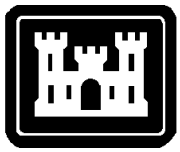

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Technical Considerations for Alamo Lake Operation

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This study evaluates polices for operating Alamo Lake in Arizona for the Los Angeles District Corps of Engineers. The analyses specifically addresses three questions of interest to the District: (1) can Alamo Lake be operated to protect against bald eagle nest inundation and if so, what are the downstream impacts; (2) can different drawn-down schemes for required dam maintenance improve the conflicting conditions; (3) can the operation plan recommended by the Bill Williams River Corridor Technical Committee by improved? Results from a combined approach using an optimization (HEC-PRM) and simulation model of the Alamo system confirmed that the proposed operating rule performs very well. Significant Improvements to operation using a flexible drawn-down scheme instead of a rigid schedule can be obtained. The chance of inundation of eagle nest inundation can be reduced from 18 to 5 percent in a year by a different operation strategy but at a significant impact to other endangered species in the downstream riverine corridor.

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Preface

This report presents a technical study regarding operation of Alamo Reservoir conducted by the Hydrologic Engineering Center (HEC). The study evaluates various operating strategies designed to reduce conflict between objectives including draw-downs for maintenance inspections, protection against inundation of eagle nests, and support for downstream riparian obligate species.

Kenneth W. Kirby performed the study while under contract with the Hydrologic Engineering Center. Joe Evelyn, Chief, Hydraulics and Hydrologic Branch, Los Angeles District Corps of Engineers provided technical support. Michael Burnham, Chief, Planning Analysis Division, HEC, provided study direction and management. Darryl W. Davis was Director of HEC during the conduct of the study. The Los Angeles District provided data and general guidance for this study.

Executive Summary

Report Summary

This study was conducted as one of several efforts under way by the Los Angeles District of the US Army Corps of Engineers to evaluate policies for operating Alamo Reservoir in Arizona. The Los Angeles District is facing some difficult operational decisions for Alamo Dam. The District recently participated in an interagency cooperative study to address conflicting operational objectives. Results of the cooperative study are outlined in the *Proposed Water Management Plan for Alamo Lake and the Bill Williams River* (BWRCTC 1994). This study addresses questions not resolved during the Bill Williams River Corridor Technical Committee study.

For the past ten years, bald eagles have been nesting around Alamo reservoir. The eagles often nest in snags, (dead trees) near the edge of the reservoir pool. If a large rain event occurs upstream of Alamo Dam, the eagle nests can be inundated by rising reservoir pool levels. The eagles also rely on the reservoir for forage, and the U.S. Fish and Wildlife Service has requested that the reservoir pool level be kept above 1,100 feet elevation to provide adequate forage area. Furthermore, the Bill Williams River downstream of Alamo Dam flows through a National Wildlife Area and supports the last extensive native cottonwood riparian habitat in Arizona. Several species protected by the Endangered Species Act depend on this riparian habitat. The health of the riparian habitat depends heavily upon operation of Alamo dam. This study attempts to provide quantitative estimates of impacts for various objectives caused by different operating strategies.

This work specifically addresses three questions of interest to the Los Angeles District Corps of Engineers:

- Can Alamo reservoir be operated to protect against bald eagle nest inundation, and if so, can impacts on the riparian habitat and other listed species be approximated?
- Can different draw-down schemes for required maintenance improve reservoir performance based on evaluation criteria used in the BWRCTC study?
- Can the operation plan recommended by the Bill Williams River Corridor Technical Committee (BWRCTC) be improved based on results from an HEC-PRM model of Alamo Reservoir system?

The following tasks were performed to address these questions:

- Comparison of results from a combined optimization and simulation modeling approach with results from the operation policy recommended by the BWRCTC.

- Evaluation of a flexible interval draw-down strategy for performing required maintenance inspections of Alamo Dam as compared to the fixed interval draw-down scheme used in the BWRCTC study.
- Development of a probabilistic simulation method to model nesting behavior of bald eagles around Alamo Reservoir.
- Estimation of the likelihood of harassment and inundation for eagle nests based on the BWRCTC proposed operating policy.
- Specification and testing of an operating policy designed to reduce the threat of eagle nest harassment and inundation.
- Estimation and comparison of tradeoffs between operational objectives using probabilistic simulation of the operating policy designed to reduce likelihood of eagle nest inundation.
- Review of the Endangered Species Act (ESA) and related literature to determine what guidance is offered to manage conflict between species protected by the ESA.

Conclusions

1. Results from a combined approach using an optimization (HEC-PRM) and simulation model of the Alamo Reservoir system confirmed that the operating rule proposed by the Bill Williams River Corridor Technical Committee performs very well.

2. The HEC-PRM model results agree with the BWRCTC findings that 1,125 feet is a good target elevation to meet operational objectives.

3. Slight modifications to the BWRCTC rule form can increase the number of pulse flow events (desirable for riparian habitat) over the simulation period.

4. A flexible draw-down scheme that schedules draw-down events based on the condition of the reservoir instead of on a rigid schedule significantly improves reservoir performance according to the evaluation criteria.

5. Based on the historical record of inflows and the physical characteristics of Alamo Reservoir, it is impossible to prevent eagle nest inundation 100% of the time.

6. Probabilistic simulation of eagle nesting behavior shows that if an operating strategy based on the BWRCTC proposed rule is implemented, there exists an 0.18 probability that an eagle nest will be inundated during a year.

7. The chance of eagle nest inundation can be reduced to 5% per year by implementing an operating policy that responds to the nesting behavior of the eagles, but this reduction in inundation risk causes significant reductions in performance for other objectives including protection of other species listed under the Endangered Species Act, and even maintenance of forage area for the bald eagles.

8. Provisions in the Endangered Species Act, such as the federal consultation process and multi species recovery plans provide a legal method for the USACE to help formulate a comprehensive long-term approach to manage conflicting interests between listed species impacted by operation of Alamo Reservoir.

Chapter 1

Introduction

1.1 Summary

This report presents technical study results performed by the Hydrologic Engineering Center for the Los Angeles District US Army Corps of Engineers. The Los Angeles District is currently evaluating possible changes to the operation plan for Alamo Reservoir. During the late 1980's, the agencies responsible for managing resources along the Bill Williams River were in conflict over their individual goals and missions. Many of the issues surrounding the conflict were addressed through an interagency cooperative study performed by the Bill Williams River Corridor Technical Committee (BWRCTC) outlined in the *Proposed Water Management Plan for Alamo Dam and the Bill Williams River* (BWRCTC 1994). However, some of the issues impacting the specification of a new operations plan were not resolved by the BWRCTC. The primary issue not resolved during the BWRCTC study is operation to prevent bald eagle nest inundation. Within recent years, eagle nests have been threatened by rising reservoir pool elevations. These events provoked further disagreement regarding how Alamo reservoir should be operated. Modifying the reservoir operations to prevent inundation during a flood event seemed, at least potentially, to be in conflict with other agreed upon operating strategies, including those for protected species downstream. The Los Angeles District desires to develop a comprehensive long-term strategy to deal with the difficult issue of competition between species protected under the Endangered Species Act. The District felt that an estimate of likely trade-offs between competing objectives for different operating strategies would be extremely helpful to craft a long-term strategy. The District was also interested to see if reservoir performance could be improved by using a different draw-down scheme for required maintenance inspections, and was curious to see how results from a combined optimization / simulation modeling approach would compare to the results obtained by the BWRCTC using only simulation modeling.

Therefore, this study addresses the following questions:

- Can Alamo reservoir be operated to protect against bald eagle nest inundation, and if so, can impacts on the riparian habitat and other listed species be approximated?
- Can different draw-down schemes for required maintenance improve reservoir performance based on evaluation criteria used in the BWRCTC study?
- Can improvements to the operation plan recommended by the Bill Williams River Corridor Technical Committee be made based on results from an HEC-PRM model of the Alamo Reservoir system?

1.2 Study Context

Alamo Lake is a multiple purpose reservoir owned and operated by the U.S. Army Corps of Engineers and is located in Arizona on the Bill Williams River approximately 39 river miles upstream of the confluence with the Colorado River (see Figure 1.1). The reservoir has a maximum capacity of 1,451,300 acre-feet (based on the 1993 storage table) with a gross drainage area of 4,770 square miles of broad desert valleys and irregularly distributed rugged mountain ranges. Steep gradients, impervious soil formations, and fan-shaped runoff patterns tend to produce high peak discharges of relatively short duration. An average annual precipitation of 13 inches over the sparsely vegetated watershed produces a mean annual runoff of 115.4 KAF despite an average annual pan evaporation of 65 inches.

During the late 1980's, agencies responsible for managing the Bill Williams River resources and Alamo Dam and Reservoir faced increasing conflict between their individual missions and perspectives. Much of the disagreement stemmed from how the Corps was operating the water conservation pool at Alamo Lake. In August 1990, believing that a cooperative effort offered the best chance to achieve a comprehensive water management agreement that would best satisfy agency management goals, the agencies instituted an interagency planning team -- the Bill Williams River Corridor Technical Committee. The BWRCTC was charged to develop a comprehensive water resource management plan for the Bill Williams River corridor addressing the following water management objectives (BWRCTC 1994):

- *Flood Control* -- The dam was authorized by Congress to provide flood control for lower Colorado River communities downstream from Parker Dam (Lake Havasu), and protect property along the Bill Williams River corridor. Alamo Dam is operated in conjunction with the U.S. Bureau of Reclamation dams on the Colorado River to reduce flood related damage.
- *Water Conservation and Supply* -- The entire water supply in the Bill Williams River (before reaching Lake Havasu) is entitled solely to Arizona. Bill Williams River flows that reach the Colorado River are allocated according to the "Law of the River" including the U.S. Supreme Court Decree in *Arizona v. California* of March 1964. To date, the Corps has not contracted with a user for water supply storage. The conservation pool has been used only for short-term storage of water, later released to Lake Havasu.
- *Recreation* -- The Arizona Game and Fish Department currently holds water rights for 25,000 acre-feet in the recreation pool. These rights are for fish, wildlife, and recreational purposes. The Arizona State Parks Department operates and maintains boat launching ramps, campgrounds, and appurtenant structures.
- *Fishery* -- Arizona Game and Fish has established a productive lake bass fishery. The productivity of the fishery is negatively affected by fluctuations in lake levels during spawning and growing seasons.
- *Endangered Species* -- Two pair of Southern Bald Eagles, a Federally listed species (recently reclassified as threatened), have nested around Alamo Lake since the early 1980's. In 1988 the U.S. Fish and Wildlife Service requested that the Corps maintain a minimum water surface elevation of 1,100 feet at Alamo Lake to ensure sufficient forage

area for the eagles. Also, the eagles occasionally nest in tree snags along the periphery of the lake, and reservoir operations have been modified to restrict boater access and prevent nest inundation.

- *Wildlife Habitat* -- The Bill Williams River Corridor includes a National Wildlife Refuge and flows through two designated wilderness areas. The river corridor is home to various neo-tropical migratory birds and several threatened or endangered species. The wildlife habitat depends on the vitality of the riparian habitat.
- *Riparian Habitat* -- The riparian habitat along the Bill Williams River contains the last extensive native cottonwood tree stands in Arizona. The U.S. Fish and Wildlife Service believes that a significant portion of the cottonwood trees have been destroyed due to the pattern of past Alamo Dam releases.

Figure 1.1 Map of Arizona and Alamo Lake (to be provided by Joe Evelyn)

1.3 Organization of Report

This report is divided into seven chapters. Chapter 2 discusses the simulation modeling effort used to conduct this study. The new model developed for this work is verified and compared against the HEC-5 model of the Bill Williams River system used by the BWRCTC. Data analysis techniques and the updated inflow record also are discussed. Chapter 3 presents how the optimization model (HEC-PRM) results are used to infer an alternate operating strategy and the results from this different approach are compared to results from the BWRCTC operating policies. Chapter 4 evaluates alternatives using a flexible interval strategy for maintenance draw-downs of Alamo Reservoir. Chapter 5 addresses the issue of eagle nest inundation, including an approach to model this stochastic behavior and an alternative to try and reduce the threat of nest inundation. Chapter 6 contains a review of the Endangered Species Act and related literature evaluate legal options available to manage competing interests between threatened and endangered species. Chapter 7 presents conclusions drawn from the analysis.