from highest to lowest score
4. Alternatives selected for detailed analysis are shown in bold text.

7*	Alternative Selected by Water Operations Rankings for Detailed Analysis
20**	Alternative Selected by ID NEPA Team for Broader Operations Analysis
10***	Alternative combined with E-3 for detailed analysis

General reasons why certain alternatives moved forward, while others were eliminated from further analysis, are summarized below (Appendix I). This analysis is partly based on an evaluation of discrete operational elements.

- **Heron Reservoir Waiver Flexibility (April 30, June 30, August 31, September 30, and No Waivers)—**Waivers extending carryover deadlines expand operational flexibility. April 30 waivers reflect current operating policy that benefits the United States, SJC Project contractors, and affords winter flows on the Rio Chama between El Vado Dam and Abiquiu Reservoir. The June 30 waiver option was not considered further because it did not provide significant benefit over the current April 30 waiver allowance and encumbered possible early snowmelt storage during the March to May time frame. The August 31 extension for carryover storage was retained for further analysis because it offered the potential to increase system-wide water storage in downstream reservoirs (El Vado or Abiquiu Reservoirs). SJC water subject to an August 31 waiver would be delivered in July and August, after snowmelt runoff. In most years, there is demand for native water in storage by late June; native water released from storage would be replaced by the release of waivered SJC water stored in Heron Reservoir. The September 30 waiver provides an additional month of flexibility over the August 31 option and was retained for analysis. A no waivers policy was eliminated because it restricts flexibility. Contractors who do not take delivery of SJC project water stored in Heron Reservoir, either by use, sale, or contracting for downstream storage, forfeit their allocation, which reverts back to SJC project storage. Eliminating waivers negatively impacts winter flows on the Rio Chama between El Vado Dam and Abiquiu Reservoir by restricting flows to only that amount required to replace water evaporated in Cochiti Lake and bypass native Rio Grande flows. Under a no waivers scenario, the Rio Chama experiences greater flow variability, being high in November and December as water is moved out of Heron Reservoir, then sharply decreasing to less than 50 cfs during January and February.
- **Abiquiu Reservoir Native Storage (20,000 AF; 75,000 AF; 180,000 AF)—**Flexibilities in storing native water in Abiquiu Reservoir were initially evaluated considering caps at 20,000; 50,000; 100,000; and 200,000 AF. To decrease the number of alternatives to be modeled, the water operations team merged the analysis of the 50,000 and 100,000 AF storage capacities to a limit of 75,000 AF. The upper 200,000 AF native storage target was modified to 180,000 AF due to a practical storage capacity limit of 183,000 AF resulting from the sediment that has accumulated since the dam became operational. The 20,000 AF native storage option provides storage of native Rio Grande spring runoff flows in Abiquiu Reservoir in storage space not being used by SJC project water. Opportunities for additional storage occur when native flows exceed downstream demands and New Mexico is in compliance with the Compact. The maximum storage elevation of 6,220 feet mean sea level cannot be exceeded by the combination of native and SJC project water. During storage of excess native flows, release rates below Abiquiu Dam are limited to 200 cfs but can be increased to meet downstream demands. Native storage at 75,000 AF is feasible, provided space is available in the reservoir as noted above. There are a number of years where native storage could be increased to provide additional water to meet multiple demands. Therefore, the 180,000 AF practical storage limit was retained to analyze maximum potential native storage acknowledging that this limit will decrease over time due to accumulating sediment.
- **Abiquiu Channel Capacity (1,200; 1,500; 1,800; and 2,000 cfs)—**Initial evaluation of possible ranges in Abiquiu channel capacity examined 600 and 800 cfs options. However, these were eliminated prior to crafting alternatives because such low capacities could not convey sufficient water to meet Compact requirements, irrigation demands, SJC project deliveries, and maintain releases to benefit endangered species. A maximum 2,500 cfs channel capacity was also evaluated and discarded due to concerns over bank erosion, flooding, and disturbance to earthen

diversion structures. The range of channel capacities cited above was retained as a feasible series of operating ranges suitable for framing discrete alternatives.

- **Cochiti Channel Capacity (7,000; 8,500; and 10,000 cfs)—**Initial examination of a base 5,000-cfs capacity was discarded because of negative impacts to Compact deliveries, lack of channel-forming discharges, decreased flood protection, decreased overbank flooding, and limitations to SJC project deliveries. An upper 12,500 cfs maximum channel capacity was also discarded due to negative impacts from bank sloughing, possible flooding of irrigated lands in the Cochiti to Bernalillo reach, and needs for additional bank and flood protection structures. The retained channel capacities were feasible and were used in discrete alternatives subjected to further analysis.
- **LFCC Operations (0-500; 0-1,000; and 0-2,000 cfs)—**The LFCC is not currently operating due to the lack of a viable outfall to Elephant Butte Reservoir. Historically, the LFCC operations were credited with assisting the State of New Mexico in maintaining Compact compliance. If a viable outfall were constructed, the LFCC could be operated to deliver between 0 and 2,000 cfs, providing additional operating flexibility to the system. All alternatives have the potential to divert into the LFCC. Potential benefits of considering the full range of LFCC operations allows for evaluation of impacts on Compact deliveries, critical habitats, and other resources in the San Acacia Section. Improved communication and coordination was also included as federal entities have been subjected to changing flow criteria related to endangered species, as mandated by courts and legislation. While actual flow or bypass targets are subject to change, the LFCC operations were modeled assuming a 250 cfs bypass at San Acacia. The modeled 250 cfs bypass occurs only when natural river flows supply this water. Because the bypass consists of natural river flows, releases from upstream storage in order to maintain a constant 250 cfs were not modeled. Flows past San Acacia will drop below 250 cfs when there is less than 250 cfs of natural flow in the river.

2.5 Preferred Alternative

Alternative E-3 is the JLA Preferred Alternative because it meets the purpose and need and threshold criteria, and best satisfies the key goals of the EIS—to provide a plan for more efficient operation of federal reservoirs and facilities as an integrated system, to improve decision-making processes and interagency coordination, to support compliance with applicable laws and regulations, and to promote ecosystem sustainability. Of the alternatives evaluated that maximize native Rio Grande conservation water storage in Abiquiu Reservoir, Alternative E-3 ranked highest in ecosystem support. The key elements of Alternative E-3 are shown in Table 2-1. Alternative B-3 was identified as the Preferred Alternative in the Draft EIS. Alternative E-3 was selected over B-3 as the Preferred Alternative in this Final EIS in response to public comments, internal comments from agency personnel, and to facilitate implementation of a single Preferred Alternative that enables all three lead agencies to best meet their respective water management responsibilities.

Beneficial and adverse impacts of each of the alternatives, including the Preferred Alternative E-3, are compared in Table 2-4 and discussed in detail in Chapter 4 of this EIS. Adverse effects of Alternative E-3, compared to No Action, were primarily experienced in the San Acacia Section and were related to diversions to the LFCC. Adverse effects include a slight decrease in reservoir ecosystem habitat, sediment management, and environmental justice (related to changes in overbank flooding and channel capacity), and a moderate decrease in SWFL habitat, compared to the No Action Alternative. Some of the benefits associated with the implementation of Alternative E-3 are listed below.

- Maximize overall flexibility for water operations in the Upper Rio Grande Basin
- Maximize overall capacity in the system

- Maximize native Rio Grande conservation water storage
- Provide improved capability for higher flows during spring runoff
- Maintain channel capacity in the Rio Chama and Rio Grande
- Improve Compact delivery and management
- Increase overbank flooding through the Central Section of the Rio Grande
- Improve ability to provide supplemental flows for RGSM
- Provide recruitment flows for RGSM spawn
- Provide greater operational flexibility in trade-off between Rio Grande and San Juan-Chama water
- Increase potential for reduction of evaporative losses
- Improve ability to carry over water to better meet downstream water demands and biological requirements
- Improve ability to store water for use during drought

Alternative B-3 was identified as the top-ranked alternative because it met the most evaluation criteria. The key elements of Alternative B-3 are shown in Table 2-1. Decision-support software was used to determine the top-ranked alternative by applying weighted decision criteria developed by the Technical Teams, Steering Committee, and Executive Committee (see full discussion in Section 4.2 and Appendix P). Alternative B-3 did not rank as high as Alternative E-3 in some of the biological performance measures, and does not maximize flexibility in system-wide water operations.

Alternative I-1 was identified as the environmentally preferable alternative because it performed slightly better in ecosystem support than the other alternatives. For reasons more specifically discussed in Section 2.4.2 and Table 2-4, Alternative I-1 was carried forward for detailed analysis in this EIS, even though it does not meet Compact and Treaty compliance, which is one of the three threshold criteria.

Implementation of the elements of Alternative E-3 would be conducted by the appropriate authorizing JLA. Reclamation is the federal agency responsible for actions at Heron Reservoir and the LFCC. The Corps is the federal agency responsible for actions at Abiquiu Reservoir, Cochiti Lake, and downstream channel capacities. It is anticipated that specific actions to implement Alternative E-3 would occur separately and over time, and that additional NEPA evaluation and coordination would first be conducted, as appropriate, by the lead federal agency.

2.6 Comparison of Impacts under Each Alternative

The criteria evaluated and the impacts found for each alternative are summarized in **Table 2-4** and described in detail in Chapter 4.

Table 2-4. Comparison of Impacts under Each Alternative

Criterion/Resource	Subcategory	ALTERNATIVES						
		No Action	**B-3**	**D-3**	**E-3**	**I-1**	**I-2**	**I-3**
Dam Safety & Flood Control		Adequate	Met	Met	Met	Met	Met	Met
Water Deliveries		Adequate	Met	Met	Met	Met	Met	Met
Compact & Treaty Compliance		Inadequate	Met	Met	Met	Not Met	Not Met	Met
Ecosystem	Riverine	—	—	—	—	—	—	—
	Reservoir	—	■	■	■	■■	■■	■■
	Riparian	—	■■	■	—	❑	—	■
	T&E Species - RGSM	—	—	—	—	❑	❑	—
	T&E Species - SWFL	—	■	■■	■■	❑	—	■■
	Other T&E Species	—	■	—	—	❑	—	■
Operating Flexibility	Reservoir	—	❑❑	❑❑	❑❑	❑	❑❑	❑❑
	River	—	—	—	—	—	—	—
Water Quality		—	❑	—	—	—	—	—
Sediment Management		—	■	■	■	■	■	■
Indian Trust Assets		—	❑	■	❑	—	—	—
Cultural Resources		—	❑❑	❑❑	❑❑	❑	❑❑	❑❑
Land Use	Agricultural	—	❑❑	❑	❑	—	—	❑
	Recreation	—	❑❑❑	❑	❑❑	—	❑	❑❑
	Other Land Uses	—	❑	❑	❑	—	❑	❑
	Hydropower	—	❑	❑❑❑	❑❑❑	❑❑	❑❑	❑❑❑
	Flood Control - Damages	—	❑❑	❑❑❑	❑❑	❑	❑❑	❑❑❑
Fairness & Equity	Environmental Justice	—	❑❑	■■■	■	—	❑	■■
			TR		**PA**	**EP**		

Legend:				
	—	No Significant Impact	T&E =	Threatened & Endangered
	❑	Slight improvement	RGSM =	Rio Grande Silvery Minnow
	❑❑	Moderate Improvement	SWFL =	Southwest Willow Flycatcher
	❑❑❑	Substantial Improvement	EP =	Environmentally-Preferred Alternative
	■	Slight Decrease	TR =	Top-Ranked Alternative
	■■	Moderate Decrease	PA =	Preferred Alternative
	■■■	Substantial Decrease		