US Army Corps
of Engineers®

WATER CONTROL MANUAL

ALAMO DAM AND LAKE
COLORADO RIVER BASIN
BILL WILLIAMS RIVER

ARIZONA

OCTOBER 2003

ALAMO DAM AND LAKE
COLORADO RIVER BASIN, BILL WILLIAMS RIVER, ARIZONA

PERTINENT DATA (English Units)
October 2003

Completion date		July 1968
Stream system		Bill Williams River
Drainage area	sq-mi	4,770
Reservoir		
Elevation (from gross area-capacity table)		
Streambed at Intake Structure	ft., NGVD	990
Recreation Pool	ft., NGVD	1,070
Water Conservation Pool	ft., NGVD	1,160.4
Flood Control Pool (Spillway Crest)	ft., NGVD	1,235
Spillway Design Surcharge Level	ft., NGVD	1,259.6
Top of Dam	ft., NGVD	1,265
Area		
Streambed at Intake Structure	ac	0.00
Recreation Pool	ac	1,151
Water Conservation Pool	ac	5,881
Flood Control Pool (Spillway Crest)	ac	13,300
Spillway Design Surcharge Level	ac	16,550
Top of Dam	ac	17,100
Capacity		
Streambed at Intake Structure	ac-ft	0.0
Recreation Pool	ac-ft	24,372 (0.10*)
Water Conservation Pool	ac-ft	321,716 (1.26*)
Flood Control Pool (Spillway Crest)	ac-ft	995,300 (3.91*)
Spillway Design Surcharge Level	ac-ft	1,361,247 (5.35*)
Top of Dam	ac-ft	1,451,300 (5.70*)
Storage Allocations Below Spillway Crest		
Recreation	ac-ft	5,000 (0.02*)
Water Conservation	ac-ft	230,000 (0.90*)
Flood Control	ac-ft	608,369 (2.39*)
Sedimentation	ac-ft	200,000 (0.79*)
Dam: - Type		Rolled Earthfill
Height Above Original Streambed	ft, NGVD	283
Top Length	ft	975
Top Width	ft	30
Spillway: - Type		Detached, broad-crested
Crest Length	ft	110
Crest Elevation	ft., NGVD	1,235
Design Surcharge Elevation	ft., NGVD	1,259.6
Design Discharge	cfs	41,600
Outlet Works:		
Tunnel Length (including gate chamber and transition sections	ft	1,290
Intake Invert Elevation	ft., NGVD	990
Outlet Invert Elevation	ft., NGVD	980
Gates – Type		tandem slide
Number and Size		
Service (downstream)		three 5'W x 8.5'H
Emergency (upstream)		three 5'W x 8.5'H
Maximum Discharge at Spillway Crest	cfs	8,715
Low-flow Bypass around Service Gate No. 3		
Pipe Size, I. D	in.	18
Control Valve – Type		Butterfly
Maximum Discharge Capacity	cfs	112
Water-Surface Elevation to Initiate operation	ft., NGVD	1002.3
Standard Project Flood (revised March 1986):		
Inflow Duration	days	7
Total Volume	ac-ft	613,000 (2.41*)
Inflow Peak	cfs	389,000
Outflow Peak	cfs	7,000
Maximum Reservoir Elevation	ft., NGVD	1,222.14
Probable Maximum Flood (revised March 1986):		
Inflow Duration	days	3
Total Volume	ac-ft	1,390,000 (5.46*)
Inflow Peak	cfs	820,000
Outflow Peak	cfs	282,142
Maximum Pool Elevation	ft., NGVD	1281.3

*Inches of runoff on 4770 sq. mi. watershed

Historic Flood Inflow Peaks of Record
6 - 9 February 1937, inflow peak 106,530 cfs. 13-22 February 1980, inflow peak 82,000 cfs.
27 February -- 4 March 1983, inflow peak 69,070 cfs.
8 January -- 28 February 1993, inflow peak 104,667 cfs.

ALAMO DAM AND LAKE
COLORADO RIVER BASIN, BILL WILLIAMS RIVER, ARIZONA

PERTINENT DATA (SI Units)
October 2003

Completion date		July 1968
Stream system		Bill Williams River
Drainage area	sq-km	12,354
Reservoir		
Elevation (from gross area-capacity table)		
Streambed at Intake Structure	m, NGVD	301.75
Recreation Pool	m, NGVD	326.14
Water Conservation Pool	m, NGVD	353.69
Flood Control Pool (Spillway Crest)	m, NGVD	376.43
Spillway Design Surcharge Level	m, NGVD	383.93
Top of Dam	m, NGVD	385.57
Area		
Streambed at Intake Structure	ha	0.00
Recreation Pool	ha	465.8
Water Conservation Pool	ha	2,380
Flood Control Pool (Spillway Crest)	ha	5,382
Spillway Design Surcharge Level	ha	6,698
Top of Dam	ha	6,920
Capacity		
Streambed at Intake Structure	ha-m	0.0
Recreation Pool	ha-m	3,006 (0.25*)
Water Conservation Pool	ha-m	39,683 (3.20*)
Flood Control Pool (Spillway Crest)	ha-m	122,768 (9.93*)
Spillway Design Surcharge Level	ha-m	167,907 (13.59*)
Top of Dam	ha-m	179,015 (14.48*)
Storage Allocations Below Spillway Crest		
Recreation	ha-m	616.74 (0.051*)
Water Conservation	ha-m	28,370 (2.29*)
Flood Control	ha-m	75,041 (6.07*)
Sedimentation	ha-m	24,669 (2.01*)
Dam: - Type		Rolled Earthfill
Height Above Original Streambed	m, NGVD	86.26
Top Length	m	297.18
Top Width	m	9.14
Spillway: - Type		Detached, broad-crested
Crest Length	m	33.53
Crest Elevation	m., NGVD	376.43
Design Surcharge Elevation	m., NGVD	383.93
Design Discharge	cms	1,178
Outlet Works:		
Tunnel Length (including gate chamber and transition sections	m	393.19
Intake Invert Elevation	m., NGVD	301.75
Outlet Invert Elevation	m., NGVD	298.70
Gates – Type		tandem slide
Number and Size		
Service (downstream)		three 1.5m W x 2.6m H
Emergency (upstream)		three 1.5m W x 2.6m H
Maximum Discharge at Spillway Crest	cfs	246.78
Low-flow Bypass around Service Gate No. 3		
Pipe Size, I.D.	cm	45.7
Control Valve – Type		Butterfly
Maximum Discharge Capacity	cms	3.17
Water-Surface Elevation to Initiate operation	m., NGVD	305.5
Standard Project Flood (revised March 1986):		
Inflow Duration	days	7
Total Volume	ac-ft	75,612 (6.12*)
Inflow Peak	cms	11,015
Outflow Peak	cms	198
Maximum Reservoir Elevation	m, NGVD	372.51
Probable Maximum Flood (revised March 1986):		
Inflow Duration	days	5
Total Volume	ha-m	171,454 (13.87*)
Inflow Peak	cms	23,219
Outflow Peak	cms	7,989
Maximum Pool Elevation	m, NGVD	390.54

*Centimeters (cm) of runoff on 12,354 sq. km. watershed

Historic Flood Inflow Peaks of Record

6 - 9 February 1937, inflow peak 3,017 cms. 13-22 February 1980, inflow peak 2,322 cms.
27 February -- 4 March 1983, inflow peak 1,956 cms.
8 January -- 28 February 1993, inflow peak 2,964 cms.

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
333 Market Street, Room 923
San Francisco, California 94105-2195

REPLY TO
ATTENTION OF:

CESPD-MT-E

11 DEC 2003

MEMORANDUM FOR Commander, Los Angeles District, ATTN: CESPL-ED-HR

SUBJECT: Approval – Alamo Dam Water Control Manual

The South Pacific Division, Water Management Team has completed the policy compliance and quality assurance review of subject document. A final copy, if printed and bounded, should be provided to this office once completed. If you have any questions, please do not hesitate in contacting Ms. Theresa Mendoza of my staff at (415) 977-8106.

FOR THE COMMANDER:

Marda Q Stothers

MARDA Q. STOTHERS
Chief, Engineering & Construction Division

WATER CONTROL MANUAL

ALAMO DAM AND LAKE
COLORADO RIVER BASIN
BILL WILLIAMS RIVER
ARIZONA

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

OCTOBER 2003

Prepared by:

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

Reservoir Regulation Section
CESPL-ED-HR

Aerial Photograph of Alamo Dam and Lake

NOTICE TO USERS OF WATER CONTROL MANUAL

Regulations specify that this Water Control Manual be published in loose-leaf format, and only those sections, or parts thereof, requiring changes will be revised and printed. Therefore, this copy should be preserved in good condition so that inserts can be made to keep the manual current.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise, contact can be made by telephone to the U.S. Army Corps of Engineers, Los Angeles District Office, Reservoir Regulation Section at (213) 452-3527 or (213) 452-3623.

WATER CONTROL MANUAL

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER BASIN, ARIZONA

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ABBREVIATIONS USED IN WATER CONTROL MANUAL

ac-ft	acre-feet
AGF	Arizona Department of Game and Fish
ASP	Arizona State Parks Department
BLM	U.S. Bureau of Land Management
BWRCTC	Bill Williams River Corridor Technical Committee
cm	centimeter
cfs	cubic feet per second
cms	cubic meter per second
DCP	Data Collection Platform
ESP	Extended Streamflow Prediction
FCBOR	Flood Control Basin Operation Report
GOES	Geostationary Observational Environmental Platform
ha	Hectare
ha-m	Hectare meter
m	meter
NGVD	National Geodetic Vertical Datum (English Units)
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
NWSRFS	National Weather Service River Forecast Center
PMF	Probable Maximum Flood
RESCAL	Reservoir Calculation program
ROC	Reservoir Operations Center
SPF	Standard Project Flood
SPL	Los Angeles District, U.S. Army Corps of Engineers
SSMA	Sacramento Soil Moisture Accounting
STORET	Storage and Retrieval Program
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCM	Water Control Manual

CONVERSION FACTORS FROM ENGLISH TO METRIC UNITS

1 inch .... 2.54 centimeters
1 foot .... 0.3049 meter
1 mile .... 1.609 kilometers
1 cubic foot .... 0.0283 cubic meter
1 acre .... 0.4047 hectare
1 acre-foot .... 0.1233482 hectare meter
1 square mile (640 acres) .... 2.59 square kilometers
1 cubic foot/second .... 0.028317 cubic meter/second

I. INTRODUCTION

I - INTRODUCTION

1-01. Authorization

The authority and directives for the preparation of this manual are contained in the following U.S. Army Corps of Engineers publications:

(1) Engineering Regulation (ER) 1110-2-240, dated 8 October 1982: Engineering and Design, Water Control Management.

(2) Engineering Technical Letter (ETL) 1110-2-335, dated 1 April 1993: Development of Drought Contingency Plans.

(3) Engineering Manual (EM) 1110-2-3600, dated 30 November 1987: Management of Water Control Systems.

(4) Engineering Regulation (ER) 1110-2-8156, dated 31 August 1995: Engineering and Design, Preparation of Water Control Manuals.

(5) Federal Standard 376B, dated 5 May 1983: Preferred Metric Units for General Use by the Federal Government.

1-02. Purpose and Scope

The purpose of this water control manual is to provide current information about Alamo Dam and Lake, the regulating policy, and a description of the organizations responsible for reservoir regulation and data collection. The manual contains (a) descriptive information pertaining to the drainage area and the project; (b) a description of the plan of operation of Alamo Dam and its application to various floods; (c) the organization for operations by the U.S. Army Corps of Engineers, Los Angeles District; and (d) sources of hydrologic data and forecasts.

1-03. <u>Related Manuals and Reports</u>

Manuals and reports relevant to Alamo Dam, Alamo Lake, and the drainage area above and below Alamo Lake are listed in Table 1-01.

1-04. <u>Project Owner</u>

Alamo Dam and Lake are on land owned by the U.S. Army Corps of Engineers (reference Section 2-05). The Los Angeles District of the U.S. Army Corps of Engineers is responsible for reservoir regulation and for operating and maintaining the dam.

1-05. <u>Operating Agency</u>

The operation of Alamo Dam is the responsibility of the U.S. Army Corps of Engineers, Los Angeles District (SPL). The District Engineer has delegated authority for this function through the Chief, Engineering Division and the Chief, Hydrology and Hydraulics Branch to the Chief, Reservoir Regulation Section. The dam is staffed by two project operators (dam tenders) who live at the dam year round. The operators are under the supervision of the Operations Branch SPL; they receive their reservoir regulation instructions from the Reservoir Operations Center (ROC), at the downtown Los Angeles office of the Reservoir Regulation Section.

1-06. <u>Regulating Agencies</u>

The U.S. Army Corps of Engineers, Los Angeles District is responsible for the maintenance of Alamo Dam, for developing the water control plan for the regulation of Alamo Lake, and for operating the dam.

The Arizona State Parks Department (ASP) manages U.S. Army Corps of Engineers' withdrawn and acquired lands at Alamo Lake (Plate 2-11) for fish and wildlife purposes under Department of the Army license DACA09-3-97-31. Arizona

Department of Game and Fish also has a role as trustee for all wildlife in the State of Arizona, including both in the reservoir area and downstream from Alamo Dam.

The U.S. Geological Survey (USGS) operates and maintains a streamflow gage on the Bill Williams River approximately 0.6 miles (0.97 Km) below Alamo Dam. Additionally, the USGS maintains for SPL a streamflow gage on the Bill Williams River 33.7 miles (54.23 Km) below Alamo Dam.

The U.S. Fish and Wildlife Service maintains the Bill Williams River National Wildlife Refuge, located on the lower 9 miles (14.5 Km) of the Bill Williams River including the confluence with the Colorado River at Lake Havasu.

The U.S. Bureau of Land Management maintains two wilderness areas along the Bill Williams River: the Rawhide Wilderness, located immediately below Alamo Dam; and the Swansea Wilderness, located approximately 20 miles (32.2 Km) downstream.

The National Weather Service's Colorado Basin River Forecast Center in Salt Lake City, Utah provides inflow forecasts to Alamo Lake during the winter flood season and at other times of the year upon request from the Corps.

Table 1-01. Related Manuals and Reports

No.	Title	Date
1	Bill Williams River and Tributaries, Arizona, 78th Congress, 2nd Session, House Document No. 625	May 31, 1944
2	Hydrology, Alamo Reservoir, bill Williams River, Arizona	March 29, 1946
3	Design Memorandum No. 3, General Design for Alamo Reservoir	April 1964
4	Design Memorandum No. 4, Master Plan for Alamo Lake	January 1975
5	Hydrology for Review of Design Features of Existing Dams, Alamo Lake, Bill Williams River, Arizona	April 1982
6	Interim Report on Hydrology and Hydraulic Review of Design Features of Existing Dams for Alamo and Whitlow Ranch Dams	March 1986
7	Bill Williams River – Alamo Lake to Lake Havasu Hydrologic Appraisal (prepared by Bill Stephens & Associates, Phoenix, AZ, for City of Scottsdale)	January 7, 1988
8	Bill Williams River Riparian Management (prepared by Bureau of Land Management, Phoenix District, Arizona)	February 1, 1988
9	Assessment of Water Resource Conditions in Support of Instream Flow Water Rights, Bill Williams River, Arizona (prepared by Bureau of Land Management, Phoenix District, Arizona	December 1988
10	Alamo Lake, Arizona Reconnaissance Study	July 1990
11	Proposed Water Management Plan for the Alamo Lake and the Bill Williams River, Final Report and Recommendations of the Bill Williams River Corridor Technical Committee, Volume I	November 1994
12	Proposed Water Management Plan for the Alamo Lake and the Bill Williams River, Final Report and Recommendations of the Bill Williams River Corridor Technical Committee, Volume II	November 1994
13	Technical Considerations for Alamo Lake Operation, U.S. Army Corps of Engineers Hydrologic Engineering Center	April 1998
14	Alamo Dam Risk Assessment Study, U.S. Army Corps of Engineers, Los Angeles District, South Pacific Division	March 1999
15	Alamo Dam Demonstration Risk Assessment: Summary Report, RAC Engineers & Economists and the Los Angeles District, U.S. Army Corps of Engineers	August 2000
16	Alamo Lake, Arizona Feasibility Report and Environmental Impact Statement, U.S. Army Corps of Engineers, Los Angeles District	July 1999
17	Alamo Lake, Arizona Feasibility Study Technical Appendices, U.S. Army Corps of Engineers, Los Angeles District	July 1999
18	Operation and Maintenance Manual for Alamo Dam, Colorado River Basin, Bill Williams River, Arizona, Department of the Army, Los Angeles District Corps of Engineers	December 1969
19	Instream Flow Request for the Bill Williams River National Wildlife Refuge, Application Number 33-96300 (submitted to Arizona Department of Water Resources)	September 1993
20	Instructions for Reservoir Operations Center Personnel (The "Orange Book")	November 2002

II. DESCRIPTION OF PROJECT

II - DESCRIPTION OF PROJECT

2-01. Location

Alamo Dam is located on the Bill Williams River, 39 miles (62.8 Km) upstream from its confluence with the Colorado River at Lake Havasu. The dam is on the border of La Paz and Mohave Counties, Arizona, about 2.5 miles (4.0 Km) (downstream from Alamo Crossing, see Plates 2-01 and 2-01a). Main access is from the town of Wenden, on U.S. Highway 60, approximately 36 miles (57.9 Km) south of the dam. The geographic coordinates of the dam are 34°13'55"N latitude and 113°36'29"W longitude.

2-02. Purpose

Alamo Dam and Lake is a multiple purpose project, which was authorized by Public Law 78-534 (22 December 1944). The various authorized purposes are described in the following paragraphs. The first four purposes were initial authorized purposes.

a. Flood Control. The project was authorized to provide flood control for lower Colorado River communities downstream from Parker Dam (Lake Havasu).

b. Hydropower Generation. The project was authorized for hydropower. Had a hydroelectric powerplant been constructed, the project would have furnished power to the Phoenix area by interconnecting the powerplant transmission line with the Parker Dam powerplant transmission line to Phoenix. This purpose, however, was not deemed feasible and a powerplant was never constructed.

c. Water Conservation and Supply. Water conservation and supply was authorized for usage both within the State of Arizona and within the Colorado River mainstem. The purpose, however, has never been implemented, since no entity has ever contracted with the Corps for a firm supply of water.

d. Recreation. The project was authorized for in-lake recreation by the establishment of a permanent pool below the flood control and water conservation pools.

e. Fish and Wildlife Benefits. Public Law 104-303 (12 October 1996) authorized Alamo Dam to be operated for fish and wildlife benefits both upstream and downstream from the dam. This authorization does not reduce the existing flood control and recreational benefits of the project.

f. Water Quality. The overall water quality management objective for Alamo Lake, formed by Alamo Dam is to maintain the best water quality possible with the framework of the flood control, water supply, recreation, and environmental enhancement purposes of the project. The quality of the water is monitored to ensure compliance with applicable Federal and State water quality standards. The current water control plan requires rapid lowering of the reservoir to the 1125-foot (342.9 m) target elevation after major flood events. With this operation, the reservoir evaporation rate is reduced. The result is prevention of an increase in reservoir salinity when the reservoir is at a higher elevation and storage. This, in turn, helps prevent high salinity loading into the lower Colorado River.

2-03. Physical Components

A general plan of the project is shown on Plate 2-02 and a detailed description of the various features is contained in the following paragraphs. All elevations mentioned are based on the National Geodetic Vertical Datum (NGVD).

a. Dam. The dam is a zoned earthfill structure with a top of dam elevation of 1265 feet (385.6 m), a crest width of 30 feet (9.1 m), and a crest length of 975 feet (297.2 m, see Photos 2-01 and 2-02). The height above the original Bill Williams River streambed is 283 feet (86.3 m). The downstream slope of the embankment is 1 vertical on 2 horizontal (1V:2H) and the upstream slope is 1V:2.5H. Both the upstream and downstream faces of the dam are protected by a layer of stone. Profiles and sections of the dam embankment are shown on Plate 2-03 (reference Photos 2-01 through 2-02).

b. <u>Spillway</u>. The detached broadcrested spillway, with a crest elevation 1235 feet (376.4 m), is located in the right abutment, as shown on Plate 2-03 (reference photo 2-03). The spillway channel, an unlined trapezoidal section 110 feet (33.5 m) wide by approximately 550 feet (167.6 m) long, cuts through a rock saddle, with the concrete spillway crest block, 3 feet wide (0.9 m), 1 foot (0.3 m) deep and 116 feet (35.4 m) long, entrenched in rock (reference Photo 2-04). The spillway profile and section are shown on Plate 2-03. The spillway discharge curve is shown on Plate 2-04. Spillway flow discharges into a gully separated from the right abutment by a rock ridge (Photo 2-05). Flow rejoins the Bill Williams River about 1500 feet (457.2 m) downstream from the toe of the dam.

c. <u>Outlet Works</u>. The outlet works are located in the left, or southeast abutment. Details of the outlet works are shown on Plates 2-05 through 2-07. The concrete-lined outlet tunnel is 1290 feet (393.2 m) long and is 12 feet (3.7 m) in diameter, except through the gate conduit section. At the entrance, there is a semicircular trashrack enveloping the intake structure, and at the exit, an unlined outlet channel (Photo 2-06). The gate chamber, just upstream from the axis of the dam, is circular in plan, and is 36 feet (10.9 m) in diameter.

Discharge is controlled by three slide gates 5.5 feet (1.7 m) wide by 8.5 feet (2.6 m) high. Upstream from each of these (service) gates is an emergency gate of the same type and dimensions. Both service and emergency gates are hydraulically operated, open or close at the rate of about one-half foot (0.15 m) per minute, and may be locked in any position. Discharge curves for the service gates are shown on Plate 2-08. A butterfly valve controls outflow through an 18-inch (45.7 cm) low-flow pipe that bypasses Service Gate No. 3. The pipe is used for releases of up to approximately 112 cfs (3.2 cms), which is the maximum discharge capacity of the butterfly valve.

During the course of regulating the lake according to the prescribed Water Control Plan, the lake level may recede to elevation 1100 feet (335.3 m) or lower. At this point, the bulkhead gate can be installed so that the outlet tunnel can be dewatered for inspection and maintenance of the outlet gates and the tunnel lining. The bulkhead gate can be installed over the intake portal by a hoist mechanism situated on a paved bench area, only if the lake level has receded to elevation 1070 feet (326.1 m), or lower. Between elevations 1070 and 1100 feet (326.1 and 335.3 m), the bulkhead gate must be installed from a barge or other floatation means from the lake surface. The bulkhead gate was designed to withstand a maximum hydrostatic loading of up to elevation 1110 feet (338.3 m) exerted by the reservoir, however, inspection and maintenance of the outlet gates and tunnel do not occur unless the lake elevation is at, or below, 1100 feet (335.3 m).

The outlet works control house is located on top of the dam approximately at the midpoint of the outlet conduit (reference Photo 5-02). The control house contains a hydraulic pump unit and control valve station, water surface recorder, selsyn gate-position indicators and recorders, radio transceiver, telephone and electric power installations, and sanitary facilities.

d. Reservoir. Reservoir boundaries are defined by the extent of the land acquired by the Federal government for flood control behind Alamo Dam. A map of the reservoir area is shown on Plate 2-09. Aerial surveys made in 1946 were used in the preparation of an uncontrolled aerial mosaic of the reservoir area. Aerial surveys were made for use in the preparation of a topographic map of the reservoir area in 1963. Area and capacity curves for Alamo Lake, generated from the topographic map, are shown on Plate 2-10. These curves are presented in tabular form in Table 2-01. Photo 2-07 is an aerial view of the reservoir area, with a water surface elevation of 1183.76 feet (360.8 m).

2-04. Related Control Facilities

There are no other significant water control facilities, such as dams or diversions, within the Bill Williams River system. Section 3-04 summarizes the operational coordination of Alamo Dam with related projects on the lower Colorado River system.

2-05. Real Estate Acquisition

The boundaries of real estate that the U.S. Army Corps of Engineers acquired for Alamo Dam and Lake are shown on Plate 2-11. A total of 22,931.74 acres (9,280.1 ha) was acquired for project operation up to the spillway crest, of which 18,377.74 acres (7,437.2 ha) were Federal lands (U.S. Bureau of Land Management) and 4,554 acres (1,842.9 ha) were State and private lands, acquired in fee.

2-06. Public Facilities

Public recreational facilities within the Alamo Lake area are jointly managed by the Arizona Game and Fish Department and the Arizona State Parks. Existing recreational facilities include five campgrounds equipped with bathroom and shower facilities, and 250 camp sites for individual use (RV hook-ups), and one campground set aside to accommodate group camping of 50 to 100 campers. There are also three boat launch areas, a fish cleaning station, a group and individual picnic areas, and privately operated concession/general store. All facilities are floodable. In addition, the Arizona State Parks Department monitors overflow camping areas, which do not have any of the aforementioned amenities. Plate 2-12 shows the recreational facilities in the reservoir area.

Photo 2-01. Downstream face of Alamo Dam. Outlet works tunnel is in lower right hand corner.

Photo 2-02. Upstream face of Alamo Dam. Water surface elevation 1130.56 feet (20 November 1985)

Photo 2-03. Aerial view of spillway adjacent to right abutment of dam.

Photo 2-04. Spillway channel looking downstream.

Photo 2-05. Gully (arrow) through which spillway flows discharge before rejoining Bill Williams River channel.

Photo 2-06. Bill Williams River channel immediately downstream from Alamo Dam.

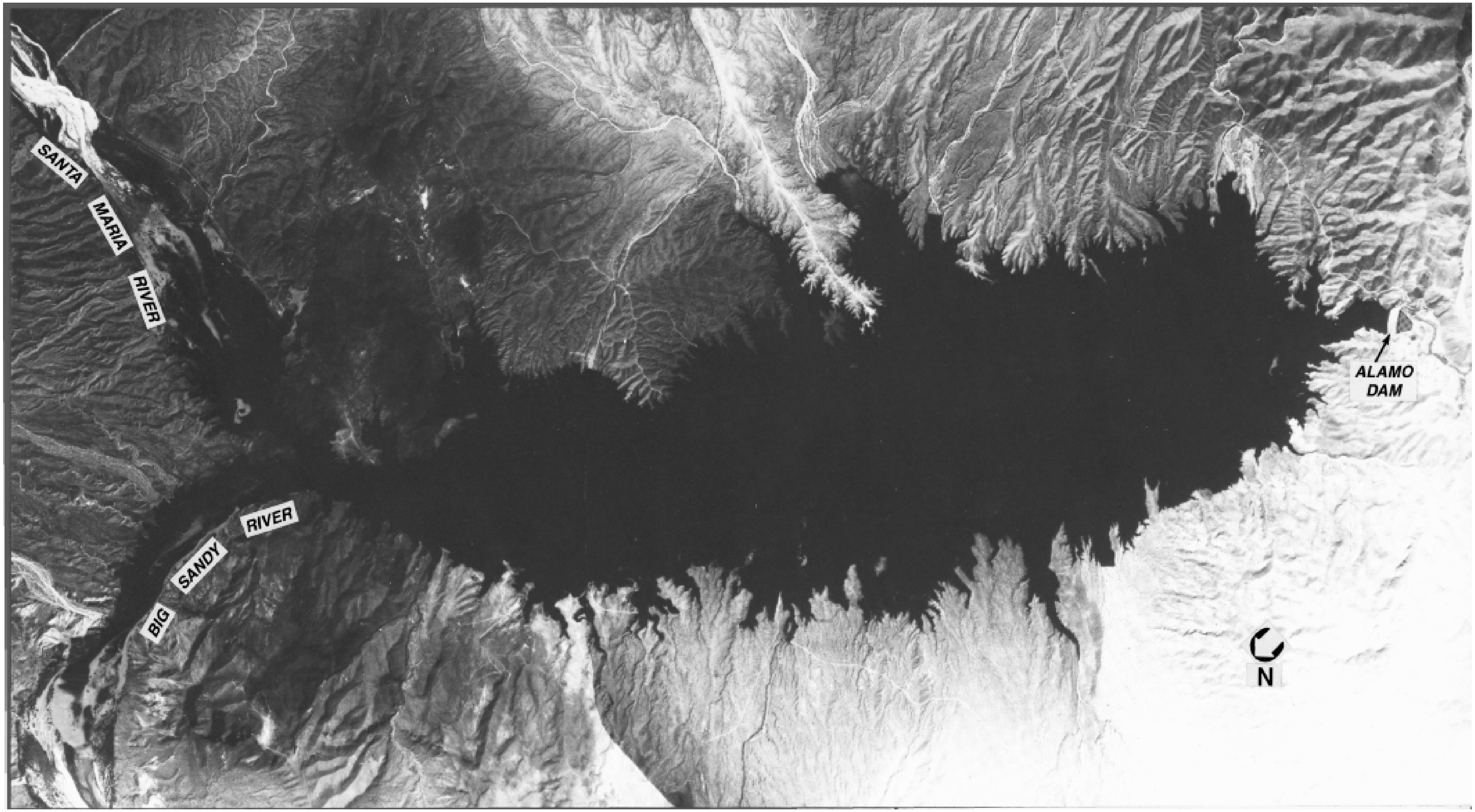


Photo 2-07. Aerial View of Alamo Lake.
Water surface elevation 1183.96 feet (4 May 1979)

III. HISTORY OF PROJECT

III - HISTORY OF PROJECT

3-01. <u>Authorization</u>

Alamo Dam was constructed under authorization of the Flood Control Act of 22 December 1944 (Public Law 534, 78th Congress, 2nd Session). The project was recommended for approval by the Chief of Engineers in his report dated 11 April 1944, published as a part of the project document (House Document No. 625, 78th Congress, 2nd Session). The project was authorized for flood control, water conservation, and recreational purposes.

Subsequent legislation under Section 301(b)(1) of the Water Resources Development Act of 1996 (Public Law 104-303) authorized Alamo Dam to be operated for fish and wildlife benefits upstream and downstream from the dam.

3-02. <u>Planning and Design</u>

The initial planning for Alamo Dam is documented in a 15 January 1941 report by the District Engineer, Los Angeles District. The report recommended a flood control dam be constructed at the Alamo site. The report also recommended that features be included in the dam and reservoir to meet future water conservation and power developments, as well as changes in flood control requirements.

After formal authorization, various hydrologic, topographic, and geologic studies were conducted from 1946 through 1963. Although the primary purpose of Alamo Dam and Lake was for flood control, the Corps entered into an agreement with the U.S. Bureau of Reclamation (USBR) for the latter to assess the water conservation and hydropower potential of the project. In a November 1961 report, the USBR concluded that there was water conservation potential, but no feasible hydropower potential. Hydropower generation was determined to have potential for the National Economic Development (NED) plan under some operating scenarios. However, a final analysis in the 1964 GDM indicated that hydropower generation would be operational too infrequently and thus would not be economically justified. As a result, although authorized, hydropower generation has never been implemented.

The original design concept was a concrete arch dam with an overflow spillway located in the center of the structure. However, following a re-study in the early 1960's, the final design was changed to an earthfill dam with a detached spillway in the right abutment, as presented in the April 1964 General Design Memorandum No. 3.

3-03. Construction

Preliminary construction at Alamo Dam began in July 1963. Access road construction began in October 1963 and was completed in October 1964. The dam and appurtenant works were started in March 1965 and completed in July 1968. Operations commenced 15 July 1968 and Alamo Lake reached the top of the original recreation pool elevation of 1046 feet (318.8 m) on 2 March 1970.

3-04. Related Projects

The regulation of Alamo Dam is closely coordinated with the regulation of dams on the lower Colorado River. The lower Colorado River Dams include those owned and operated by the USBR, as well as dams operated by other agencies. The USBR office in Boulder City, Nevada, is responsible for regulation of the lower Colorado River system by means of its lower Colorado River dams and through coordination with facilities, such as Alamo Dam, on tributaries to the Colorado River. Plate 3-01 is a schematic of the lower Colorado River system, showing the location of all dams, USGS operated stream gages, and listing the channel and levee capacity of the Colorado River main stem.
The USBR dams that Alamo Dam operations are coordinated with are described in the following paragraphs.

a. Glen Canyon Dam. Glen Canyon Dam is on the Colorado River in north-central Arizona, about 15 miles (24.1 Km) upstream of Lee Ferry and 12 river miles (19.3 m) downstream of the Arizona-Utah state line. The dam, completed in 1964, has a structural height of 710 feet (216.4 m), a crest length of 1,560 feet (475.5 m), and contains 4,901,000 cubic yards (3,747,083 cubic meters) of concrete. Lake Powell, the reservoir impounded by the dam, has a total storage capacity of 27,000,000 acre-feet (3,330,401 ha-m), extends 186 miles (299.3 Km) up the Colorado River, has 1900 miles (3,057.8 Km) of shoreline, and is the 2nd largest reservoir in the country. The reservoir provides the long-term regulatory storage needed to permit the states of the Upper Colorado River Basin to use their apportioned water and still meet their flow obligations at Lee Ferry, Arizona, under the terms of the 1922 Compact of the Colorado River. The powerplant provides the principal portion of the electrical energy generated by the Colorado River Storage Project. Surplus revenue from the sale of this energy helps the Upper Basin States to repay the costs of the project as authorized by Congress in 1956. The powerplant has eight generating units providing a total generating capacity of 1,042,000 kilowatts. Water is conveyed from the reservoir to the turbines through eight 15-foot diameter penstocks embedded within the dam. Four river outlet conduits are located near the left abutment of the dam to release water for downstream commitments when the powerplant is not in operation and to assist in making releases during floods. The conduits, each having a diameter of 96 inches (243.8 cm), have a total capacity of 15,000 cfs (424.8 cms) with releases controlled by 96-inch (243.8 cm) diameter hollow jet valves. One spillway is provided on each abutment of the dam to make releases during large floods. Discharges from each spillway are controlled by two 40- by 52.5-foot (12.2m x 16m) radial gates in each intake structure providing a total spillway discharge capacity of 276,000 cfs (7,815.5 cms).

b. Hoover Dam. Hoover Dam is on the Colorado River between Arizona and Nevada, about 7 miles (11.3 Km) northeast of Boulder City, Nevada. The dam, completed in 1936, has a structural height of 726 feet (221.3 m), a crest length of 1,232 feet (375.5 m), and contains 4,400,000 cubic yards (3,364,041 cubic meters) of concrete. Lake Mead, the reservoir impounded by the dam, has a total storage capacity of

28,537,000 acre-feet (3,519,987 ha-m), extends 115 miles (185 Km) up the Colorado River, and has 550 miles (885 Km) of shoreline. The dam and reservoir provide flood control, water supply for irrigation and municipal use, power generation, and recreation. The powerplant is one of the major electrical generating facilities in the southwestern United States. The powerplant has 19 generating units providing a total generating capacity of 1,434,000 kilowatts. Water is conveyed from the reservoir to the turbines through 13-foot (3.9 m) diameter penstocks connecting to 30-foot (9.1 m) diameter steel pipes located within the old diversion tunnels inside of each abutment of the dam. River outlet conduits continue downstream from the penstocks in each abutment of the dam to release water for downstream commitments when the powerplant is not in operation and to assist in making releases during floods. One spillway is provided within each abutment of the dam to make releases during large floods. Discharges are controlled by four 16- by 100-foot (4.9m x 30.5m) drum gates in each intake structure providing a combined discharge capability of 130,000 cfs (3,681.2 cms) for each spillway tunnel.

c. Davis Dam. Davis Dam spans the Colorado River in Pyramid Canyon, 67 miles (107.8 Km) downstream from Hoover Dam and 88 miles (141.6 Km) upstream from Parker Dam. The Dam provides re-regulation of the Colorado River below Hoover Dam and facilitates water delivery beyond the boundary of the United States, as required by treaty with Mexico. The Mexican Treaty of 1944 required the United States to construct Davis Dam for regulation of water to be delivered to Mexico. The Dam also provides for production and transmission of electrical energy, contributes to flood control, irrigation and municipal water supplies, navigation improvement, recreation, and wild waterfowl protection and related conservation purposes. Davis Dam, rising 200 feet (6.7 m) above the lowest point of the foundation and about 140 feet above the level of the river, is a zoned earthfill structure with concrete spillway, intake structure, and powerplant. The dam has a crest length of 1,600 feet (487.7 m), and a top width of 50 feet (15.2 m). The reservoir, Lake Mohave, has a total storage capacity of 1,818,300 acre-feet (224,284 ha-m), and, at high-water stages, extends 67 miles (107.8 Km) upstream to the tailrace of the Hoover Powerplant.

d. Parker Dam. Parker Dam is located on the Colorado River, approximately 16 miles (25.7 Km) northeast of Parker, Arizona and 155 miles (249.5 Km) downstream from Hoover Dam, in a short section of gorge cut through low-lying hills. It is a gravity-arch dam with a structural height of 320 feet (97.5 m), a crest length of 856 feet (260.9 m) at elevation 455 feet (138.7 m), and provides water storage and power production. The reservoir formed by the dam, Lake Havasu, stores water for municipal and industrial use by southern California and by the Central Arizona Project. With a reservoir elevation of 450 feet (137.2 m) and a tailwater elevation of 366 feet (155.6 m), Parker Dam has a differential hydrostatic load of 84 feet. The spillway consists of five 50- by 50-foot (15.2m x 15.2m) Stoney gates located across the top of the dam above elevation 400 feet (121.9 m). The gates are placed between hollow piers that contain the gate guides and hold the gate hoist structure. The five bay gate-hoist structure rises 63 feet (19.2 m) above the top of the dam.

Releases from Alamo Dam that are large enough to enter Lake Havasu, are coordinated with the USBR to obtain maximum benefits. These benefits include water supply, power generation, and incidental flood control (if releases are made within the water conservation pool).

3-05. Modifications to Regulations

The original regulations for Alamo Dam and Lake were based on a plan developed in General Design Memorandum No. 3. These regulations are described in the paragraphs below.

(1) A recreation pool was designated from streambed up to elevation 1046 feet (318.8 m). The downstream release from the recreation pool was stipulated as outflow-equal-to-inflow up to a maximum of 10 cfs (0.28 cms), to meet water rights requirements.

(2) A water conservation pool was designated from elevation 1046 feet (318.8 m) to elevation 1160.4 feet (353.7 m). Releases in the water conservation pool were to be a maximum of 2,000 cfs (56.6 cms).

(3) A flood control pool was designated from elevation 1160.4 feet (353.7 m) to elevation 1235 feet (376.4 m). Releases from the flood control pool were to be held to a maximum of 7,000 cfs (198.2 cms), which was considered to be the non-damaging channel capacity of the Bill Williams River downstream.

After completion of Alamo Dam, a number of issues arose that have resulted in significant changes to the aforementioned operating regulations. These issues are described in the sections herein.

a. Change in Recreation Pool Elevation. Approximately 6 years after operations began, the Arizona Department of Game and Fish requested that the top of the recreation pool elevation be increased from 1046 feet (318.8 m) to 1066 feet (324.9 m), which has since, by agreement, been revised to 1070 feet (326.1 m). The Corps agreed to the request after determining that the increase would not have an adverse impact upon the flood control capability of the reservoir. The request was formally approved 8 July 1981 by the Arizona Department of Water Resources, which also determined that the increase would not adversely impact existing water rights.

b. Above-Normal Runoff. During the period 1978-1980, the entire Colorado River basin experienced several significant flood events generating above-normal runoff. The runoff peaked in 1980 (calendar year) when the total flow volume entering Mexico (at the Northern International Boundary) was 6,934,000 acre-feet (855,296 ha-m), or 260 percent of the 1950-80 average. Inflows into Alamo Lake also peaked in 1980 with an annual total of 503,148 acre-feet (60,062 ha-m) or 456 per cent of the normal annual volume. During this period, Alamo Lake reached the highest historic elevation of 1207.33 feet (368.0 m) and the peak release from Alamo Dam of 3,900 cfs (110.4 cms) was the highest of record until 1993.

In order to alleviate flooding on the lower Colorado River, a multi-agency meeting was convened 28 March 1980 to discuss what appropriate measures should be taken. A decision was made whereby the Corps would gradually lower the elevation in Alamo Lake to 1110 feet (338.3 m), and then maintain that elevation as long as conditions warranted. The 1110-foot (338.3 m) elevation was chosen because it was determined to be an optimal value for flood control, water supply and recreational interests. The elevation was maintained as a result of subsequent high run-off years that lasted into the mid-1980's.

c. Modification to Recreational Facilities. Although the 1110-foot (383.3 m) elevation described in the above section was never formally authorized as a permanent change to operations, local interests in and around the lake had to modify their operations as a result of the higher impoundment. Arizona State Parks (ASP) was obliged to replace boat launch ramps and other recreational facilities inundated by the higher lake elevation. The ASP proceeded to construct boat launch ramps and other facilities that were designed for usage at this elevation. The new facilities, coupled with the higher lake elevation, increased annual recreational usage because of greater lake surface area. ASP has planned expansion of the recreational facilities around the lake based upon continued maintenance of the lake being around the 1110-foot (383.3 m) elevation.

d. Southern Bald Eagles. In early 1980's a pair of Southern Bald Eagles were discovered nesting in a partially inundated tree within the upper reaches of the Alamo Lake (Photo 3-01). Subsequently, another pair was discovered nesting in the canyon wall downstream from the dam. The two nests, which have been occupied ever since, have prompted the USFWS to stipulate that the lake elevation remains within the range of 1100-1135 feet (335.3 – 345.9 m) for the preservation of the eagles. This stipulation was made in accordance with the National Environmental Policy Act and the Endangered Species Act. The 1100-1135 (335.3 – 345.9 m) foot elevation range is designed to prevent inundation or access to any reservoir nest and to assure a lake surface with a foraging area sufficient for both nests.

3-06. Principal Regulation Problems

Although Alamo Dam has never spilled, there have been several problems associated with operations. These problems are summarized in the sections below.

a. Erosion. In the spring of 1980, a release of about 2,500 cfs (70.8 cms) resulted in an erosive eddy effect downstream of the outlet works, which in turn, caused scouring of random fill adjacent to the toe of the dam. As a consequence of this occurrence, scouring is now monitored during high releases.

b. Cavitation. Cavitation and abrasion have occurred on the service gates and service gate seals when these gates were set at openings of one-half foot or less to regulate discharges. The cavitation and abrasion ultimately resulted in leakage of as much as 13 cfs (0.37 cms) through the gate-gate seal contact when the gates were fully closed. Although the gates and gate seals were repaired and the leakage stopped, modified regulations prevent the service gates from being set at an opening of less than a half-foot (0.15 m).

c. Downstream River Crossings. Although no significant damage has occurred from releases less than 2,000 cfs (56.6 cms), releases in the 300-500 cfs (8.5 – 13.2 cms) range have made crossing the Bill Williams River virtually impossible at key locations downstream from Alamo Dam. As a consequence the Corps is required to notify a number of local agencies and citizens prior to making releases that equal or exceed the aforementioned ranges.

d. Hydrogen-Sulfide. During the summer and early fall, Alamo Lake stratifies, resulting in an anoxic hypolimnion. The anoxic conditions cause the generation of hydrogen-sulfide (H_2S) as a dissolved gas in the hypolimnic water. The H_2S escapes from the dissolved state as water is released through the outlet works. When the releases being made are low-flow through the butterfly valve, the gas tends to permeate into the outlet works gate chamber and gate shaft. The H_2S gas is potentially lethal and, consequently, operating personnel cannot enter the chamber or shaft if high concentrations are present. The result is that a change in the release from the butterfly valve (which can only be operated from within the chamber) may have to be delayed until the H_2S dissipates. In addition, the H_2S tends to be corrosive to the electrical equipment in the chamber and shaft.

Photo 3-01. Partially inundated tree in upper reaches of Alamo Lake (lake elevation 1097.95 feet (334.7 m), 27 October 1987). Example of a tree where Southern Bald Eagles have nested within the lake.

Photo 3-02. High-pressure gasline across Bill Williams River 13.5 miles below Alamo Dam.

Photo 3-03. Bill Williams River National Wildlife Refuge, showing stands of cottonwood trees.

IV. WATERSHED CHARACTERISTICS

IV – WATERHSED CHARACTERISTICS

4-01. General Characteristics

The drainage area above Alamo Dam, approximately 4,770 square miles (12,354 sq Km) in size, is generally mountainous, and lies in west-central Arizona. The drainage area is bounded on the north by Cottonwood Cliffs; on the east by the Juniper and Santa Maria Mountains; on the south by Date Creek and the Harcuvar Mountains; and on the west by the Hualpai Mountains.

The Bill Williams River is formed about 47 miles (75.6 Km) upstream from its mouth by the confluence of the Big Sandy and Santa Maria Rivers. From the confluence, the flow is southwest for about 8 miles (12.9 Km) on an average gradient of 18 feet (5.5 m) per mile to Alamo Dam. Bullard Wash is the largest tributary along this reach. Below Alamo Dam, the river flows almost due west to its confluence with the Colorado River.

The Big Sandy River, the larger of the two main tributaries to the Bill Williams River, drains an area of about 2,840 square miles (7,355.6 sq Km, Photo 4-01). This stream, which is formed by the confluence of Trout and Knight Creeks, flows southward about 49 miles (78.9 Km) on an average stream gradient of 38 feet (11.6 m) per mile to its confluence with the Santa Maria River. Burro Creek is the largest tributary in this reach.

The Santa Maria River drains an area of about 1,550 square miles (4,014.5 sq Km, Photo 4-02). This stream, which is formed by the confluence of Kirkland and Sycamore Creeks, flows southwestward about 51 miles (82 Km) to its junction with the Big Sandy River. The stream gradient of the Santa Maria River is about 30 feet (9.1 m) per mile. Date Creek is the largest tributary in this reach. The streambed gradients of many of the minor upstream tributaries in the Bill Williams River system are greater than 100 feet (30.5 m) per mile. Streambed profiles for the Bill Williams system are presented on Plate 4-01.

4-02. Topography

The drainage area consists essentially of broad desert valleys and irregularly distributed ranges of rugged mountains. Relief is moderate to high. Elevations in the drainage area vary from about 990 feet (301.8 m) above sea level at the base of the dam to 8,226 feet (2,507.3 m) at Hualpai Peak on the northwest boundary. Plate 4-01a shows the topography of the Alamo Dam drainage area.

4-03. Geology and Soils

The Bill Williams River is a perennial stream, although subterranean in some reaches. The river, along the upstream part of its course, has cut a deep narrow canyon between the Buckskin Mountains on the south and the Rawhide Mountains on the north. The Alamo dam site is within a narrow part of this canyon, about 2.5 miles (4.0 Km) downstream from Alamo Crossing. The site is in a region of rugged mountains with rough and steep slopes that are broken by ledges and cliffs and dissected by narrow defiles and gullies. The gullies are separated by sharp-crested, irregular ridges. The Bill Williams River drainage area upstream from the dam site consists of broad desert valleys and short, rugged mountain ranges. The basin is bounded on the north by the Peacock Mountains and the Cottonwood cliffs; on the east, by the Juniper and Santa Maria Mountains and the Sierra Prieta; on the south, by the Weaver, Date Creek, and Harcuver Mountains; on the west by the Buckskin, Rawhide and Hualpai Mountains.

Downstream from the junction of the Big Sandy and Santa Maria Rivers, the Bill Williams River flows about 6 miles (9.7 Km) southwestward through a sandy flood plain that broadens to a mile in width. The river in this reach is bordered on each side by dissected bluffs composed of alluvial fan debris. The alluvial fans extend in gently ascending slopes for several miles north and south of the river.

Downstream from the sandy flood plain, the Bill Williams River flows about 7 miles (11.3 Km) through a narrow rock-walled canyon. The Alamo Dam site is about 1 mile (1.6 Km) downstream from the head of the canyon. At the dam site, the rock walls of the canyon rise abruptly about 300 feet (91.4 m) above the canyon floor, which ranges in width from 50 to 150 feet (15.2 to 45.7 m). The ground surface of the stream channel along the axis of the dam is at a minimum elevation of 982 feet (299.3 m) above mean sea level. The bedrock surface under the overburden of the stream channel is at a minimum elevation of 918.4 feet (279.9 m).

As previously mentioned, flow in some segments of the Bill Williams River is subterranean, except during periods of high runoff or releases. The longest segment is between Lincoln Ranch and Planet Ranch (Photo 4-03), a distance of approximately 23 river miles (37 Km). Comparison of surface flows at either end of this segment were made for the period October 1929 through September 1946, when the USGS stream gages at the Alamo Dam site (No. 09426000) and at Planet Ranch (No. 09426500) were concurrently in use. The comparison indicated that the aquifer stored a significant portion of the higher flows recorded near the Alamo Dam site and discharged a significant amount of the higher base flows recorded at Planet, when flows at the Alamo site were minimal. Additionally, the aquifer is recharged by runoff originating from tributary basins along its course; water in the aquifer is also withdrawn through wells that serve irrigation and domestic uses. The principal water bearing unit of the aquifer is fill deposit (boulder to pebble size conglomerate).

Rock formations in the vicinity of the dam site and reservoir consist of metamorphic rocks of Precambrian age and younger, sedimentary strata (rock beds) of Tertiary age or older, and volcanic rocks of Tertiary age. Alluvium in the region is Recent and older.

The metamorphic rocks occur at the dam site in the general vicinity of the Rawhide Mountains and the Buckskin Mountains. The metamorphic rocks consist of banded gneiss, which comprise a lower section of rock in the vicinity of the dam site, is of rather widespread occurrence, and extend to great, but undetermined depths. The granitic gneiss occurs in the ridge of the right abutment. The undifferentiated rocks, which have been intensely contorted by ancient folding, occur in the upper part of both abutments and in the general vicinity of the dam site. The contact between the gneiss and the overlaying undifferentiated metamorphic rocks shows a regional upstream dip ranging from about 10 to 20 degrees in the dam site area.

The sedimentary strata (red beds), consisting of alternating layers of reddish hard siltstone and sandstone of unknown thickness, crop out along the Bill Williams River about a mile (1.6 Km) upstream from the dam site. Outcrops of these sedimentary strata begin at the upstream limits of the metamorphic rocks and extend about 6 miles (9.7 Km) upstream. The volcanic rocks occur in a narrow band between the metamorphic rocks and the sedimentary strata.

The Recent alluvium along the axis of the cutoff trench at the streambed has a maximum thickness of about 65 feet (19.8 m). The Recent alluvium along the channels of the Bill Williams River and its tributaries upstream from the dam site is of unknown thickness. The older alluvium, which comprises the bluffs along the sides of the river channel upstream from the dam site, ranges in thickness from 10 to 25 feet (3.0 to 7.6 m). The older alluvium is underlain by the sedimentary strata.

Bedrock at the dam site consists of banded gneiss, undifferentiated rocks, and granitic gneiss; alluvium at the site is Recent. The banded gneiss occurs in the lower parts of both abutments and under the alluvium in the river channel; the granitic gneiss occurs in the ridge at the spillway site; the undifferentiated rocks occur in the upper parts of the left and right abutments and on the upstream and downstream slopes of the ridge at the spillway. The Recent alluvium fills the canyon bottom of the Bill Williams River.

Surface soils in the southern and central parts of the drainage area and in the district along the Big Sandy River vary in texture from fine gravels to clay. Shallow, rocky soils occur in a few isolated areas near the mountain summits.

4-04. Sediment

The estimate of sediment that would accumulate in Alamo Lake is based on recorded data for nearby streams and for existing reservoirs in the general area. The storage space required for a 100-year accumulation of sediment was estimated to be 200,000 acre-feet (24,670 ha-m). This estimate was obtained by applying a sedimentation rate of 0.42 acre-feet (0.05 ha-m) per square mile per year to the drainage area of 4,770 square miles (12,354 sq Km). The sediment was assumed to be distributed in proportion to the reservoir area up to the water surface for the reservoir design flood.

The original reservoir area survey was made in March 1963. The results of this survey were modified somewhat by a bottom survey of May 1968 and by new capacity computations in June 1977. A bathymetric survey of the reservoir was conducted in 1985 to determine the sediment accumulation over a 17-year period. The survey encompassed the reservoir elevation range from the bottom up through elevation 1120 feet (341.4 m). The current (1993) reservoir elevation-storage curve (Plate 2-10) and reservoir elevation-storage table (Table 2-01) reflect the results of the bathymetric survey along with assumptions made on accumulation of sediment above elevation 1120 feet (341.4 m).

In order to check sedimentation periodically, six index ranges were established in the reservoir area and four index ranges were established along the downstream channel. Locations of these ranges are shown on Plates 4-02 and 4-03, respectively. Index ranges in the reservoir area are labeled "A" and index ranges in the downstream channel are labeled "C" on the aforementioned plates.

4-05. Climate

The climate is typically desert in character over the lower elevations of the basin, with short, mild winters and long, hot summers. In the higher elevations, the summers are milder, and the winters colder and longer. The Alamo basin has two distinct rainfall seasons: winter and summer, with a dry fall and a very dry late spring. A summary of climatological data for five Arizona stations, each just outside the drainage area above Alamo Dam, is given in Table 4-01 (Refer to the Tables section of this manual). These data are reproduced from the National Oceanographic and Atmospheric Administration (NOAA) publication, Climatography of the United States No. 20, for Arizona. The stations are: Parker, Kingman, Chino Valley, Prescott, and Wickenburg. These stations range in elevation from 425 feet (129.5 m) NGVD (below the elevation of Alamo Dam) to 5,510 feet (1679.5 m, representative of the higher elevation portions of the drainage) NGVD. There are no stations within the Alamo drainage area for which data are published.

a. Temperature. Table 4-01 (pgs. T4-1 through T4-6) lists, among other items, the mean daily maximum and minimum temperature and record highest and lowest temperature for each month of the year at the five stations surrounding the Alamo drainage area. Average daily minimum and maximum temperatures (degrees Fahrenheit) over the lower portions of the watershed range from about 65 and 35 respectively in winter to about 108 and 75 in summer (see Table 4-01: Parker and Wickenburg). In the higher elevations of the watershed, the values are about 15 to 25 degrees lower (see Table 4-01: Chino Valley and Prescott). High diurnal (day-to-night) temperature variations are characteristic of the region. All-time high and low temperature extremes are about 120 and 15, respectively; in the lower elevations, to about 100 and minus 20 in the highest mountains of the drainage. Significant periods of minimum temperatures below freezing are rare in the lower desert areas, but are common during the winter above 4,000 feet (see Table 4-01: Kingman, Chino Valley, and Prescott).

b. Precipitation. The 90-year (1868-1957) normal annual precipitation (Plate 4-04) ranges from about 8 inches (20.3 cm) at the dam to about 22 inches (55.9 cm) over the higher mountains of the headwater area with an average of 14.7 inches (37.3 cm) for the drainage area. The heaviest precipitation occurs in the summer, with about one-third of the annual precipitation normally occurring in July and August and one-half during the fall and winter months. The driest time of the year is late spring (see Table 4-01).

Table 4-01 lists the mean and maximum monthly and annual precipitation and snowfall, as well as the maximum precipitation (both daily and monthly) and maximum monthly snowfall for each month of the year, at the five stations. Also listed in Table 4-01 are the probabilities (from 5 to 95 percent) for each month of the year that the monthly total precipitation will be equal to or less than the indicated amounts. This table demonstrates that there can be great year-to-year variability in annual, monthly, and daily precipitation. The minimum observed monthly precipitation values are usually zero or near zero.

A description of general winter storms, general summer storms, and local thunderstorms, all of which produce precipitation in the basin, are given in the following subparagraphs:

(1) General Winter Storms. General winter storms usually occur during the period from December through March. They originate over the Pacific Ocean and move slowly eastward across Arizona. These storms last anywhere from a few hours to several days and can result in widespread precipitation over western Arizona, with snow at the higher elevations.

(2) General Summer Storms. General summer storms usually occur during the period August through early October. They are associated with an influx of tropical maritime air originating over Mexico and the adjacent tropical Pacific Ocean and enter the area from a south or southeast direction. Such storms are often associated with the remnants of a tropical cyclone. General summer storms are often accompanied by relatively heavy precipitation over large areas for periods of from 12 hours to 4 days.

(3) Local Thunderstorms. The local thunderstorms can occur at any time of the year, either during general storms or as isolated phenomena. However, they are most common during the period July through September, when the basin is frequently covered by moist, unstable air originating over Mexico or the Gulf of California. These storms cover comparatively small areas and result in high-intensity precipitation of short duration (up to 3 hours).

c. Snow. Snow falls occasionally at the higher elevations in the basin, but usually melts within a few days. Although snow rarely falls below 3,000 feet (914.4 m, Table 4-01: Parker and Wickenburg), it has occasionally fallen at the dam. Above 4,000 feet (1,219.2 m), snow becomes increasingly common with elevation (Table 4-01: Chino Valley and Prescott); over the higher mountains nearly all winter precipitation falls as snow. Most snow in the Alamo drainage below 6,000 feet (1,828.8 m) usually melts or sublimates (evaporates directly) within a few days after falling. Snowmelt is normally not a major factor in runoff generation in the Alamo drainage; but snowmelt, teamed with antecedent rainfall, can assist in saturation of the ground prior to a major flood-producing rainstorm.

d. Evaporation. Evaporation data for Alamo Dam (available from 1974 through 2000) indicate that mean monthly reservoir evaporation ranges from under 2 inches (5.1 cm) in early winter to more than 12 inches (30.5 cm) in early summer. Table 4-02 shows this seasonal variation in mean monthly pan evaporation, and also reveals the great variation that occurs from one well-exposed location to another. Individual daily values show that evaporation can greatly exceed 1 inch (2.54 cm) per day during very dry, windy conditions.

Table 4-02
Monthly Lake Evaporation at Alamo Dam

Month	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Mean Evaporation (in)	5.87	2.64	1.18	1.37	1.99	4.33	7.63	10.91	13.33	12.8	10.92	8.34
Mean Evaporation (cm)	14.91	6.71	2.99	3.48	5.05	11.0	19.38	17.71	33.86	32.51	27.74	21.18
Years of Data	26	26	25	24	25	25	26	26	26	26	27	26

Notes:
1) Period of record from March 1974 to September 2000. Location: Longitude (deg-min-sec) 34-13-51, Latitude (deg-min-sec) 112-36-28. Elevation: 1265 ft, NGVD.
2) Data for Alamo Dam are compiled from Corps of Engineers records.
3) Each evaporation station consists of a National Weather Service Class A Pan Readings are adjusted for observed rainfall to yield net evaporation. Reservoir evaporation values herein reflect measured pan evaporation multiplied by pan coefficient of 0.7. The pan coefficient remains fairly consistent at approximately 0.7 throughout the year.

e. Wind. The prevailing winds are from the east and are usually light, although severe windstorms occur on occasion as the result of local thunderstorms, tropical storms, intense winter storms, or unusually strong Great Basin high pressure cells.

4-06. Storms and Floods

Historical accounts indicate that many damaging floods have occurred in the Bill Williams River watershed, particularly within the following years: 1884, 1891, 1905, 1906, 1910, 1916, 1927, 1931, 1932, 1937, 1938, 1939, 1940, 1941, 1951, 1954, 1978, 1979, 1980, 1983, and 1993. A summary of annual peak discharges at the Alamo Dam site for water years 1927 and 1929-1999 seasons are included in Table 4-03. Indications are that these floods were the result either of general storms or, in a few cases, of tropical cyclones centered in or near the Bill Williams River watershed. Table 4-03a shows the cumulative annual damages prevented for with project conditions. Within the last 20 years, there was one year (1983) where significant flood damages were reported by the City of Yuma. Total damages were estimated to be $2,944,000.

Table 4-03
Recorded Annual Peak Discharges at Alamo Dam Site*

Water Year	Discharge (cfs)	Discharge (cms)	Water Year	Discharge (cfs)	Discharge (cms)
1927	125,000	3,540	1967	38,900	1,102
1929**	28,884	818	1968	16,000	453
1930	73,474	2,081	1969	9,940	281
1931	92,152	2,609	1970	5,117	145
1932	58,793	1,665	1971	5,115	145
1933	252	7	1972	598	17
1934	1,187	34	1973	8,458	240
1935	18,416	521	1974	90	3
1936	3,462	98	1975	537	15
1937	106,531	3,017	1976	43,396	1,229
1938	70,296	1,991	1977	250	7
1939	86,000	2,435	1978	78,007	2,209
1940	2,700	76	1979	65,408	1,852
1941	46,000	1,303	1980	82,245	2,329
1942	407	12	1981	623	18
1943	2,480	70	1982	5,095	144
1944	11,000	311	1983	69,225	1,960
1945	7,380	209	1984	9,751	276
1946	972	28	1985	28,433	805
1947	7,230	205	1986	7,990	226
1948	2,070	59	1987	207	6
1949	2,900	82	1988	14,324	406
1950	1,850	53	1989	193	5
1951	65,100	1,843	1990	2,575	73
1952	37,600	1,065	1991	70,967	2,010
1953	193	6	1992	50,273	1,424
1954	34,700	983	1993	104,667	2,964
1955	4,610	131	1994	207	6
1956	162	5	1995	62,743	1,777
1957	12,100	343	1996	241	7
1958	13,000	368	1997	4,966	141
1959	2,900	82	1998	12,094	342
1960	3,420	97	1999	40	1
1961	16,300	462	2000	2687	76
1962	8,400	238	2001	3796	107
1963	10,300	292	2002	176	5
1964	25,600	725			
1965	12,300	348			
1966	41,900	1,186			

*From 1927-1939, discharges are correlated from gage at Planet. From 1939 to 1968, discharges are from gage at Alamo. From 1968 to present, discharges are computed inflows into Alamo Lake.

**Peak discharge for 1928 not available.

Table 4-03a. Alamo Dam and Lake - Cumulative Annual Damages Prevented

Fiscal Year	Damages Prevented	Fiscal Year	Damages Prevented
1982	$1,511,000	1993	$14,511,000
1983	$1,511,000	1994	$14,511,000
1984	$1,511,000	1995	$21,511,000
1985	$1,511,000	1996	$21,511,000
1986	$1,511,000	1997	$21,511,000
1987	$1,511,000	1998	$21,511,000
1988	$1,511,000	1999	$21,511,000
1989	$1,511,000	2000	$21,511,000
1990	$1,511,000	2001	$21,762,000
1991	$1,511,000	2002	$21,762,000
1992	$1,511,000		

Note:

1. Damages prevented information not available for prior to 1982.

Brief descriptions of the more significant past storms and floods are given in the following subparagraphs:

a. <u>Early Storms and Floods</u>. Several of the greatest floods on record on the Bill Williams River occurred prior to 1930. The U.S. Geological Survey (USGS) has made estimates of the peak flows on the Bill Williams River at Planet (below the site of the present Alamo Dam), going back to the year 1883-84 and measurements beginning in the water year 1928-29. Annual peak discharge estimates include more than 100,000 cfs (2,832 cms) in February or March 1884, more than 200,000 cfs (5,663 cms) in February 1891, approximately 185,000 cfs (5,239 cms) in January 1916, and approximately 125,000 cfs (3,540 cms) in February 1927. Each of these flows resulted from an unusually heavy low-latitude warm winter storm that occurred over ground thoroughly saturated by other such storms during the previous days or weeks. Not published with these figures were the floods of January and February 1862, which resulted from some of the greatest storminess of this type ever known. Daily precipitation for selected stations in and near the Alamo drainage for 13 storms from 1905 through 1941 are published as Tables 8-20 in <u>Hydrology, Alamo Reservoir, Bill Williams River, Arizona</u>, U.S. Engineer Office, Los Angeles, California, 29 March 1946. Three of these storms and floods, as well as more modern events, are described below:

b. Storm and Flood of 6-9 February 1937. After a very cold January, with snowfall to unusually low elevations, a series of warm, low-latitude storms moved into Arizona from out of the west, dropping relatively heavy rain in the mountains. Prescott recorded 4.05 inches (10.29 cm), while Wikieup measured 3.90 inches (9.91 cm). The peak discharge on the Bill Williams River at Planet, which may have been aided at least slightly by snowmelt, was measured by the USGS at 92,500 cfs (2,619 cms).

c. Storm and Flood of 26 February - 5 March 1938. This flood resulted from a series of several very heavy low-latitude storms that moved across southern California (with record flooding) and into western and northern Arizona. Precipitation totals included 4.91 inches (12.47 cm) at Prescott, 4.78 inches (12.14 cm) at Yarnell, 3.73 inches (9.47 cm) at Bagdad, and 3.65 inches (9.27 cm) at Wikieup. The heaviest rain fell on 2 and 3 March, where one-day totals up to 3.21 inches (8.15 cm) were measured at Prescott, with 2.88 inches (7.32 cm) at Yarnell. This storm resulted in a peak discharge on the Bill Williams River at Planet of 61,000 cfs (1,727 cms).

d. Storm and Flood of 3-8 September 1939. This storm had two centers covering large areas, one northeast of the Imperial Valley in California and one from Needles and Parker to Truxton and Wikieup in Arizona. The unusually heavy precipitation during the storm was associated with three tropical cyclones originating off the west coast of Mexico, one of which traveled northward through the Gulf of California and dissipated over the lower Colorado River Valley. A total of 6 to 7 inches (17.78 cm) of precipitation fell over an area of more than 2,300 square miles (5,957 sq Km) within the center near Imperial Valley and over an area of more than 3,000 square miles (7,770 sq Km) within the center of the storm over Arizona. Totals in and near the Alamo drainage included 7.03 inches (17.86 cm) at Wikieup, 6.55 inches (16.51 cm) at Truxton, 6.50 inches (16.51 cm) at Yarnell, and 5.45 inches (13.84 cm) each at Kingman and Parker. Many stations reported more than 4 inches (10.16 cm). The maximum precipitation intensities in this storm were also high. The recording gage at Yuma measured 2.17 inches (5.51 cm) in 90 minutes; and at Phoenix, 2.41 inches (6.12 cm) fell in 6 hours. The Bill Williams River at Planet measured a peak discharge of 73,000 cfs

(2,067 cms), while the USGS estimated 77,000 cfs (2,180 cms) on the Bill Williams River near the Alamo Dam site. The Big Sandy River below Burro Creek, at Signal, Arizona, had a peak discharge of about 100,000 cfs (2,832 cms) from an area of 2,670 square miles (6,915 sq Km). Peak discharges for the storm are given in Table 4-04.

Table 4-04
Peak discharges from 3-8 September 1939 storm

Location	Peak Discharge (CFS)	Date
Big Sandy River near Signal	*100,000	6 September 1939
Santa Maria River near Alamo	22,300	6 September 1939
Bill Williams River near Alamo	86,000	6 September 1939
Bill Williams River at Planet	73,000	7 September 1939

* Estimated

e. <u>Storm and Flood of 27 – 30 August 1951</u>. The storm of late August 1951 was the heaviest general summer storm to hit the Alamo drainage basin during the period of record. A strong flow of tropical air from the south invaded Arizona during the latter half of August. This was augmented during the last several days of the month when a tropical storm crossed northern Baja California and dissipated over the mouth of the Colorado River, sending its remnants into western Arizona. Total storm precipitation ranged from less than 3 inches (7.62 cm) in the center of the Alamo basin to more than 8 inches (20.32 cm) in the mountains of the eastern portion of the Santa Maria River drainage. The station, Bagdad 8NE, measured 7.40 inches (18.80 cm), all falling in just over 36 hours. Camp Wood recorded 7.10 inches (18.03 cm), and Bagdad 2E recorded 5.24 inches (1331 cm). The basin average was computed at 3.86 inches (9.80 cm). The peak inflow was measured at 64,500 cfs (1,826 cms) on 29 August at 1730 hours.

f. <u>Storm and Flood of 28 February – 3 March 1978</u>. During a series of low-latitude winter storms, one especially intense storm stalled just off the southern California coast, pumping abundant tropical moisture into western and central Arizona. Some very heavy rainfall totals resulted, with a basin average of 3.82 (9.70 cm) inches in 78 hours. The heaviest rain occurred on saturated ground early 1 March, with basin-average precipitation up to 0.31 inch (0.79 cm) for 1 hour and effective rain of 0.20 inches (0.51

cm) in 1 hour. Total storm effective runoff was 0.79 inch (2.01 cm). The observed flood hydrograph on the Bill Williams at Alamo Dam shows a triple peak on 1 March. The third peak, of 77,500 cfs (2,195 cms) at 1400 hours, was slightly higher than the other two (see Plate 4-05).

g. <u>Storm and Flood of 17-19 December 1978</u>. Following a very sharp cold spell in early December 1978, a deep low-pressure area formed off the Southern California coast in mid-month. The circulation around this low brought abundant tropical moisture into Arizona from well south of the tip of Baja California. This moisture was forced up against the mountains and lifted orographically, producing very heavy rainfall in foothill and upslope areas. A number of stations reported more than 3-4 inches (7.62 – 10.16 cm) for the storm. In the Alamo drainage, basin-wide precipitation aver-ages only 0.10 to 0.15 inch (0.25 – 0.38 cm) per hour, but rain fell for most of 48 hours, and the accumulation of 2.46 inches (6.25 cm, basin average) on the cold ground resulted in a broad flood hydrograph with a peak discharge of 67,000 cfs (1,897 cms) on 18 December at 2100 hours (see Plate 4-06).

h. <u>Storm and Flood of 28-30 January 1980</u>. At the end of January 1980, a low-latitude low developed off the Southern California coast similar to that of March 1978. The resultant flow of tropical moisture against the mountains, which was plowed into by a sharp cold front, brought more than 48 hours of intermittent precipitation to the Alamo drainage, with a basin-average total of 2.51 inches (6.38 cm). This rain included several hours of intensities greater than 0.20 inch (0.51 cm) per hour basin-wide, climaxed by one hour of 0.30 inch (0.76 cm) followed by one hour of 0.28 inch (0.71 cm). Effective precipitation was high, and the resulting flood hydro-graph of inflow to Alamo Lake shows a peak discharge of 76,000 cfs (2,152 cms) on 30 January at 1000 hours (see Plate 4-07).

i. <u>Storm and Flood of 13-22 February 1980</u>. During mid-February 1980 a series of six warm, low-latitude Pacific storms moved inland across Southern California and Arizona, resulting in several periods of intense rainfall. The Alamo watershed received virtually continuous light precipitation between 13 and 15 February, punctuated by a very heavy two-hour burst around noon on 14 February, with basin-average rates of up to 0.41 inch (1.04 cm) in one hour. This produced a peak discharge into Alamo Lake of 53,000 cfs (1,500 cms) on 15 February from 0600-0700 hours. After occasional light rain on 17-18 February, two bursts of rain up to 0.18 inch (0.46 cm) in one hour fell on 19 February. With the ground saturated, effective rates were up to 0.12 inch (0.30 cm) per hour. This produced a peak inflow of 82,000 cfs (2,322 cms) on 20 February from 0200-0300 hours (see Plate 4-07). The total basin-average precipitation for the storm was 4.80 inches (12.19 cm).

j. Storm and Flood of 27 February - 4 March 1983. The winter season of 1982-83 was characterized by several series of low-latitude Pacific storms that moved across Southern California and Arizona from the west, driven by a very prominent El Niño condition in the equatorial Pacific Ocean. The climax of the season occurred from 27 February through 4 March, when storms stalled just southwest of San Diego and produced large quantities of tropical moisture in western Arizona. Nearly 2.5 inches (6.35 cm) fell at Alamo Dam, mostly on 3 and 4 March, while the upper portions of the basin received an estimated 3-4 inches (7.62 – 10.16 cm). The ground had been saturated by antecedent rainfall, and the rainfall was highly effective. The peak inflow to Alamo Lake was 69,070 cfs (1,956 cms) on 3 March at 1500 hours (see Plate 4-08).

k. Storm and Flood of 8 January-28 February 1993. The winter season of 1992-93 was characterized by a series of low-latitude Pacific storms that moved across Southern California and Arizona from the west, driven by cooler than normal temperatures across the North Pacific Ocean. The first significant storm period occurred from 7 to 19 January. The Bagdad precipitation station recorded 2.05 inches (5.21 cm) in a 24-hour period between 7 and 9 January. The second significant storm period occurred between 8 and 28 February. The Bagdad station recorded 3.87 inches (9.83 cm) between 8 and 10 February and 3.22 inches (8.18 cm) between 19 and 20 February. Antecedent precipitation in December 1992 partially saturated the ground, thus serving to increase the effective runoff of the 1993 storm events. The peak 24-hour inflow to Alamo Lake was 52,159 cfs (1,477 cms) on 20 February (see Plate 4-09).

4-07. Runoff Characteristics

Rapid concentration of water in the main channel produces runoff characterized by high peaks and channel velocities. Runoff is relatively high because of a combination of well-entrenched streams having steep gradients, impervious soil formations, fanshaped collecting systems, and irregular distribution of rainfall. Perennial inflow in some reaches of the Bill Williams, Santa Maria, and Big Sandy Rivers results from rising water at subterranean bedrock constrictions. Normally, natural streamflow occurs only during and immediately following major storms, except for occasional snowmelt runoff from headwater areas. Table 4-04a shows the available annual average inflow data to Alamo Lake for the period of record.

Table 4-04a. Annual Average Inflow to Alamo Lake

Year	Flow (cfs)	Flow (cms)	Year	Flow (cfs)	Flow (cms)
1969	48	1.4	1985	206	5.8
1970	39	1.1	1986	78	2.2
1971	20	0.6	1987	9	0.25
1972	8	0.2	1988	85	2.4
1973	218	6.2	1989	7	0.2
1974	4	0.1	1990	8	0.2
1975	4	0.1	1991	157	4.4
1976	1	0.03	1992	156	4.4
1977	4	0.1	1993	973	27.6
1978	444	12.6	1994	-4 *	-.01
1979	442	12.5	1995	335	9.5
1980	754	21.4	1996	3	0.08
1981	12	0.4	1997	22	0.6
1982	78	2.2	1998	150	4.2
1983	373	10.6	1999	8	0.2
1984	48	1.4	2000	11	0.3

* Evaporation was greater than inflow to the lake.

4-08. Water Quality

The Corps, for many years, has conducted a water quality monitoring program at Alamo Dam and Lake. The water quality parameters sampled and analyzed include the following categories: (1) limnological (temperature, pH, dissolved oxygen, specific conductance, and oxidation-reduction potential); (2) chemical (nitrogen, phosphorous, sulfides, sulfates, chlorophyll, pheno-phytin, and various ions of the aforementioned); and (3) bacteriological (total coliform, fecal coliform, and fecal streptococci). The latest "Annual Report on Water Quality Management." for Water Year 2002, dated January 2003, reported the following results for each parameter within the categories tested. These parameters measured high or exceeded their range of values, however, comparing results from prior years of water quality testing, they have been fairly consistent with no notable changes:

Alkalinity (Range: 0 – 300 mg/L): Measured in Lab at 235 mg/L
Dissolved Solids (Range: 0 – 1000 mg/L): Measured in Lab at 419mg/L
Total Residue (Range: 0 – 50 mg/L): Measured in Lab at 425 mg/L
Magnesium (Range: 0 – 25 mg/L): Measured in Lab at 22.1 mg/L
Manganese (Range: 0 – 25 ug/L): Measured in Lab at 23 ug/L

The water quality data sampled and analyzed are incorporated into SPL's Annual Report on Water Quality Management and are transmitted into the Environmental Protection Agency's STORET water quality database, and the results discussed in the "Annual Report on Water Quality Management."

Generally, water quality concern is primarily with the anaerobic conditions that continue to exist at Alamo Lake, when the lake becomes fully stratified and the lake hypolimnion forms. The anaerobic water causes the generation of hydrogen-sulfide gas at significant concentration levels, which, in turn, permeate into the outlet works. The presence of hydrogen-sulfide gas in the outlet works often precludes routine inspection and maintenance of the outlet works because of hazardous conditions for operation/maintenance personnel. Additionally, corrosion on various electrical components within the dam is attributed to hydrogen sulfide gas. Deterioration of the concrete in the outlet works has also been caused by the presence of dissolved hydrogen sulfide in the water released. Recreational activity around the reservoir results in a nominal nutrient loading that contributes to the anaerobic conditions in the reservoir hypolimnion. The upstream watershed has little impact upon the quality of water in the lake. Because downstream releases are generally small, normally 10-50 cfs (0.28 – 1.42 cms), the water quality in Alamo Lake has little, if any, impact on the water quality downstream and on the Colorado River.

4-09. <u>Channel and Floodway Characteristics</u>

The Bill Williams River downstream from Alamo Dam flows through a series of narrow canyons alternating with wide valleys. The canyons are, in places, 200 feet (61 m) or less in width. Within the valleys, the river meanders to widths of 1 to 1.5 miles (1.61 – 2.41 Km). The average slope of the river between Alamo Dam and the mouth is 16 feet (4.88 m) per mile. Although 7,000 cfs (198.2 cms) has been designated as the maximum non-damaging channel capacity, the 7,000 cfs (198.2 cms) release made during the storm and flood of 1993 destroyed the road through the Bill Williams River National Wildlife Refuge. The road, which provides access to Planet Ranch, had not been repaired at the time this Water Control Manual was published. In the past the road had suffered washouts from releases of 2,000 cfs (56.63 cms), or greater. Additionally, stream fords in the Planet Ranch area have become impassable from releases of as little as 500 cfs (14.16 cms). Table 4-05 shows the travel times of spillway flow at various locations downstream of Alamo Dam. A schematic of capacities for the Bill Williams River channel is presented on Plate 4-10.

Table 4-05. Spillway Flow Travel Times Downstream of Alamo Dam

Distance from Alamo Dam (miles)	Distance from Alamo Dam (Km)	Location	Average Elevation (ft, NGVD)	Average Elevation (m, NGVD)	Time (hours)
3.4	5.5	D/S of Alamo Dam Outlet	966	294	0.25
7.9	12.7	Near Lincoln Ranch at Reid Valley	872	266	1.0
8.5	13.7	At Rankin Ranch Road	812	247	1.25
15.9	25.6	-	685	209	3.5
18.5	29.8	-	643	196	4.0
22.5	36.2	At Planet Ranch Road	582	177	5.0
25.0	40.2	-	542	165	5.5
28.7	46.2	-	482	147	9.0
35.4	57.0	D/S of Parker Dam	374	114	8.25
41.2	66.3	-	375	114	9.5
45.0	72.4	-	371	113	10.5
46.5	74.8	-	368	112	11.0
50.1	80.6	Parker Valley	351	107	12.0
53.6	86.3	Parker Valley	343	105	13.0
59.9	96.4	Parker Valley	335	102	14.0
66.8	107.5	Parker Valley Indian Reservation	315	96	17.0
69.4	111.7	Parker Valley Indian Reservation	310	94	19.0
73.7	118.6	Parker Valley Indian Reservation	300	91	21.0
79.9	128.6	Palo Verde Valley	290	88	22.0
82.7	133.1	Palo Verde Valley Indian Reservation	283	86	25.0
85.6	137.8	Colorado River Indian Reservation	278	85	28.0
90.7	146.0	Palo Verde Valley	267	81	30.0
97.3	156.6	Palo Verde Valley	253	77	50.0
99.4	160.0	Palo Verde Valley	250	76	50.5
106.4	171.2	Palo Verde Valley	242	74	59.5
113.4	182.5	Cibola Valley	235	72	62.5
121.3	195.2	Cibola Valley Refuge	216	66	65.0
129.5	208.4	-	210	64	70.0
134.7	216.8	Taylor Lake	206	63	71.5
145.8	234.6	Martinez Lake	197	60	78.5
152.5	245.4	Imperial Dam	192	59	81.5
156.7	252.2	Mittry Lake	154	47	85.0
160.4	258.1	North Gila Valley	144	44	91.0
161.7	260.2	North Gila Valley	135	41	91.25
166.6	268.2	Fort Yuma Indian Reservation	130	40	93.0
169.6	272.9	Fort Yuma Indian Reservation	123	37	97.5
172.6	277.8	Near U.S. Marine Corps Air Station	116	35	97.5
177.3	285.3	Yuma Valley Cocopah Indian Reservation	109	33	118.0
183.5	295.3	Yuma Valley	95	30	130.0
187.2	301.3	Yuma Valley	77	23	135.0

Note: This information is from the Alamo Dam Emergency Action and Notification Subplan prepared in June 1986. The Inundation maps, which are part of this plan, are located at U.S. Army Corps of Engineers, Los Angeles District, Reservoir Operation Center, and also at the dam site.

4-10. Upstream Structures

There are no hydraulic control structures upstream of Alamo Dam.

4-11. Related Structures

Alamo Dam operation is closely coordinated with the operation of the U.S. Bureau of Reclamation dams on the lower Colorado River (Hoover, Davis, Parker and Imperial Diversion). The coordination is designed to optimize flood control, hydropower, water supply, water quality, and recreational benefits on the Colorado River. The maximum controlled release of 7,000 cfs (198.2 cms) from Alamo Dam was derived assuming a Colorado River channel capacity of 25,000 cfs (707.9 cms) below Parker Dam and an 18,000 cfs (509.7 cms) release from Hoover Dam.

Table 4-05 contains the names and locations (in river miles) of other dams on the lower Colorado River below Parker Dam whose operations could be affected by Alamo Dam regulation.

Table 4-06
Dams on lower Colorado River below Parker Dam.

Dam	Distance (River Mile)	Distance (Km)
Morelos	22.1	35.6
Laguna	43.2	69.5
Imperial	49.2	79.2
Palo Verde Diversion	133.8	215.3
Headgate Rock	177.9	286.3

4-12. Economic Data

a. Population. Alamo Dam affords protection to all property downstream from Parker Dam to Mexico. The area protected has a population of approximately 1,172,000.

Table 4-07a lists pertinent population data for the regions affected by operation of Alamo Dam.

Table 4-07a. Population Data for Alamo Dam Watershed and Downstream

	1980	1990	1998*
Watershed Area City or Indian Reservation (County)			
Bagdad (Yavapai County)	2,349	1,858	2,613
Downstream Area along the Colorado River City or Indian Reservation (County)			
Colorado River Indian Reservation (La Paz)	2,504	3,035	3,318
Parker (La Paz)	2,542	2,897	2,990
Enrenberg (La Paz)	1,210	1,226	1,561
Blythe (Riverside)	NA	NA	2,150
Cocopah Indian Reservation (Yuma)	835	515	894
San Luis (Yuma)	1,946	4,212	11,090
Somerton (Yuma)	3,969	5,282	6,625
Yuma (Yuma)	42,481	54,923	68,160
San Luis Rio Colorado, Sonora, Mexico	NA	NA	200,000
Mexicali, Baja California, Mexico	NA	NA	800,000
Calexico, California	NA	NA	25,650

Source: Arizona Department of Commerce Alamo Dam Risk Assessment Study
Department of Finance California
* Latest data available to date

b. Industry. Table 4-07b and 4-07c lists pertinent industrial data in relation to employment and agriculture for the regions affected by operation of Alamo Dam. The data presented on these tables are the latest available, at the time in which this manual was completed.

Table 4-07b. Agricultural Data for Alamo Dam (1997*)

Acreages for Various Crops						
	Watershed Area	Downstream Area along the Colorado River				
Crop	Yavapai	Riverside	Imperial	La Paz	Mohave	Yuma
Corn	NA	0	0	NA	NA	8,077
Wheat	NA	25,606	78,48	7,540	NA	35,116
Barley	NA	2,235	NA	NA	320	2,313
Cotton	0	12,71	6,058	23,228	3,977	27,972
Hay-Alfalfa	3,305	90,926	232,734	59,065	7,469	42,520
Vegetables	197	38,041	86,816	8,293	NA	86,329
Orchards	167	68,191	7,479	164	18	24,370

Source: United States Department of Agriculture
* Latest available data to date

Table 4-07c. Unemployment Rate and Number People Employed by Sector (2001*)

For Alamo Dam Watershed and Downstream Areas						
	Yavapai	La Paz	Mohave	Yuma	Riverside	Imperial
Labor Force	70,821	6,417	66,777	64,487	711,500	43,700
Unemployment Rate	2.93%	6.3%	4.5%	24.4%	5.2%	21.3%
Employment by Sector						
Agriculture	0	648	461	22,902	16,300	12,600
Manufacturing	3,375	300	3,200	2,350	53,600	1,900
Mining and Quarrying	1,075	0	100	0	500	0
Construction	4,875	100	4,700	2,800	52,500	1,600
Transportation, Comm. and Public Utilities	1,325	100	2,225	1,475	15,100	2,000
Trade	13,700	1,650	12,375	11,600	117,200	10,400
Finance, Insurance, and Real Estate	1,575	100	1,425	1,325	15,900	1,300
Services and Miscellaneous	15,275	550	10,775	10,125	127,300	5,700
Government	9,975	2,150	7,600	11,975	90,300	16,100

Source: Arizona Department of Commerce
California Employment Development Department
* Latest available data to date

c. Flood Benefits. Plate 4-12 shows the area that would have been inundated by the reservoir design flood prior to the construction of Alamo Dam. Practically all economic development protected by Alamo Dam is along the lower Colorado River; very few improvements are located on the Bill Williams River below the dam. Property of significant value is situated in the lowlands of the Colorado River between Parker Dam and the Mexican border, a distance of about 200 river-miles. The principal downstream areas are designated as: Parker Dam to Parker, Parker Valley, Palo Verde and Cibola Valleys, and Yuma Valley. Areas susceptible to damage contain residential, business, and industrial property, and various facilities such as irrigation and flood control works, highways, and public facilities. The Alamo Dam Risk Assessment estimated the value of the depreciated replacement of the property located in the floodplain to be $5,615,258,000.

Table 4-08 herein, shows the damage-discharge relationships for various points along the Colorado River below Alamo Dam. The table also shows the respective annual exceedance probability of these discharges from Alamo Dam. The probabilities are based on operating Alamo Dam according to the revised operating plan and are computed from the available period of record 1929-1998.

Table 4-08
Damage-Discharge Data Below Alamo Dam

Discharge (cfs)	Exceedance[2] (Percent)	Exceedance (Years)	Damage (Parker)	Damage (Blythe)	Damage (Yuma)
20,000	2.88	35	$0	$0	$0
30,000	1.94	50	$0	$0	$0
40,000	1.52	65	$0	$0	$60,679,000
60,000	0.96	100	$0	$0	$99,008,000
70,000	0.84	120	$13,470,000	$0	$117,087,000
80,000	0.74	135	$25,976,000	$0	$123,169,000
90,000	0.64	156	$29,801,000	$0	$123,169,000
100,000	0.56	180	$31,898,000	$0	$129,252,000
150,000	0.32	310	$48,726,000	$33,779,000	$138,588,000

1. Based on 2002 price levels.
2. Based on computed probability curve.

A damage discharge curve was created based on the information provided on Table 4-08, as shown on Plate 4-11, and can be used as a gauge by Reservoir Regulation Section to estimate the amount of damages that would occur if the corresponding discharge occurred at the particular location on the Colorado River. The value of these damages, however, is expected to change in the future as the price levels and hydraulic conditions changes. SPL's Economic Section will be responsible for calculating the changes in the flood damages due to changes in the price level. The changes in the price level should be based on the price indexes provided by Marshall & Swift Valuation Service, or equivalent.

Photo 4-01. Big Sandy River Basin.

Photo 4-02. Santa Maria River Basin

Photo 4-03. Sediment of Bill Williams River between Lincoln Ranch and Planet Ranch, where normal flows are subterranean. Photo was taken immediately upstream of Planet Ranch.

V. DATA COLLECTION AND COMMUNICATION NETWORKS

V - DATA COLLECTION AND COMMUNICATION NETWORK

5-01. Hydrometeorological Stations.

a. Facilities. Precipitation, stream flow, reservoir water level, air temperature, evaporation, and wind data are collected and monitored by SPL and USGS equipment located throughout the Bill Williams watershed. Plate 5-01 shows the location of these data collection sites. All of the SPL sites are equipment with satellite telemetry data collection platforms (DCP). Except for evaporation and wind data which is manually recorded by the dam tender, all of the collected information is transmitted to the SPL Water Control Data Processing System (WCDS) by the DCPs every 4-hours. The WCDS processes and stores the data and makes the information immediately available to SPL staff and also to the general public via the SPL web page. The DCPs transmissions are also directly received and processed by other agencies such as the US Geological Survey and the National Weather Service's Colorado Basin River Forecast Center. Tables 5-01and 5-02 lists the active hydrometeorological stations in the Bill Williams watershed.

Also, the USGS has established two gages upstream and two downstream of Alamo Dam as shown on Plate 5-01. Water quality monitoring is also performed at these gaging stations by contract with the USGS. Currently, water quality samples are taken from the lake and the downstream channel during non-inflow events. The river upstream is dry most of the time for this project. The water quality program contract allows for sampling additional areas, including the river upstream, when necessary. Details on water quality monitoring are provided in section 5-02. Details for the USGS gages are provided on Table 5-02.

Table 5-01
Active Precipitation, Stream Flow, Reservoir, and Evaporation Stations in Bill Williams Basin

Gage Name	Responsible Agency	COE ID	GOES ID	NCDC ID	USGS ID	County	Latitude	Longitude	Elev.	Parameters
Alamo Dam	SPL	ALMO	CE475D94	100		La Paz	34:14:00	113:35:00	1290	R, P, T, W, E
Bagdad	SPL	BAGD	CE474EE2			Yavapai	34:35:32	113:10:41		P, T
Bagdad	NCDC			586		Yavapai	34:34:00	113:10:00	3705	C
Big Sandy River near Wikieup	USGS	SAND	162AC7EA		9424450	Mohave	34:27:45	113:37:25	1400	S, P, T
Bill Williams River blw Alamo Dam	USGS/SPL	BWRA	CE227058		9426000	La Paz	34:13:51	113:36:29	967	S
Bill Williams River near Parker	USGS	BWRP	CE22A630		9426620	La Paz	34:15:45	114:01:37		S
Burro Creek near Bagdad	SPL	BURO	CE1367A4			Mohave	34:32:30	113:26:40	1880	P, T
Campwood	SPL	CAMP	CE2280DC			Yavapai	34:48:20	112:52:40	5710	P, T
Diamond M Ranch	NCDC			2527		Mohave	35:17:00	113:22:00	5480	C
Goodwin	BLM	GOOD	324C62BC			Yavapai	34:35:00	113:18:00		P
Lookout Wash near Fort Rock	SPL	LOKU	CE477B78			Mohave	35:11:51	113:21:47		P, T
Parker	NCDC			6250		La Paz	34:11:00	114:13:00	375	C
Santa Maria River near Bagdad	USGS	SMRB	CE134148		9424900	Mohave	34:18:21	113:20:47	1360	S, P, T
Skull Valley	SPL	SKLL	CE473872			Yavapai	34:35:37	112:37:46		P, T
Wikieup	SPL	WIKI	CE474030			Mohave	34:57:46	113:41:53		P, T
Wikieup	NCDC			9309		Mohave	34:42:00	113:36:00	2010	C

Agency Notes
SPL = Los Angeles District, Corps of Engineers
NCDC = National Climatic Data Center
USGS = US Geological Survey
BLM = Bureau of Land Management

Parameter Notes:
C = NCDC Weather Station
R = Reservoir Water Level
P = Precipitation
S = Stream Flow
T = Air Temperature
W = Wind
E = Evaporation

Table 5-02. Bill Williams Basin Precipitation, Streamflow and Evaporation Stations

Station (abbr.)	Type	Latitude	Longitude	Elevation
		(Degrees-Minutes-Seconds)		
USGS4432 (4432)	Flow	34-45-42	113-15-34	3260
USGS4447 (4447)	Flow	34-32-30	113-26-40	1880
USGS4450 (4450)	Flow	34-27-45	113-37-25	1400
USGS6000 (6000)	Flow	34-13-51	113-36-29	967
Corps (CEVP)	Evap	34-14-00	113-35-00	1360
Alamo 1 (A1)	Prcp.	34-16-00	112-24-00	1100
Alamo6ESE (A6)	Prcp.	34-15-00	113-28-00	1480
Bagdad (BGD)	Prcp.	34-35-00	113-10-00	3820
BagdadR (BGDR)	Prcp.	34-35-00	113-11-00	3750
Hillside (HS)	Prcp.	34-29-00	112-53-00	3320
Lookout Ranch (LR)	Prcp.	35-12-00	113-27-00	5000
Perner Ranch (PR)	Prcp.	35-22-00	113-17-00	5600
Round Valley (RV)	Prcp.	35-06-00	113-40-00	3740
Signal (SG)	Prcp.	34-28-00	113-38-00	1652
Signal13SW	Prcp.	34-22-00	113-48-00	2500
Skull Valley (SV)	Prcp.	34-30-00	112-41-00	4254
Trout Creek (TC)	Prcp.	34-53-00	113-39-00	2850
Tonto Springs (TS)	Prcp.	34-37-00	112-45-00	4800
Wikieup (WK)	Prcp.	34-43-00	113-37-00	2009
Yava6ESE (Y6)	Prcp.	34-27-00	112-48-00	3780

b. <u>Reporting</u>. The reporting of data to the District office is accomplished by the following means:

(1) <u>Manual</u>. The dam tender observes precipitation, reservoir water surface, downstream flow, gate settings, pan evaporation (see photo 5-01), air temperature, and wind measurements. The dam tender also notes general conditions around the dam. During flood events, the dam tender usually reports by telephone on a schedule established by the ROC. During non-flood periods, reports are given by telephone (or radio) to the ROC once per day on weekdays (weekends and holidays are exempt). Further reporting details for the dam tender are discussed in section 5-03 and 5-05.

(2) <u>The Geostationary Operational Environmental Satellite (GOES) Telemetry System</u>. SPL, USGS, and the BLM operate a network of GOES DCPs which provide SPL with real-time information about precipitation, stream flow, reservoir water level, and air temperature affecting regulation of Alamo Dam. The GOES satellite telemetry system is managed, operated, and maintained by the National Environmental Satellite, Data, and Information Service (NESDIS). The GOES primary mission is to continuously observe changing weather phenomena from satellite based sensors situated approximately 23,000 miles from Earth. As a collateral duty, the GOES system supports a radio relay or Data Collection System (DCS). The DCS enables a large variety of environmental data to be relayed from hydrologic ground stations, through GOES and back to a receiving station (DCS Automated Processing System) operated by NESDIS in Wallops, Virginia. Other users equipped with a GOES Direct Readout Ground Station (DRGS) can also receive these data transmissions. NESDIS then disseminates the data to SPL and other GOES system users by relaying the data through a commercial domestic satellite (DOMSAT) to a DOMSAT receiving station. SPL maintains a DOMSAT receiving station at the District office. GOES data collected at each station is transmitted to one of two GOES satellites, then to a ground station. Collected data include precipitation, air temperature, reservoir level, and river stage. SPL GOES DCPs collect data in regular time intervals ranging from fifteen minutes to one hour depending on the parameter and site conditions. Eight hours of data is then transmitted every four hours. The eight-hour block of reported data includes the latest four hours of data plus the previous four-hour data block. The GOES data is collected and processed by a DOMSAT receive station located at the SPL office. After processing the data, the DOMSAT system stores the data in a HECDSS database system on the Water Control Data System (WCDS) computer. GOES data can be viewed using the WCDS menu system or from the Reservoir Regulation Section web site.

(3) Automated Local Evaluation in Real-Time (ALERT) System. Yavapai County has jurisdiction over the operation of two ALERT rain gages within the Alamo Dam drainage that provides current or "real time" information about hydrologic conditions in the basin. The ALERT system is a network of rain, stream, and weather gages which provide current or "real time" information regarding hydrologic conditions in Arizona. Data is transmitted via VHF radio from these gages to an ALERT base computer whereupon the information is quickly compiled, stored, and made available for display and analysis. Additionally, the collected data can be relayed by VHF radio to the National Weather Service office for entry into their database. The Corps of Engineers, Los Angeles District, does not receive ALERT data for this project.

(4) Weather Data. Weather information is provided in forecasted and real-time formats. A contract meteorologist provides forecasted precipitation distributions called Quantitative Precipitation Forecasts (QPF) to the ROC so that proper preparations can be made to operate the reservoir in the upcoming flood event. Updates to the QPF are provided on an as needed basis.

The National Weather Service (NWS) provides an array of weather data, including short and long-range forecasts, precipitation totals, watches and warnings, and severe weather statements. Additionally, the NWS, through its Colorado River Forecast Center (CRFC) in Salt Lake City, Utah, provides flow forecasts encompassing the entire Lower Colorado River system including inflow to Alamo Lake.

Data Transmission Network (DTN) is a real-time, global, weather data system which provides the ROC with satellite loops, radar renderings, temperature dispersions, and forecast synopses for areas within SPL.

c. Maintenance. Each operating agency is responsible for the maintenance of its own gages. Gages under the Corps' responsibility are scheduled for normal bi-annual maintenance by the hydrographic technicians. Other visits to the stations (e.g., unscheduled repairs) are performed as required.

d. Cooperative Stream Gage Program. The Corps participates in a national program with the USGS Water Resources Division (WRD) known as the Cooperative Stream Gage Program. Funding for the upkeep of each station in the program is shared by federal, state, and local agencies. The USGS has established two stream gages upstream and two downstream of Alamo Dam as listed on Table 5-02, and shown on Plate 5-01. The Corps incurs all the cost of maintaining the two upstream gages and also the gage just downstream of the dam. The Bureau of Reclamation, the USFWS, and the Corps provide matching funds for the cost of maintenance at the station near Parker. Telemetry from these sites is transmitted by GOES satellite (as discussed earlier) thus providing current information to the District regarding areas under a possible flood threat.

5-02. Water Quality Monitoring.

a. Facilities. The office of U.S. Fish and Wildlife Service (USFWS), Region 2, Arizona FRO, Parker, Arizona has been contracted by the Corps to administer a program consisting of periodic sampling and analysis of ambient water quality at Alamo Dam. The sampling includes specimens from the reservoir and at the USGS gage just downstream of the dam. Four locations within the reservoir and at the downstream gage are sampled on a monthly basis: (1) closest to the dam; (2) mid-lake; (3) upper lake; and (4) at downstream USGS gaging station. The sampling schedule is presented in table 5-02 herein.

Table 5-03
Alamo Lake Water Quality Monitoring Schedule[1]

Month	Parameters Sampled
October	lim, chem, chl, phe, bact
November	lim, chem
December	lim
January	lim, chem, bact
February	lim
March	lim
April	lim, chem, bact
May	lim, chem, bact
June	lim, chem, chl, phe, bact
July	lim, chem, chl, phe, bact
August	lim, chem, chl, phe, bact
September	lim, chem, chl, phe, bact
Sampling Locations: (1) near dam; (2) mid-lake; (3) upper lake; and (4) d/s USGS gaging station.	
Legend: lim = limnology phe = pheophytin a chem = chemistry bact = bacteriology chl = chlorophyll a	
[1] Sampling schedule subject to change on an annual basis. Note: Sampling depths vary from surface, to 6 ft (4.9 m), or a maximum depth of 15 ft (4.6 m).	

b. Reporting. Tasks assigned to the USFWS are limited to sample collection and laboratory analysis only. The The U.S. Army Corps of Engineers, Los Angeles District (SPL) has the task of interpreting the data and preparing any associated written reports. The Corps prepares the "Annual Report on Water Quality Management" for each water year, in accordance with Engineering Regulation (ER) 1110-2-8154, "Water Quality and Environmental Management for Civil Works Projects", which establishes reporting requirements and objectives for water quality programs at existing Corps of Engineers Civil Works Projects. Eventually, Access to the STORET for storage and retrieval of data will be available through the Internet. SPL plans on using the Environmental Protection Agency's STORET water quality data base system on an as needed basis.

The following water quality information reported by the USFWS to the Corps are included within this report: (1) limnology; (2) general chemistry; (3) chlorophyll-pheophytin chemistry; (4) additional chemistry; and (5) bacteriology. Required limnology parameters are lake elevation, temperatures, pH, dissolved oxygen, specific conductance, oxidation-reduction potential, and secchi disk readings. General chemistry parameters sampled are phosphorous, total suspended solids, orthophosphate, total dissolved solids, kjeldahl nitrogen, total residue, ammonia, alkalinity, sulfide and turbidity. Chlorophyll-pheophytin chemistry parameters include chlorophyll a, pheophytin a, and the chlorophyll a to pheophytin a ratio. Additional chemistry requirements are iron, manganese, sulfate, calcium, and total organic carbon. Bacteriological data includes total coliform, fecal coliform (fc), fecal streptococci (fs), and fc/fs ratio.

c. Maintenance. The U.S. Army Corps of Engineers, Los Angeles District, has no maintenance responsibilities with respect to water quality stations.

5-03. Sediment Stations.

a. Facilities. In order to check the sedimentation periodically, six sedimentation stations in the reservoir and four along the downstream channel were established during the construction of the project. These stations are shown on plates 4-02 and 4-03, respectively, of the water control manual. They are respectively referred to as "'A' Index Ranges" and "'C' Index Ranges."

b. Reporting. At present, sedimentation data are not available at the Los Angeles District office. The USGS collects, compiles, and publishes sediment data on an annual basis in Water Resources Data for California.

c. Maintenance. The U.S. Army Corps of Engineers, Los Angeles District maintains the sediment stations by performing reconnaissance surveys after each major storm event to determine if an appreciable amount of sediment has accumulated in the reservoir and if a comprehensive survey is necessary. The advent of aerial mapping has precluded the need to use the sediment stations as part of a comprehensive reservoir survey; however, the sediment stations are still useful for the reconnaissance surveys.

5-04. Recording Hydrologic Data.

Each agency maintains records of its own data. During storm events, reservoir reports from the SPL dam tender are received by telephone on a schedule established by the ROC. During the remainder of the year, the dam tender at Alamo Lake normally reports by telephone to the Reservoir Regulation Section by 0900 hours Pacific Standard Time (PST) each workday (excluding weekends and holidays) or as requested. The reservoir data reported to the ROC are recorded and immediately entered into an HECDSS database using the Los Angeles District's reservoir computation program (Rescal).

Data from GOES DCPs are collected every 4-hours and stored in an HECDSS database housed on the District Water Control Data System. The data can be viewed either on the Reservoir Regulation Section web site or through the WCDS menu system. The period of record collected and verified, to date, spans from 1927 to 1999.

Daily flows at the following selected gaging stations pertinent to the operation of Alamo Lake are published annually in the "United States Geological Survey Water Supply Papers" and on the Hydrodata CD-ROM from Hydrosphere, Inc.:

(1) Big Sandy River near Wikieup, AZ
(2) Santa Maria River near Bagdad, AZ
(3) Bill Williams River blw Alamo Dam, AZ
(4) Bill Williams River near Parker, AZ

Daily rainfall records for Alamo Dam and for other precipitation stations in the Bill Williams River basin are published in the U.S. Weather Service's monthly publication entitled "Climatological Data" and annually on CD-ROM (Hydrodata). This rainfall data is archived at the NOAA, National Climatic Data Center in Asheville, North Carolina.

5-05. Communication Network.

The communication facilities at Alamo Lake are described as follow:

a. Commercial Telephones - are installed in the dam tender's residence and in the project office. Telephones are the principal communication device between the ROC and Alamo Dam.

b. FM Radio Transceiver - is installed in the project office to communicate with the Los Angeles District Office, the Los Angeles District Base Yard, and the Arizona office. Radio transmissions are conducted with the ROC through the Backbone Microwave Repeater System. Radio signals transmitted from either station are directed by line-of-sight mode to the repeater station on Smith Peak, Arizona, which then relays the signal on through a system of microwave repeater stations to the receiving destination. In the ROC, two radio consoles are capable of communicating with the dam: (1) Centracom Series I, located in back of the ROC; and (2) Zetron, located at the radio operator's station. Radio transmissions are received at the project site via an antenna located atop the control house (photo 5-02).

5-06. Communication with Project.

a. Between ROC and Alamo Dam. During the year when no storm events are occurring, a routine phone call is made at least once each weekday from Alamo to the ROC. This reservoir operation report is usually made prior to 0900 hours PST. During flood events, the reporting interval is more frequent as determined by the ROC. Reporting of the reservoir data is initiated by either the ROC or the dam operator depending on the mode selected by the ROC. Other routine or non-routine radio or telephone calls are made as necessary.

In the event that all communications with the District Office, including the Baseyard, should be interrupted, a set of "Standing Instructions to the Project Operator for Water Control" have been compiled and is presented as Exhibit A of this water control manual.

b. Between Alamo Dam and Others. No routine or non-routine communication between staff at Alamo Dam and other agencies is required. All notifications to other agencies affected by the regulation/operation of Alamo Dam are made by the LA District personnel.

c. Between ROC and Others. Flood operations at Alamo Lake are implemented with careful consideration given to the operation of dams on the Colorado River and the condition of the channel downstream of Alamo Lake. Flood releases are carefully determined after discussions with the U.S. Bureau of Reclamation (USBR) about reservoir operations on the Colorado River main stem. As previously mentioned, the NWS's CRFC in Salt Lake City, Utah provides a rainfall and inflow forecast for Alamo Lake and the lower Colorado River basin from which Alamo Dam release considerations can be developed. During various reservoir release conditions, other federal, state, and local entities are notified as to proposed operational procedures. For riparian/wildlife releases, notifications are given to the Arizona State Parks, USGS, Bill Williams Refuge, Arizona Game and Fish Department, and Bureau of Land Management, in order to monitor each agency's habitat concerns.

When flood control releases greater than 500 cfs or designated target reservoir elevations are expected, notifications are given to the Arizona Department of Water Resources, city of Scottsdale, Bureau of Reclamation, Mohave County, Arizona Public Service, Colorado River Board of California, International Boundary and Water Commission, La Paz County, Central Arizona Project, other personnel at the Corps of Engineers, U.S. Fish and Wildlife Service, Arizona Department of Environmental Quality, Bureau of Land Management, and Arizona Game and Fish. In the event of spillway flow, notification is given to National Weather Service, other personnel at the

Corps of Engineers, La Paz County, and Yuma County. The actual notification roster and conditions thereof are presented in the ROC's "Instructions for Reservoir Operations Center Personnel (the 'Orange Book')". This roster is updated once a year, and as needed, to maintain the most recent points of contacts.

5-07. Project Reporting Instructions.

The dam tender at Alamo Lake is required to perform the following:

a. Be present at the dam when rainfall or runoff is occurring or furnish the ROC at the District Office a telephone number through which he or she can be reached.

b. See that all equipment at the reservoir such as recorders, indicating gages, gate mechanisms, power units, radios, etc., is in operating condition.

c. Operate gates in accordance with instructions from the ROC, then report back via telephone/radio to confirm.

d. Keep ROC notified of any unusual developments such as trash accumulation, power failure, mechanical difficulties, etc.

e. Follow the current fixed-gate operation schedule posted in the control house when a loss of communication with the ROC occurs.

f. Assist engineers dispatched by the ROC during flood emergency.

g. Maintain routine records such as water surface elevations, outflow gage heights, precipitation amounts, gate openings, and a daily log on prescribed forms.

h. Notify local authorities and interested agencies of anticipated releases from the reservoir when instructed to do so by the ROC or if communications are interrupted.

i. Obtain hydrologic and hydraulic data from other agencies upon request of the ROC.

5-08. Warnings.

The responsibility for issuing all weather watches and warnings in addition to all flood and flash flood watches and warnings rests with the National Weather Service (NWS). Local emergency officials of cities and counties are responsible for issuing any public warnings regarding unusual overflows, evacuations, unsafe roads or bridges, toxic spills, etc. The SPL makes notifications to local authorities when critical water surface elevations are reached and critical release rates are initiated. The notifications list is updated on an annual basis and can be found in the SPL's "Instructions For Reservoir Operations Center Personnel" commonly referred to as the "Orange Book". In the event of a dam break or other emergency, the Emergency Action and Notification Subplan is used to determine appropriate actions. Copies are located in the ROC and the SPL's Emergency Operations Center (EOC), and at the dam site.

Photo 5-01. Evaporation pan at Alamo Dam and Lake.

Photo 5-02. Alamo Dam control house.

VI. HYDROLOGIC FORECASTS

VI - HYDROLOGIC FORECASTS

6-01. General

The agencies responsible for hydrologic forecasts and their tasks are described herein.

a. Role of the Corps of Engineers. The LAD does not make any formal hydrologic forecasts for Alamo Dam. Water quality conditions in Alamo Lake or in the Bill Williams River are not predicted by the Corps. Despite lack of formal hydrologic forecasts, the LAD monitors reservoir water surface elevation, outflow, inflow and reservoir evaporation on a daily basis. The Corps notifies other agencies, along with private concerns, of any significant changes in reservoir elevation, outflow, and inflow. The Corps provides the Bureau of Reclamation office in Boulder City, Nevada with the daily reservoir elevation, storage, inflow, and outflow values.

b. Role of Other Agencies. The National Weather Service (NWS) has responsibility for preparing hydrometeorological data and forecasts for the Bill Williams River drainage basin, which include inflow forecasts to Alamo Lake. These data and forecasts are, in turn, obtained by Reservoir Regulation Section personnel, who analyze the various hydrometeorological data and forecasts received at the District office and keep themselves appraised of any precipitation or other unusual weather that could affect the drainage above and below Alamo Dam.

The data and forecasts obtained consist of both alphanumeric text and visual displays, the latter comprised of weather charts and satellite images. The alphanumeric text, consisting of data summaries, discussions and forecasts, is available from the NWS Weather Forecast Office in Phoenix, Arizona and is also on the RFC internet home (Web) page. This data is stored on the District's Water Control Computer and can be selectively printed out. The weather charts, consisting of analyses and computer-prepared forecasts, are obtained via communications satellite and are printed on a line printer or a laser printer. The satellite images, also obtained via communications satellite, are displayed on a computer monitor and are selectively printed on a facsimile recorder.

6-02. <u>Flood Condition Forecasts</u>

NWS inflow forecasts are made on a daily basis. By routinely evaluating inflow, observed precipitation, and forecast precipitation, the NWS also provides inflow forecasts in flood situations. Plate 6-01 illustrates the methodology NWS uses in river forecasts and flood predictions. Using such information, the Reservoir Operation Center can evaluate if flood flows will increase or decrease over the next 24 hours. Plate 5-01 shows the location of precipitation and stream gages in and near the Bill Williams River basin and the key control points downstream of Alamo Dam.

6-03. <u>Conservation Purpose Forecasts</u>

Since there is no subscribed user for water stored in the water conservation pool, no conservation purpose forecasts are made.

6-04. <u>Long Range Forecasts</u>

The NWS has implemented an extended range forecasting procedure for the Bill Williams drainage basin to provide an estimate of inflows into Alamo Lake. The procedure uses the NWS Extended Streamflow Prediction (ESP) program. The ESP program uses conceptual hydrologic/hydraulic models to predict future streamflows using the current river, soil moisture, and snowpack conditions, along with historic hydrological and meteorological data. The ESP program is useful in predicting water supply and drought conditions, as well as predicting flood flows. Plate 6-02 illustrates the methodology the NWS uses in ESP.

The forecasting procedure for the Bill Williams River basin was calibrated in 2000 using the National Weather Service River Forecast System (NWSRFS), a streamflow model which incorporates the Sacramento Soil Moisture Accounting (SSMA) methods. The basin was divided into three areas: the Santa Maria River near Bagdad; the Big Sandy near Wikieup; local area above Alamo Dam and below the previous two areas. These three areas are combined to generate the inflow forecast to Alamo Lake. The Reservoir Operations Center, in turn, uses the inflow forecasts to predict lake elevations and/or schedule releases, as appropriate.

6-05. Drought Forecasts

Drought forecasts are made using the ESP program as described in Section 6-04.

VII. WATER CONTROL PLAN

VII - WATER CONTROL PLAN

7-01. General Objectives

The primary purposes of Alamo Dam and Lake are (1) to provide protection for the lower Colorado River from floods originating within the Bill Williams River watershed; (2) to prevent flooding along the Bill Williams River below Alamo Dam from flows greater than 7,000 cfs (198.2 cms); (3) to provide storage for lake recreation; (4) to provide storage for water conservation; and (5) to provide storage and appropriate releases for environmental objectives. Plate 7-01 is a diagram of Alamo Lake storage allocations for the aforementioned purposes.

7-02. Operational Constraints

There are several issues that present operational constraints in the regulation of Alamo Dam and Lake. These issues are briefly described herein:

a. Lower Colorado River. Releases from Alamo Lake ultimately enter Lake Havasu, which is formed by Parker Dam on the lower Colorado River. Parker Dam is one of three Bureau of Reclamation (USBR) dams on the lower Colorado River with the necessary storage space for regulating streamflow. The other two dams are Davis and Hoover Dams, both located upstream from Parker Dam in respective order. Hoover Dam is operated mainly for water supply with hourly adjustments for power generation and, as such, is normally committed to specific releases scheduled on a monthly basis. Both Davis and Parker Dams serve to re-regulate the power releases from Hoover Dam, to ensure that excess amounts of water are not sent to the Gulf of California. Additionally, the two downstream dams have hydroelectric power facilities of their own, and Parker Dam serves as the forebay structure for the Colorado River Aqueduct (Metropolitan Water District of Southern California) and the Granite Reef Aqueduct (Central Arizona Project). Most of the time Lake Havasu (formed by Parker Dam) and Lake Mohave (formed by Davis Dam) are at least 90 percent full, which means that any significant releases from Alamo Dam will cause Parker Dam to spill unless coordinated with the USBR in advance.

b. Channel Capacity. Under a 1963 Arizona State Senate resolution, the Arizona State Department of Water Resources was tasked with precluding any development along the Bill Williams River corridor within the floodway defined by a 7,000 cfs (198.2 cms) release from Alamo Dam. Although major development has not taken place, some existing facilities, such as the Planet Ranch Road and landowner river crossings have been damaged by releases less than 2,000 cfs (56.6 cms).

c. Streambed Crossings. Several crossings of the Bill Williams River streambed become inundated and impassable at flows as little as 300 to 500 cfs (8.5 – 14.2 cms). These crossings are used primarily by ranchers who have lands on both sides of the river. However, every rancher and other party have alternate routes for ingress/egress to their property, when usage of the aforementioned crossings is interrupted by releases from Alamo Dam.

d. Hydrogen-Sulfide in Outlet Works Gate Chamber. Excessively high concentrations of hydrogen-sulfide (H_2S) gas in the outlet works gate chamber are hazardous and potentially lethal to operating personnel. Consequently, operating personnel may not be able to enter the chamber and make scheduled or requested adjustment to riparian releases, since these releases are made through the low-flow butterfly valve, which can only be operated from inside the gate chamber.

7-03. Overall Plan for Water Control

Alamo Dam is operated to conform with the objectives and specific provisions of the authorizing legislation, along with the stipulations of subsequent Congressional acts that are applicable to the operation of Federal facilities. The original authorizing legislation specified that Alamo Dam would be operated for flood control, water conservation, recreation, and water rights. Subsequent legislation has stipulated that

Alamo Dam will also be operated for endangered species, water quality, and other environmental objectives, such as riparian habitat and wildlife. Operation for these objectives and stipulations requires that the U.S. Army Corps of Engineers coordinate with other Federal, State and local agencies, and with local individuals.

a. Bill Williams River Corridor Technical Committee. The Bill Williams River Corridor Technical Committee (BWRCTC) was an interagency committee formed in 1991 for the purpose of cooperatively developing a revised water management operations proposal for Alamo Lake and the Bill Williams River. The BWRCTC was comprised of the following agencies: Arizona Game and Fish Department, Arizona State Parks, Arizona Department of Water Resources, the Bureau of Reclamation, the Fish and Wildlife Service, the Bureau of Land Management, and the Corps of Engineers. The BWRCTC ultimately developed a recommended plan for re-operation of Alamo Dam and Lake by the process described herein.

1) The BWRCTC was divided into subcommittees, whose purpose was to develop independent water management prescriptions for each of the following resource categories: riparian corridor, fisheries, wildlife, recreation, and reservoir operations.

2) The aforementioned prescriptions were blended together to create alternative operating plans for Alamo Dam and Lake that balanced all of the prescriptions' objectives.

3) Based on subcommittee recommendations, evaluation criteria were developed for each resource category to determine how each of the re-operation alternatives maximized benefits to the categories as a whole. The recommended alternative -- the one with the 1125-foot (342.9 m) target elevation -- provided the optimum overall resource benefits.

b. Alamo Lake Feasibility Study. The Alamo Dam and Lake Feasibility Study was authorized under Section 216 of Public Law 91-611 (Flood Control Act of 1970) and Section 301(b)(1) of the Water Resources Development Act of 1996. The study was authorized to investigate the feasibility of implementing environmental restoration activities with recreational benefits at Alamo Lake and along the Bill Williams River. The study's primary purpose was to complete the planning process of formulating and evaluating the array of alternative operating plans that were identified in the BWRCTC studies, as well as previous studies, rather than formulate additional alternatives. The Reconnaissance Guidance Memorandum, dated 18 December 1996, recognized the extensive formulation activities of the previous studies and determined that no additional alternatives need be formulated. The study and accompanying Environmental Impact statement are contained in a July 1999 report. The Record of Decision for the study (Exhibit C) was executed on 12 May 2000.

c. Adopted Operation Plan. The adopted Water Control Plan was based on the BWRCTC's recommended alternative. The concept of operation is based on keeping Alamo Lake at or near elevation 1125 feet (342.9 m) for as long as possible to maximize downstream benefits. This elevation is considered optimal for the benefit of all project purposes and is consistent with the objectives of the authorizing legislation. A schematic of the storage allocations is shown on Plate 7-01 and the Water Control Plan is presented in tabular format on Plate 7-02. The maximum controlled outflow from the dam is 7,000 cfs (198.2 cms). Also provided on this plate is the "maximum rate of release increase" schedule, which must be followed when making releases corresponding to lake elevations that exceed 1125 feet (342.9 m). When Alamo Lake is at or below elevation 1125 feet (342.9 m) releases will vary between 10 and 50 cfs (0.28 and 1.4 cms) depending upon specific lake elevation, time of year, and other factors. If necessary, the lake elevation will be drawn down to elevation 1110 feet (338.3 m) in order to facilitate inspection and maintenance of the upstream side of the outlet tunnel. Refer to section 7-15.b(2) for further details regarding inspection/maintenance of the upstream tunnel.

7-04. <u>Standing Instructions</u>

Exhibit A contains the Standing Instructions to the Project Operator for Water Control for the regulation of Alamo Dam and Lake. It includes instructions to the Project Operator for normal conditions, during communication outages and during unforeseen emergency events requiring deviation from the Water Control Plan. Because of the remoteness of Alamo Dam and the inherent difficulty in communications with the District Office, it is essential that the operators thoroughly understand all facets of the Standing Instructions.

7-05. <u>Flood Control</u>

Alamo Dam flood control operations are coordinated with USBR's Lower Colorado River Regional Office, which has operational responsibility over Hoover, Davis, and Parker Dams on the Colorado River. The objective of the coordination is to limit flows along the Parker Strip of the Colorado River mainstem to 19,000 cfs (538 cms), which is the maximum non-damaging capacity for this reach. In a similar manner, Alamo Dam flood operations are coordinated with other Federal, State, and local agencies that have interests and concerns along the Bill Williams River. Normally when any significant release changes are to be made, 24-hour notification is made to downstream entities, and the scheduling of these release changes is coordinated in advance with these entities. Although the maximum allowable Alamo Dam flood control release is 7,000 cfs (198.2 cms), this release may be curtailed to permit flood control releases from other dams within the lower Colorado River system, or to enable repairs to downstream channel improvements to restore hydraulic conveyance capacity. Plate 7-02 provides the elevation-release schedule for releases commencing at the top of the target elevation of 1125 feet (342.9 m). The "maximum rate of release increase" schedule provided on Plate 7-02 must be followed when making releases corresponding to lake elevations that exceed 1125 feet (342.9 m).

If the Alamo Lake water surface rises above elevation 1235 feet (376.4 m, spillway crest), floodwaters pass through the uncontrolled spillway. When the reservoir water surface elevation reaches 1244.3 feet (379.3 m), uncontrolled spillway outflow equals the maximum scheduled release of 7,000 cfs (198.2 cms).

In the case where forecasts of reservoir inflow indicate that the reservoir water surface may exceed the maximum surcharge elevation of 1259.6 feet (383.9 m), and the outlet works should remain at 80% gate opening throughout spillway flow (the "non-spillway flow transfer option" schedule). If extended streamflow forecasts of reservoir inflow indicate that there is a high degree of confidence in not exceeding the maximum design surcharge elevation of 1259.6 ft (383.9 m), then outflows may be transferred from the outlet works to the spillway, maintaining the maximum scheduled outflow of 7,000 cfs (198.2 cms) up to elevation 1244.3 feet (379.3 m), (the "spillway flow transfer option"). Plate 7-02 shows the gate schedule for transfer of flow to the spillway. If the water surface elevation rises above 1250 feet (381 m), the three outlet gates are opened to the maximum 6.8-foot (2.1 m) setting, and releases are strictly for dam safety. Should the lake water surface rise above 1259.6 feet (383.9 m), the dam operator(s) shall leave the dam site for their own safety.

7-06. Recreation

The authorized top of recreation pool is elevation 1070 feet (326.1 m) however, due to the revamping of the original recreation facilities (reference Section 3-05) to take advantage of the higher pool elevation maintained for endangered species, the current defacto top of recreation pool elevation is 1100 feet (335.3 m). This elevation is within the lower range of lake elevations where boat ramp accessibility to the lake is possible. The Water Control Plan does not require specific operational releases from Alamo Dam for recreation; however, the releases made within the authorized recreational pool between El 990 to El 1070 (301.8 to 326.1 m) are those necessary to satisfy water rights, defined as an average release of 10 cfs (reference Section 7-14). Releases from elevation 1070 feet (326.1 m) up to elevation 1125 feet (342.9 m) benefits the fish and wildlife objectives described in Section 7-08. These releases benefit recreational objectives in that lake fluctuations are kept minimal and promote recreational aesthetics such as preventing the "bathtub ring" effect around the lake shoreline.

The recreation facilities can function within an elevation range from 1094 to 1144 feet (333.5 to 348.7 m), which includes the optimal 1115 to 1125-foot (339.9 to 342.9 m) operating range for boat access and overall recreational benefits. The highest range of lake elevations affording boat ramp accessibility is from 1154 to 1178 feet (351.7 to 359.1 m). Recreational facilities at Alamo Lake consist of boat launching ramps, campgrounds, and appurtenant structures. All recreational facilities are operated and maintained by the Arizona State Parks Department.

7-07. Water Quality

Alamo Dam is not operated specifically for water quality enhancement. The relative contribution to the Colorado River by the Bill Williams River releases is low, however, Alamo Dam ca be operated in coordination with the Colorado River Project to benefit overall water quality in the Colorado River.

7-08. Fish and Wildlife

a. Riparian Releases. The Water Control Plan was derived in accordance with the USFWS' Biological Opinion (Exhibit D) to achieve adequate long-term water to support riparian habitat along the Bill Williams River. Reservoir releases provided on Plate 7-02 are the result of adjustments based on the water needs of the riparian habitat, in coordination with the natural resource agencies (USFWS, AGF, and BLM). Riparian releases ranges from 25 – 50 cfs (0.71 – 1.4 cms), up to the maximum outlet capacity of 7,000 cfs (198.2 cms). Releases made within the higher reservoir elevations have the desired effect of "high flushing" flows which also fosters cottonwood-willow habitat regeneration rehabilitating and sustaining the riparian corridor resources downstream from Alamo Dam.

b. Fisheries. Part of the continuing benefits derived from the prescribed Water Control Plan is that sport fishery resources at Alamo Lake are maintained, as well as provide a possible secondary fishery in the Bill Williams River below the dam for warm water fish and native fish. Alamo Lake contains a variety of warm water sport fish, including largemouth bass, which has made Alamo Lake one of the premier warm water fishing lakes in Arizona. Other non-native fish downstream of the dam include channel catfish, carp, green sunfish, and red shiners; however, the emphasis of maintenance through the Water Control Plan is largely in support of the existing warm water fishery or establishing a native fish fishery.

c. Wildlife. In general, all species within its assigned scope of concern benefits from the prescribed Water Control Plan. The Wildlife Subcommittee determined that all threatened and endangered species, neotropical migratory birds, other sensitive species, waterfowl, and other wildlife best benefit from the creation and maintenance of a healthy, diverse riparian ecosystem along the Bill Williams River corridor below Alamo Dam. It was determined that only under extreme, prolonged drought conditions would water management needs of the species at Alamo Lake conflict with maintenance of a healthy riparian ecosystem downstream.

Since the early 1980's specific efforts have been made to sustain the population of the Bald Eagles. Pairs of Bald Eagles, an endangered species, have been observed within the Alamo Lake area. The regulation of Alamo Lake provides a minimum pool for sufficient foraging area for nesting eagles all year round. In addition to the habitat for the Bald Eagles, favorable nesting areas are also provided for the Southwestern Willow Flycatchers, which were recently declared endangered without critical habitat in February 1995. The Corps, USFWS, and the Arizona Game and Fish Department (AGF), as necessary, will continue to coordinate efforts to minimize adverse impacts to bald eagle and Southwestern Willow Flycatchers' nests within the reservoir area.

7-09. Water Conservation

The water conservation pool is between elevations 1070 and 1160.4 feet (326.1 and 353.7 m), regulated to enhance the Colorado River water supply. The schedule of normal releases for the water conservation pool is shown on Plate 7-02. These releases are designed to balance water conservation, wildlife enhancement and water rights objectives. Actual releases may be modified with the agreement between Corps and the other agencies that have an interest in Alamo Dam operations. The goal is to at all times manage the water conservation pool to maximize project benefits. SPL will coordinate all water conservation releases with USBR reservoir operations, as well as coordinate with other Federal agencies and State agencies that have interests and concerns along the Bill Williams River and lower Colorado River.

7-10. Hydroelectric Power

There are no hydroelectric facilities at Alamo Dam. Consequently, there is no operation for hydroelectric power.

7-11. Navigation Operation

There are no operational releases made from Alamo Dam for navigation purposes.

7-12. Drought Contingency Plans

The Drought Contingency Plan for Alamo Dam and Lake was completed in June 1992 under the authority of ER 1110-2-1941, dated 15 September 1981. This plan is designed to alleviate water shortages for the following entities: Central Arizona Project; Metropolitan Water District of Southern California; Mexico; Gila Gravity Main Canal; the All American Canal System; and Arizona Department of Water Resources. Copies of the plan are located in the Reservoir Regulation Section of SPL.

7-13. Flood Emergency Action Plan

A flood emergency action plan for Alamo Dam was prepared in accordance with ER 1130-2-419 (Dam Operations Management, dated 18 May 1978) and ER 1110-2-1802 (Reporting Earthquake Effects, dated 25 July 1979). The plan, entitled "Emergency Action and Notification Subplan -- Alamo Dam", dated July 1986, covers identification of impending and existing emergencies, emergency operations and repairs, and post earthquake response procedures. Downstream areas potentially subject to inundation are identified for the case of dam failure with reservoir at full capacity, spillway crest elevation of 1235 feet (376.4 m). Copies of this plan are in the Reservoir Operations Center (ROC) and the Emergency Operations Center (EOC) of SPL and at the dam site.

7-14. Water Rights

The original (August 1970) edition of the Alamo Dam Water Control Manual indicates that no vested water rights had been determined at the time that the manual was published, but that a study of past records indicated that releasing inflow up to a maximum of 10 cfs would satisfy water rights. At present, water rights remain unadjudicated. The 10 cfs release specified in the original water control manual served as a starting point for formulating alternative operation plans during the Bill Williams River Corridor Technical Committee Study and is a basic feature of the adopted water control plan. Except during flood events, inflows are normally 1 to 3 cfs. In the absence of any other releases, an average minimum release of 10 cfs will be made at all times. If it is necessary to shut off all releases due to inspection, maintenance, or repair activities, and subsequent releases will be increased, if necessary, to maintain a daily 10 cfs average outflow.

7-15. Inspection and Maintenance

a. Monthly Gate Exercise. In order to ensure that the outlet works gates remain functional throughout the year, a monthly gate exercise is performed on the first Monday of each month. The exercise may be postponed, if conditions so warrant. The monthly gate exercise is accomplished as follows:

1) The dam tender checks with the ROC for permission to perform the exercise.
2) The dam tender checks the downstream channel from the dam to the USGS streamgage immediately downstream to ensure no one is in the area.

3) All service gates and the low-flow butterfly valve are closed.

4) Each emergency gate is fully closed.

5) Each service gate is fully opened and then closed. The low-flow butterfly valve is also fully opened and closed.

6) Each emergency gate is fully opened.

7) Releases prior to the gate exercise are resumed.

b. Outlet Tunnel Inspection and Maintenance Operation.

(1) Lower Portion of Outlet Tunnel. When inspections or short-term repairs are to be conducted on the outlet tunnel downstream from the emergency gates, releases are shut off, as necessary, in order to accomplish these tasks. Compensating releases to satisfy downstream water requirements will be coordinated with the other agencies, as appropriate, once the inspection/repairs are completed.

(2) Upper Portion of Outlet Tunnel. The opportunity for inspecting the upper portion of the outlet tunnel would not be scheduled until the lake level recedes low enough, through normal operation of the dam, to allow installation of the bulkhead. The elevation at which the bulkhead can be installed is at, or below, 1110 feet (338.3 m). Should an emergency situation arise where inspection/maintenance of the upstream tunnel is required, and the lake level is above elevation 1110 feet (338.3 m), then the lake level will be drawn down in order to facilitate emergency inspection/maintenance activities. Once the bulkhead is in place, the Corps will receive daily inflow forecasts from the National Weather Service's Colorado Basin River Forecast Center (CRFC) in Salt Lake City. If the CRFC forecasts that inflows from a storm event are large enough to cause the lake water surface elevation to rise above 1110 feet (338.3 m), the Corps will immediately commence removing the bulkhead and placing Alamo Dam back into operation.

Removing the bulkhead is a two-step process. The first step is to equalize hydrostatic pressure on both sides of the bulkhead by opening the 6-inch (15.24 cm) filling line. The filling process takes about 10 hours. The second step is the removal of the bulkhead using divers and cables from barges in the lake. The barges are positioned in a manner such that there is a minimal angle of pull between the orientation of the gate guides and the barge cable winch. This requirement is to minimize lateral stresses on the gate guide A-frame structure, which, if significant enough, could result in a structure failure. However, if there is an extreme exigency for removal of the bulkhead wherein mobilization of the barges would take an inordinate amount of time, an alternate procedure can be followed. This procedure calls for the lifting of the bulkhead by using winches located on the operation and maintenance access road. Details of this procedure are contained in the following document: "Bulkhead Gate Instructions for Placing and Removing, Alamo Dam Outlet Gate Rehabilitation, Mohave and Yuma Counties, Arizona, DACW09-90-C-0027."

7-16. Deviation from Normal Regulation

Deviations from normal operation inevitably occur, because every possible circumstance affecting the operation of the dam cannot be covered in the water control plan. Guidance for covering deviations from approved water control plans within the South Pacific Division (SPD) is contained in Regulation CESPD R 1110-2-8, dated 12 September 2002 (Exhibit E). This guidance describes the types of deviations and the procedures for implementing these deviations.

Approval for all deviations must be obtained from the SPD Commander. An emergency deviation situation may warrant an immediate action, rendering prior approval impossible. All planned deviations, however, must be approved by the SPD commander or delegated representative prior to their implementation. SPD approval authority for deviations is delegated to the Chief of the Water Management Team or his/her designated representative. The Chief, Water Management Team shall consult with the Chief, Technical Engineering and Construction Division, and appropriate CESPD Staff. The Director of Military and Technical Services shall be advised by Division staff of the temporary change to the Water Control Plan. Approval may be made by telephone, E-mail, or FAX.

The preparation and funding for processing the deviation request is provided by the agency requesting the deviation. The deviation request must undergo an independent technical review (ITR) process by an independent technical review team (ITRT) within the LA District. Upon completion of the ITR process, a District certification is prepared, and sent to SPD with the deviation request package for acceptance and approval of the deviation request. Processing a deviation request can be costly and time consuming, and because an incomplete or inadequate package can delay approval, SPL personnel are encouraged to coordinate any questions or concerns about potential deviations and to discuss any atypical situations with their SPD counterparts early in the process.

7-17. <u>Rate of Release Change</u>

The maximum rates of release change are listed in Plate 7-02. These rates of release change values were selected to prevent rapid changes in downstream flows and river stages that would pose a safety hazard to the public.

VIII. EFFECT OF WATER CONTROL PLAN

VIII - EFFECT OF WATER CONTROL PLAN

8-01. General

Alamo Dam is operated for flood control, water conservation, and recreation and wildlife enhancement. The effects of operating for these purposes, along with flow and elevation frequencies are described in the following sections.

8-02. Flood Control

a. Spillway Design Flood. The original spillway design flood was based on the summer occurrence of a maximum probable flood with an antecedent flood which was equivalent to the reservoir design flood. The estimate of the probable maximum flood has since been superseded, however, it still remains as the spillway design flood. The antecedent flood had a peak inflow of 220,000 cfs (6,230 cms) and a 3.54-day volume of 253,844 acre-feet (31,311 ha-m). The spillway design flood (summer maximum probable flood) had a peak inflow of 580,000 cfs (16,424 cms) and a 4-day volume of 847,144 acre-feet (104,495 ha-m). Flood routing was begun on the first day of the antecedent flood. The starting reservoir water surface elevation was assumed to be the top of the water conservation pool or 1160.4 feet (353.7 m). The peak reservoir water surface elevation of the combined antecedent-spillway design flood was 1259.6 feet (383.9 m). The peak discharge was 50,660 cfs (1,435 cms), as shown on Plate 8-01.

b. Standard Project Flood -- Original. The original standard project flood (SPF), which is the reservoir design flood, was based on a synthetic winter storm that was selected upon review as the most severe storm reasonably characteristic of the geographic area. The original SPF had a peak discharge of 317,000 cfs (8,976 cms) and a 7-day volume of 422,000 acre-feet (52,054 ha-m). In routing the original SPF through the reservoir, the controlled outflow was 7,000 cfs (198.2 cms) and the resultant peak reservoir water surface elevation attained was 1215.2 feet (370.4 m). Although conventional practice would have been to place the spillway crest at the 1215.2-foot

(370.4 m) elevation, further project studies (including routings and cost estimates) showed that there was no discernable difference in project cost from locating the spillway crest at an elevation anywhere between elevation 1215.2 (370.4 m) and 1235 feet (376.4 m). The basis for this conclusion was balancing of the deeper depth of cut required for lower elevation spillway crests balanced by the minimal increase in required dam embankment elevation for higher elevation spillway crests. The spillway crest was, accordingly, set at 1235 feet (376.4 m).

c. Standard Project Flood -- Revised. The revised standard project flood (SPF) has a peak discharge of 389,000 cfs (11,015 cms) and a 7-day volume of 613,000 acre-feet (75,613 ha-m), as referenced in the March 1986 "Interim Report on Hydrology and Hydraulic Review of Design of Existing Dams for Alamo and Whitlow Ranch Dams". The revised SPF was routed through the reservoir using the current operating plan, with the starting reservoir water surface elevation assumed to be the 1125-foot (342.9 m) target elevation. The maximum outflow was 7,000 cfs (198.2 cms), or the maximum allowable flood control release; the peak water surface elevation was 1222.1 feet (372.5 m), as referenced in the March 1999 "Alamo Dam Risk Assessment Study". The revised SPF routing is shown on Plate 8-02.

d. Probable Maximum Flood. Two methods of flood routing were used to determine the highest water surface elevation that could possibly occur during the spillway design flood. In one method, the October PMF and December PMF were routed with no antecedent flow using the top of the flood control pool as a starting water surface elevation. This is the typical routing procedure used for reservoir design because it is reasonably representative of "worst case" conditions. The other procedure used involved routing an antecedent flood prior to routing the PMF. This procedure assumes that any antecedent flow occurring prior to the PMF will not exceed the reservoir design capacity.

Referring to the "Interim Report on Hydrology and Hydraulic Review of Design Features of Existing Dams for Alamo and Whitlow Dams," dated March 1986, the "worst case" condition was derived from routing the antecedent flood consisting of the revised

SPF, routed prior to the PMF routing. The reservoir water level would rise from the starting elevation of 1160.4 feet (net storage) and overtop the dam at elevation 1265. The revised December PMF peak discharge for Alamo Dam is 820,000 cfs (23,220 cms) with a 3-day volume of 1,390,000 acre-feet (171,456 ha-m). The revised October PMF peak discharge is 859,000 cfs (24,324 cms) with a 3-day volume of 1,180,000 acre-feet (145,552 ha-m). The original design PMF peak discharge was 580,000 cfs (16,424 cms) with a 3-day volume of 893,000 acre-feet (110,151 ha-m). The revised December PMF routing is shown on Plate 8-02a.

The revised December PMF, because of greater volume than the October PMF, was then used to evaluate current spillway adequacy and dam safety (Reference the March 1986 "Interim Report on Hydrology and Hydraulic Review of Design of Existing Dams for Alamo and Whitlow Ranch Dams" and the March 1999 "Alamo Dam Risk Assessment Study"). The December PMF was routed in association with the antecedent revised SPF, whose routing is summarized in section 8-02c. The PMF storm event was assumed to commence immediately after cessation of the SPF storm event. As such, the starting reservoir water surface elevation for the PMF was 1220.89 feet (372.1 m). The PMF was routed according to the revised operating plan assuming no transfer of flow to the spillway (maximum outlet release maintained above spillway crest). The routing, nevertheless, resulted in overtopping of the dam embankment. The maximum (theoretical) water surface elevation was 1281.3 feet (390.5 m); the maximum outflow was 282,142 cfs (7,989 cms). This routing assumes no flow over the top of the dam and the (maximum) water surface elevation assumes the dam embankment is constructed to this elevation plus the required freeboard. The spillway configuration (geometry) is assumed to also extend to the higher (theoretical) top of dam.

e. <u>Threshold Flood</u>. The flood that results in a peak reservoir water surface elevation equal to the maximum design reservoir water surface elevation, 1259.6 feet (383.9 m), is defined herein as the Threshold Flood. The Threshold Flood was determined by successive routings using varying percentages of the December PMF. The starting water surface elevation was identical to PMF starting conditions, as summarized in section 8-02d. This event was determined to be 45 percent of the PMF, with an inflow peak of 369,000 cfs (10,449 cms) and a volume of 659,100 acre-feet (81,300 ha-m). Therefore, assuming an antecedent SPF routing, the spillway at Alamo Dam is capable of safely passing floods up to 45 percent of the PMF, occurring immediately after the SPF. The Threshold Flood routing is shown on Plate 8-03. The adopted water control plan produces an increase in dam safety, as compared to the GDM operation plan, by increasing the magnitude of the threshold flood capable of being passed safely from 33 percent to 45 percent of PMF. Reference paragraph 8-12.f. for a brief description of a risk assessment study performed for Alamo Dam.

f. **Other Floods**. The historic floods summarized in Sections 4-06f through 4-06k were routed according to the current water control plan. Plates 8-04 through 8-08 show the respective routings for these floods.

8-03. Recreation

With the current water control plan, recreational opportunities are enhanced by maintaining Alamo Lake at or near a maximum, the target elevation being 1125 feet (342.9 m), to the extent that reservoir inflow balances releases and evaporation losses from the lake. When the lake elevation is within the 1115-1125-foot (339.9-342.9 m) range, the functionality of the boat ramps is maximized. In addition, this elevation range maximizes access and recreational opportunity at other locations around the lake.

8-04. Water Quality

The current water control plan requires rapid lowering of the reservoir to the 1125-foot (342.9 m) target elevation after major flood events. With this operation, the reservoir evaporation rate is reduced. The result is prevention of an increase in reservoir salinity when the reservoir is at a higher elevation and storage. This, in turn, helps prevent high salinity loading into the lower Colorado River. During dry periods, when reservoir salinity normally increases due to low inflows, releases are limited to those necessary for water rights and downstream riparian needs. These releases are small enough such that the impact of salinity on the lower Colorado River is negligible.

8-05. Fish and Wildlife

The lake surface area supports a fish population sufficient for the foraging requirements of the two pairs. The regulation at Alamo Dam supports the habitat of nesting pairs of bald eagles by maintaining minimum lake elevations. This also provides favorable conditions for the Southwestern Willow Flycatchers, which were declared as endangered without critical habitat in February 1995. Keeping the lake elevation from exceeding 1134 feet (345.6 m) prevents inundation of the lowest habitable nest site within the reservoir. Over the years, a downward trend of the local eagle population has been observed by the U.S. Fish and Wildlife Service (USFWS), and it is speculated that this was partially due to loss of occupied eagle snags from inundation. One solution suggested by the USFWS, in order to stimulate the growth of the eagle population, was that artificial perches be established within the lake area.

Between water surface elevations 1070 (326.1 m) and 1125 feet (342.9 m), baseflow releases are made which are designed to provide sufficient water for maintenance of riparian habitat along the Bill Williams River corridor, including within the National Wildlife Refuge. Baseflow releases range from 10 to 50 cfs (0.28 to 1.4 cms), depending on lake elevation and season. If necessary, hydrologic investigations will be made to more accurately define a sustainable baseflow regime that will better fulfill the riparian system's needs.

8-06. Water Supply

Based upon a 1961 Bureau of Reclamation study, operating Alamo Dam in conjunction with the Bureau's Hoover, Davis and Parker Dams can increase water supply in the Colorado River system by an average of 4,500 acre-feet (555 ha-m) per year. Under the present operating plan, conservation storage can be evacuated rapidly from

Alamo Lake. While evacuating storage from Alamo Lake, releases from Lake Mead are normally curtailed by an equivalent amount. The practice maximizes lower Colorado River system water supply for consumptive uses.

8-07. Hydroelectric Power

Although Alamo Dam has no hydroelectric power facilities, the 1961 USBR study concluded that coordination of Alamo Dam releases with releases from Hoover and Parker Dams can increase the average annual firm energy generation from those facilities as follows:

Hoover - 5 million kwh

Parker - 7.58 million kwh

The present operating plan provides the necessary flexibility in release patterns from Alamo Dam to achieve the predicted increase in energy generation. Coordination of Alamo Dam releases with USBR operation of mainstem lower Colorado River reservoirs is the key to achieving the power production increases.

8-08. Navigation

There are no benefits for or impacts on navigation from the operation of Alamo Dam.

8-09. Drought Contingency Plan

The Drought Contingency Plan for Alamo Dam and Lake was completed in June 1992 under the authority of ER 1110-2-1941, dated 15 September 1981, and available at the U.S. Army Corps of Engineers, Los Angeles District office. However, because there is presently no prescribed user for water stored in the water conservation pool, water released from Alamo Dam that reaches the Colorado River is distributed to water users in accordance with the laws and rights governing consumptive use of Colorado River water.

Water stored in Alamo Lake could be used to augment deliveries to the Central Arizona Project, the Metropolitan Water District of Southern California, and Mexico.

8-10. Flood Emergency Action Plan

The plan entitled, "Emergency Action and Notification Subplan for Alamo Dam", dated July 1986, implements the Corps' program to prepare emergency plans for all Corps projects and provides a guide for actions to identify impending and existing emergencies, and to notify other parties about impending or existing emergencies, emergency operations or repairs, and post earthquake response procedures. The plan also identifies downstream areas potentially subject to inundation in the case of dam failure at spillway crest elevation 1235 feet (376.4 m). A copy of the Emergency Action Plan is available in the Los Angeles District Office, Reservoir Operation Center and at the dam site.

8-11. Frequencies

The frequency analysis report was prepared by a contractor for the U.S. Army Corps of Engineers, Los Angeles District, as a part of a risk assessment study (see section 8-12f), which was performed in August 2000, for the period of record (1929-1998). In deriving the frequency curves, volume frequency curves were generated for the 1-, 2-, 3-, 5-, 10-, 20-, and 30-day. Balanced hydrographs for reservoir inflow were then constructed for the 1 in 50, 1 in 100, 1 in 200, 1 in 500, 1 in 5,000, 1 in 10,000, 1 in 50,000, 1 in 500,000, and 1 in 1,000,000, based on the volume frequency relationships and using the HEC-1 computer program. These balanced hydrographs and the SPF and PMF events were routed through the reservoir using the HEC-5 computer program and considered the Bill Williams River Corridor Technical Committee (BWRCTC) dam operation plan modified to reflect the Colorado River reservoir system operations for flood control.

a. Inflow Frequency. Plate 8-09 shows the volume inflow volume frequency curves for Alamo Lake. Plate 8-09a shows the 50-year balanced hydrograph, and Plate 8-09b shows the peak annual inflow frequency curve. The period of record data specifically used to generate the frequency plots are from the following sources: Alamo Dam and Lake operating records (1968-1999); USGS Gage No. 09426000 at Alamo Dam site (1940-1967); USGS Gage No. 09426500 at Planet, approximately 30 miles (48.2 Km) downstream from Alamo Dam. Flows were correlated for Alamo Dam site using linear regression (1927, 1929-1939).

Except for the extreme high events, recorded flows at Planet were adjusted for the Alamo Dam site using a correlation developed from the seven-year period (1940-1946) in which both the Alamo and Planet gages were concurrently in use.

b. Elevation Frequency. Plate 8-10 shows the Alamo Lake stage-frequency and outflow-frequency relationships for existing conditions and the existing dam without modifications. This data is from the risk assessment analysis performed in August 2000 (refer to section 8-12f).

c. Outflow Frequency. Plate 8-10 shows the outflow frequency in relation to stage for existing conditions at the existing dam for a range of Exceedance probabilities. This data is from the risk assessment analysis performed in August 2000 (refer to section 8-12f).

d. Elevation-Duration-Frequency. Plate 8-11 shows the elevation-duration curve for the period of record. This data is from the risk assessment analysis performed in August 2000 (refer to section 8-12f).

8-12. Other Studies

The following paragraphs summarize other various studies concerning Alamo Dam and lake:

a. The Los Angeles District conducted a Section 216 reconnaissance study (Flood Control Act of 1970) during Fiscal Year 1988-89 on potential reallocation of storage and re-operation of Alamo Dam. A final study report, published in July 1990, contained nine alternative operating plans.

b. The U.S. Bureau of Land Management (BLM) published a report, in December 1988, entitled "Assessment of Water Resources Conditions in Support of In-stream Flow Water Rights." The study recommended a monthly release schedule to satisfy instream water rights below Alamo Dam.

c. An interagency committee, known as the Bill Williams River Corridor Technical Committee (BWRCTC), was formed in 1991 for the purpose of developing a revised water control plan that would best meet the objectives of the member agencies. The water control plan presented in Chapter VII is the result of the various studies conducted and recommendations prescribed by the BWRCTC.

d. As a follow-up to the BWRCTC study and the recommended operating plan, the Corps, in 1996, completed a second reconnaissance study based on the 1970 Flood Control Act. The reconnaissance study was then followed by the Alamo Dam and Lake Feasibility Study. The Feasibility Study Report and the accompanying Environmental Impact Statement were completed in 1999.

e. The Corps' Hydrologic Engineering Center (HEC), in April 1998, conducted a computer simulation study for Alamo Dam and Lake operation using HEC's Prescriptive Reservoir Model optimization program. The objectives of the study were to optimize Alamo Dam and Lake operation for 1) protection of the in-lake bald eagle nests, 2) development of lake drawdown schemes for dam maintenance that would not conflict with other project purposes and 3) ascertain whether the recommended plan of the BWRCTC could be improved.

f. The Corps, in 1998-99, conducted a risk assessment study on Alamo Dam. The Alamo Dam Risk Assessment Study was a demonstration project in the development of risk assessment guidance for the Corps' Dam Safety Assurance Program. Some specific outcomes in the risk study included 1) an understanding of potential dam failure modes; 2) an evaluation of the risk posed by the existing dam against various risk-based criteria; and 3) an assessment of risk reduction and the cost effectiveness of risk reduction expected for various structural and non-structural measures. The Risk Assessment Study recognized that the existing spillway was deficient in that the PMF could not be passed without overtopping the dam, with the threshold flood being only 45% of the PMF (reference sections 8-02d and 8-02e). However, there are no current plans to modify the dam or the spillway, due to the extremely low probability of PMF occurrence and the low risk and impact to life and property downstream on the Bill Williams River and on the Colorado River main stem, should a PMF event occur.

IX. WATER CONTROL MANAGEMENT

IX - WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization

a. Corps of Engineers. Alamo Dam is owned, operated, and maintained by the U.S. Army Corps of Engineers, Los Angeles District, which has complete regulatory responsibility for the dam and the reservoir area.

The Reservoir Regulation Section of the U.S. Army Corps of Engineers, Los Angeles District, conducts reservoir regulation of Alamo Dam and Lake. Table 9-01 is an organizational chart depicting the chain of command for the Reservoir Regulation decisions.

Gate operation instructions to the dam tender are issued by the Reservoir Regulation Section's Reservoir Operations Center (ROC), as mentioned in sections 5-05 and 5-06. In the event that communication between the ROC and Alamo Dam are interrupted, reference to the "Standing Operating Instructions to Project Operator for Water Control" should be made, which are included in this manual as Exhibit A. Dam tenders are part of the Operations Branch, under the Construction-Operations Division of the U.S. Army Corps of Engineers, Los Angeles District.

b. Other Federal Agencies. The U.S. Geological Survey (USGS) operates and maintains four stream gages within the Bill Williams River basin. The USGS also collects water quality samples at a site known as Bill Williams River near Planet. This site (there is no gaging station) is located at the confluence of Mineral Wash and the Bill Williams River. The U.S. Bureau of Land Management (BLM) is responsible for maintenance of the six- mile riparian corridor segment immediately downstream from the dam. The U.S. Fish and Wildlife Service (USFWS) is responsible for maintenance of the Bill Williams River National Wildlife Refuge along the last eight-mile segment of the Bill Williams river before the Colorado River confluence.

c. State and County Agencies. The Arizona Department of Water Resources is responsible for issuance of all water rights claimed for water in the Bill Williams River basin. The Arizona State Parks Department (ASP) manages U.S. Army Corps of Engineers' withdrawn and acquired lands at Alamo Lake (Plate 2-11) for fish and wildlife purposes under Department of the Army license DACA09-3-97-31. Arizona Department of Game and Fish also has a role as trustee for all wildlife in the State of Arizona, including both in the reservoir area and downstream from Alamo Dam.

d. Private Organizations. There is no involvement of private organizations in the operation or maintenance Alamo Dam.

9-02. Interagency Coordination

The U.S. Army Corps of Engineers coordinates with other Federal, State, County, and local organizations, as well as with the press, concerning the water control for Alamo Lake. These organizations, along with a brief explanation of their relationship to the operation of Alamo Lake, is given in the following subparagraphs.

a. Local Press and Corps of Engineers Bulletins. The Public Affairs Office of the U.S. Army Corps of Engineers, Los Angeles District, is responsible for interfacing with the press regarding operations at Alamo Dam and flows on the Bill Williams River downstream of the dam. This is accomplished through both interviews and the occasional issuance of press releases. The Corps of Engineers does not publicly issue flood watches or warnings or other status reports or forecasts. These are the responsibility of the National Weather Service.

b. National Weather Service (NWS). The National Weather Service (NWS) Colorado Basin River Forecast Center, in Salt Lake City, Utah, is the River Forecast office for the Colorado River and its tributaries. Flood conditions, weather forecasts, and precipitation reports for the Bill Williams River are routinely obtained by the Los

Angeles District, via a leased telephone line. The NWS also provides SPL with extended streamflow prediction forecasts for the Bill Williams basin.

c. U.S. Geological Survey (USGS). The USGS's Arizona District operates stream gaging stations both upstream and downstream of Alamo Dam. The two upstream stations, which are maintained by the USGS's Tempe office, are the Big Sandy River near Wikieup and the Santa Maria River near Bagdad. The two downstream stations, which are maintained by the USGS' Yuma office, are the Bill Williams River below Alamo Dam and the Bill Williams River near Parker. These gages are operated under a cooperative agreement between the Corps and the USGS. Streamflow records from these gages are published in the annual "Streamflow Data for Arizona."

d. U.S. International Boundary and Water Commission (IBWC). The IBWC, in El Paso, Texas, is interested in the operation of Alamo Dam because of the Commission's responsibilities relating to the 1944 Water Treaty with Mexico.

e. U.S. Bureau of Reclamation (USBR). The U.S. Bureau of Reclamation's Lower Colorado Regional Office in Boulder City, Nevada operates Parker Dam, and controls the elevation of Lake Havasu at the confluence of the Bill Williams and Colorado Rivers. The Bureau is responsible for operation of the lower Colorado River system and for flood protective work on the main stem of the river. Hydrologic and hydraulic data are exchanged between the Bureau's Boulder City office and the Reservoir Regulation Section of the U.S. Army Corps of Engineers, Los Angeles District. This information includes reservoir data and precipitation reports, as well as discharges along the lower Colorado River and outflow from Alamo Dam.

f. U.S. Fish and Wildlife Service (USFWS). The USFWS monitors the activities of all endangered wildlife within the vicinity of Alamo Dam and Lake, and also manages the Bill Williams River National Wildlife Refuge.

g. U.S. Bureau of Land Management (BLM). The BLM is responsible for maintenance of the riparian corridor immediately downstream from Alamo Dam.

h. Arizona State Parks Board. The Arizona State Parks Board, in Phoenix, Arizona is the recreational licensee for Alamo Lake.

i. Arizona Game and Fish Department. The Arizona Game and Fish Department (AGF) manages U.S. Army Corps of Engineers' withdrawn and acquired lands at Alamo Lake (Plate 2-11) for fish and wildlife purposes under Department of the Army license DACA09-3-97-31. The AGF also has a role as trustee for all wildlife in the State of Arizona, including both in the reservoir area and downstream from Alamo Dam.

9-03. Interagency Agreements

The Corps annually contracts for water quality monitoring at Alamo Lake through the U.S. Fish and Wildlife Service (USFWS), as discussed in Section 5-02a. The Corps also has a cooperative stream gaging agreement with the USGS to calibrate, maintain, and publish data from the stream gage immediately downstream from Alamo Dam. Details about the cooperative stream gaging program can be found in Section 5-01d.

9-04. Commissions, River Authorities, Compacts, and Committees

Alamo Dam is on a tributary to the Colorado River main stem, however, the facility is not part of any river authority, compact or committee.

9-05. Non-Federal Hydropower

There is no non-Federal hydropower facility at Alamo Dam.

9-06. Reports

The U.S. Army Corps of Engineers, Los Angeles District, prepares and files several types of reports.

If requested, during the runoff season, November through April, a flood situation and runoff potential report is prepared and sent to the South Pacific Division of the Corps of Engineers.

Six specific forms are also prepared in conjunction with the District's reservoir operations. A copy of each of these forms, as listed in the following, is shown as Figures 9-01 through 9-06: Flood Control Basin Operation Report (prepared by each dam tender), Rainfall Record (from manual readings of glass tube rain gages), Reservoir Operation Report, Record of Data from Digital Recorders, Reservoir Computations, and Record of Calls (both radio and telephone).

The Corps of Engineers also collects and files charts from recording instruments at Alamo Dam, including precipitation, evaporation, and reservoir water surface elevation. Daily precipitation and evaporation totals and, as needed, other data (such as unusually high precipitation intensities) are manually extracted from the precipitation charts, and the charts are sent to the National Climatic Data Center of NOAA and published in the annual "Precipitation Records for Arizona." The other charts are maintained on file at the Corps of Engineers, Los Angeles District.

Table 9-02 lists the general documents that the Corps of Engineers, Los Angeles District prepares annually. Information pertaining to Alamo Dam and Lake is contained in each of these reports.

Table 9-01
Chain of Command for Reservoir Operations Decisions

Corps of Engineers
Los Angeles District

- District Engineer
Phone (213) 452-3961
Pager (213) 391-2087
  - Water Control Decisions
    - Chief, Engineering Division
(213) 452-3629
      - Chief, Hydrology and Hydraulics Branch
(213) 452-3525
        - Chief, Reservoir Regulation Section
(213) 452-3527
          - Chief, Reservoir Regulation Unit
(213) 452-3530
  - Operations and Maintenance Decisions
    - Chief, Construction-Operations Division
(213) 452-3349
      - Chief, Operations Branch
(213) 452-3385
        - Chief, Operations and Maintenance Section
(626) 401-4008
          - Dam Tender Foreman
(626) 401-4006
            - Dam Tender
Radio Call Sign WUK 437

Table 9-02
Reports Prepared Annually by Corps of Engineers, Los Angeles District

Report Name	Description of Report Contents
Annual Report on Water Quality Management	Summary of District water quality program and significant water quality issues.
Annual Report on Water Control Management	Summary of operation and maintenance activities; significant operational issues; planning studies; personnel training.
Annual Instructions for Reservoir Operations Personnel (the "Orange Book")	Instructions for District reservoir operations personnel, lists of individuals and agencies to notify in conjunction with reservoir operations.

FIGURES

U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS

FLOOD CONTROL BASIN OPERATION REPORT

Name **Month** **Year**

Day	Reservoir W.S.Elev			Outlet channel		Gate operation																	OPERATOR
	Time	Type of Gage	Gage reading in feet	Time	Gage height in feet	Time	Gate opening in feet																
							No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	No.13	No.14	No.15	No.16	

REMARKS: Bypass flow in c.f.s.

SPL FORM 19 1 Mar 55 Reinstating SPL Form 19 – 25 Jun 52

FIGURE 9-01

RAINFALL RECORD

STATION					☐ HOURLY ☐ DAILY		DATE
HR	DAY	TIME OF READING	GAGE READING	STORM TOTAL	SEASON TOTAL	OBSERVER	REMARK (SNOW, TEMP, ETC.)
0000	1						
0100	2						
0200	3						
0300	4						
0400	5						
0500	6						
0600	7						
0700	8						
0800	9						
0900	10						
1000	11						
1100	12						
1200	13						
1300	14						
1400	15						
1500	16						
1600	17						
1700	18						
1800	19						
1900	20						
2000	21						
2100	22						
2200	23						
2300	24						
2400	25						
	26						
	27						
	28						
	29						
	30						
	31						
TOTAL							

RESERVOIR OPERATION REPORT

DATE ____________________

RADIO CALL SIGN WUK4	NAME OF DAM	LOCAL TIME	WATER SURFACE ELEVATION (FT)	STEP 1 INVERT	REMARKS	RAINFALL (INCHES) GLASS TUBE: SINCE LAST REPORT	STORM TOTAL	SEASON TOTAL	GATE SETTINGS (@ STANDBY) 1 2 3 4 5 6 7 8 / 9 10 11 12 13 14 15 16
411	SEPULVEDA			710.2 668.0					9.0 9.0 9.0 9.0
415	WHITTIER NARROWS RIO HONDO		W. PIT	184.0					2.6 19.0 19.0 19.0
			E. PIT	184.0					
			COMB.	192.5 184.0					LACDPW DIVERSION GATE OPEN ____________
415	WHITTIER NARROWS SAN GABRIEL		TELMARK						
			W. STAFF	200.0					0 0 0 0 0 0 0.5 0
			E. STAFF	200.0					0
			COMB.	206.0 200.0					
416	BREA			213.0 208.0					3.5 3.5
417	FULLERTON			274.0 261.0					1.1 1.1
412	HANSEN			994.0 990.0					1.0 1.0 1. 0 1.0 1. 0 1.0 1.0 1.0
412	LOPEZ			1273.0 1254.0					5.0
418	CARBON CANYON			419.0 403.0					0 1.0
421	PRADO			490.0 460.0					1.0 0 0 0 0 1.0
420	SAN ANTONIO			2164.0 2125.0					0.3 0 0
419	SANTA FE			456.0 421.0					0 0 0 0 0 0 0 0 0 0 0 0 0 0.5 0 0
429	PAINTED ROCK		RES. ____________ B. PIT	550.0 530.0					0.5 0.5 0.5 C H L HOOK: ____________ ANEMOMETER: ____________
437	ALAMO			1070.0 990.0					0 0 0 Emg= Bypass: ________ cfs HOOK: ____________ C H L ANEMOMETER: ____________

FIGURE 9-03

RECORD OF DATA FROM DIGITAL RECORDERS				NAME OF DAM	
DATE	TIME	WATER SURFACE	GAGE HEIGHT	PRECIPITATION	OPERATOR

SPL FORM 1 FEB 77 648

FIGURE 9-04

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS

RESERVOIR COMPUTATIONS

☐ HOURLY ☐ DAILY

DAM	TIME OF READING (IF DAILY)	DATE

COMPUTED BY	CHECKED BY	DATA SOURCE

HR.	DA.	WATER SURFACE ELEV. FT.	STORAGE AC. FT.	GATE STEP NO.	INST. OUTFLOW OUT-LETS CFS	INST. OUTFLOW DOWNSTREAM G. HT. FT.	INST. OUTFLOW DOWNSTREAM FLOW CFS	HRS.	STORAGE CHANGE ACRE-FEET	STORAGE CHANGE CFS	AV. OUT-FLOW CFS	AV. INFLOW CFS	GATE SETTINGS FT.
PREVIOUS REPORT													
0100	1												
0200	2												
0300	3												
0400	4												
0500	5												
0600	6												
0700	7												
0800	8												
0900	9												
1000	10												
1100	11												
1200	12												
1300	13												
1400	14												
1500	15												
1600	16												
1700	17												
1800	18												
1900	19												
2000	20												
2100	21												
2200	22												
2300	23												
2400	24												
	25												
	26												
	27												
	28												
	29												
	30												
	31												

REMARKS					
	TOTAL				
	MEAN				

SPL FORM 30 27 JUN 58 PREVIOUS EDITIONS MAY BE USED; REPLACES SPL FORM 29 WHICH MAY BE USED

FIGURE 9-05

RECORD OF CALLS ☐ Radio ☐ Telephone						Date
Local Time	From		To		Check Repeatable calls	Message or Remarks
	Person and/or Call Sign	Telephone and City	Person and/or Call Sign	Telephone and City		

*Reportable telephone calls include collect calls, charge calls and long distance calls that can not be dialed without a code number.

FIGURE 9-06

TABLES

TABLE 2-01.

ALAMO LAKE -- CAPACITY TABLE

SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)

COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)

(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION (FEET)	CAPACITY (ACRE-FEET) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
990.0	0	0	0	0	0	0	0	0	0	0
991.0	0	0	0	0	0	0	0	0	0	0
992.0	0	0	0	0	0	0	0	0	0	0
993.0	0	0	0	0	0	0	0	0	0	0
994.0	0	0	0	0	0	0	0	0	0	0
995.0	0	0	0	0	0	0	0	0	0	0
996.0	0	0	0	0	0	0	0	0	0	0
997.0	0	0	0	0	0	0	0	0	0	0
998.0	0	0	0	0	0	0	0	0	0	0
999.0	0	0	0	0	0	0	0	0	0	0
1000.0	0	0	0	0	0	0	0	0	0	0
1001.0	0	0	0	0	0	0	0	0	0	0
1002.0	0	0	0	0	0	0	0	0	0	0
1003.0	0	0	0	0	0	0	0	0	0	0
1004.0	0	0	0	0	0	0	0	0	0	0
1005.0	0	0	0	0	0	0	0	0	0	0
1006.0	0	0	0	0	0	0	0	0	0	0
1007.0	0	0	0	0	0	0	0	0	0	0
1008.0	0	0	0	0	0	0	0	0	0	0
1009.0	0	0	0	0	0	0	0	0	0	0
1010.0	0	0	0	0	0	0	1	1	1	1
1011.0	1	1	1	1	2	2	2	2	2	3
1012.0	3	3	3	4	4	4	4	5	5	5
1013.0	5	6	6	6	7	7	7	8	8	8
1014.0	9	9	10	10	10	11	11	12	12	12
1015.0	13	13	14	14	15	15	16	16	17	17
1016.0	18	18	19	19	20	20	21	22	23	23
1017.0	24	25	26	27	28	29	30	31	32	34
1018.0	35	36	38	39	41	42	44	46	48	50
1019.0	52	54	56	59	61	64	67	69	72	75
1020.0	79	82	85	89	93	97	101	105	110	115
1021.0	120	125	130	135	141	147	153	159	166	173
1022.0	180	187	194	202	210	218	227	235	244	253
1023.0	263	272	282	293	303	314	325	336	348	360
1024.0	372	384	397	410	422	435	448	461	474	488
1025.0	501	515	528	542	556	570	584	598	613	627
1026.0	642	656	671	686	701	716	731	746	761	776
1027.0	792	807	822	838	854	869	885	901	917	933
1028.0	949	965	982	998	1014	1031	1047	1063	1080	1097
1029.0	1113	1130	1146	1163	1180	1197	1214	1231	1248	1265
1030.0	1282	1299	1316	1333	1351	1368	1386	1403	1421	1439
1031.0	1457	1475	1493	1511	1529	1547	1566	1584	1603	1622
1032.0	1640	1659	1678	1697	1716	1735	1755	1774	1794	1813
1033.0	1833	1853	1872	1892	1912	1933	1953	1973	1994	2014
1034.0	2035	2055	2076	2097	2119	2140	2162	2184	2206	2228
1035.0	2250	2273	2295	2318	2341	2364	2388	2411	2435	2459
1036.0	2483	2508	2532	2557	2582	2607	2633	2659	2685	2711
1037.0	2738	2764	2791	2819	2846	2874	2902	2930	2958	2987
1038.0	3016	3045	3075	3105	3135	3165	3195	3226	3257	3289
1039.0	3320	3352	3384	3417	3449	3482	3515	3549	3583	3617

TABLE 2-01.

ALAMO LAKE -- CAPACITY TABLE
SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)
COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)
(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION	CAPACITY (ACRE-FEET)									
(FEET)	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1040.0	3651	3685	3720	3755	3790	3825	3861	3896	3932	3968
1041.0	4004	4041	4077	4114	4151	4188	4225	4263	4300	4338
1042.0	4376	4414	4453	4492	4531	4570	4610	4649	4689	4730
1043.0	4770	4811	4852	4894	4935	4977	5019	5062	5104	5147
1044.0	5190	5234	5278	5322	5366	5410	5455	5500	5545	5590
1045.0	5636	5682	5728	5774	5821	5868	5915	5962	6010	6058
1046.0	6106	6154	6203	6251	6300	6349	6399	6448	6498	6547
1047.0	6597	6647	6698	6748	6799	6850	6901	6952	7004	7055
1048.0	7107	7159	7211	7263	7316	7368	7420	7473	7526	7579
1049.0	7632	7685	7738	7791	7845	7899	7952	8006	8060	8114
1050.0	8168	8223	8277	8332	8386	8441	8496	8552	8607	8663
1051.0	8719	8774	8830	8887	8943	9000	9056	9113	9170	9228
1052.0	9285	9343	9400	9459	9517	9575	9634	9693	9752	9812
1053.0	9871	9931	9991	10052	10112	10173	10234	10295	10357	10419
1054.0	10481	10543	10605	10668	10731	10795	10858	10922	10986	11051
1055.0	11115	11180	11246	11311	11377	11443	11510	11576	11643	11710
1056.0	11778	11846	11914	11982	12050	12119	12188	12257	12327	12397
1057.0	12466	12537	12607	12678	12749	12820	12891	12963	13035	13107
1058.0	13179	13252	13325	13398	13472	13546	13621	13696	13771	13847
1059.0	13922	13999	14075	14153	14230	14308	14386	14464	14543	14623
1060.0	14702	14782	14863	14943	15024	15105	15187	15269	15351	15433
1061.0	15516	15599	15683	15766	15850	15935	16019	16104	16189	16275
1062.0	16361	16447	16533	16620	16708	16795	16883	16971	17060	17149
1063.0	17239	17328	17419	17509	17600	17691	17783	17875	17967	18060
1064.0	18153	18246	18340	18434	18529	18623	18718	18814	18909	19005
1065.0	19101	19198	19295	19392	19490	19588	19686	19784	19883	19982
1066.0	20082	20182	20282	20383	20483	20585	20686	20788	20891	20994
1067.0	21097	21200	21304	21409	21513	21618	21724	21830	21936	22043
1068.0	22150	22257	22365	22473	22581	22690	22800	22909	23019	23130
1069.0	23241	23352	23464	23576	23688	23801	23915	24028	24143	24257
1070.0	24372	24487	24603	24719	24836	24953	25070	25188	25307	25426
1071.0	25545	25664	25784	25905	26026	26147	26269	26391	26514	26637
1072.0	26761	26884	27009	27134	27259	27385	27511	27637	27765	27892
1073.0	28020	28148	28277	28406	28536	28666	28796	28927	29059	29191
1074.0	29323	29456	29589	29723	29857	29991	30126	30261	30397	30533
1075.0	30669	30806	30943	31081	31219	31358	31497	31636	31776	31916
1076.0	32057	32198	32339	32482	32624	32767	32910	33054	33198	33343
1077.0	33488	33633	33779	33926	34073	34220	34368	34516	34665	34814
1078.0	34963	35113	35264	35415	35566	35718	35871	36024	36177	36331
1079.0	36486	36641	36796	36952	37109	37265	37423	37581	37739	37898
1080.0	38058	38217	38378	38539	38700	38862	39024	39187	39350	39514
1081.0	39678	39843	40008	40174	40340	40507	40674	40842	41010	41179
1082.0	41348	41518	41688	41859	42030	42201	42373	42546	42719	42893
1083.0	43066	43241	43416	43592	43768	43944	44121	44298	44476	44655
1084.0	44834	45013	45193	45374	45555	45737	45919	46102	46286	46470
1085.0	46654	46840	47025	47212	47399	47586	47774	47963	48153	48342
1086.0	48533	48724	48915	49108	49300	49494	49687	49882	50077	50272
1087.0	50469	50665	50862	51060	51259	51457	51657	51857	52058	52259
1088.0	52460	52663	52866	53069	53273	53478	53683	53889	54096	54303
1089.0	54510	54718	54927	55137	55347	55557	55768	55980	56193	56406
1090.0	56619	56833	57048	57263	57479	57695	57912	58129	58348	58566

TABLE 2-01.
ALAMO LAKE -- CAPACITY TABLE
SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)
COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)
(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION	CAPACITY (ACRE-FEET)									
(FEET)	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1091.0	58785	59004	59224	59445	59666	59888	60110	60332	60556	60779
1092.0	61004	61228	61454	61680	61906	62132	62359	62587	62815	63043
1093.0	63272	63501	63731	63962	64192	64423	64655	64887	65120	65353
1094.0	65586	65820	66054	66289	66524	66760	66996	67233	67470	67708
1095.0	67946	68184	68423	68663	68903	69143	69384	69625	69867	70109
1096.0	70352	70595	70839	71083	71327	71572	71817	72063	72309	72556
1097.0	72803	73050	73298	73546	73795	74044	74294	74544	74794	75045
1098.0	75296	75548	75800	76053	76306	76559	76813	77067	77322	77577
1099.0	77832	78088	78345	78602	78859	79117	79375	79633	79892	80152
1100.0	80411	80672	80932	81194	81455	81717	81979	82242	82506	82769
1101.0	83033	83298	83563	83829	84095	84361	84628	84895	85163	85431
1102.0	85699	85968	86237	86508	86778	87049	87320	87591	87863	88136
1103.0	88409	88682	88956	89230	89505	89780	90055	90331	90608	90885
1104.0	91162	91440	91718	91997	92276	92556	92836	93116	93397	93679
1105.0	93961	94243	94526	94809	95093	95377	95662	95947	96233	96519
1106.0	96806	97093	97380	97669	97957	98246	98536	98826	99117	99408
1107.0	99699	99991	100284	100577	100871	101165	101460	101755	102051	102347
1108.0	102644	102941	103238	103537	103836	104136	104436	104736	105038	105340
1109.0	105642	105945	106249	106553	106858	107163	107469	107776	108083	108391
1110.0	108699	109008	109317	109628	109938	110249	110561	110873	111186	111499
1111.0	111813	112127	112442	112758	113074	113390	113707	114025	114344	114662
1112.0	114982	115302	115622	115943	116265	116587	116910	117233	117557	117881
1113.0	118206	118532	118858	119185	119512	119840	120168	120497	120827	121157
1114.0	121488	121819	122150	122483	122815	123148	123482	123816	124151	124486
1115.0	124822	125158	125494	125832	126169	126507	126846	127184	127524	127864
1116.0	128205	128546	128887	129229	129572	129915	130258	130602	130946	131291
1117.0	131636	131982	132328	132675	133022	133370	133718	134066	134416	134765
1118.0	135115	135465	135816	136168	136520	136873	137226	137579	137934	138288
1119.0	138643	138999	139355	139712	140070	140427	140785	141144	141504	141864
1120.0	142224	142585	142946	143308	143670	144033	144397	144760	145125	145490
1121.0	145855	146221	146587	146954	147322	147689	148058	148426	148796	149166
1122.0	149536	149907	150278	150650	151022	151395	151768	152142	152516	152891
1123.0	153266	153642	154018	154395	154773	155150	155529	155907	156287	156667
1124.0	157047	157428	157809	158191	158573	158956	159339	159723	160108	160327
1125.0	160546	160765	160984	161371	161758	162145	162533	162922	163311	163700
1126.0	164090	164480	164870	165262	165653	166045	166437	166830	167223	167617
1127.0	168011	168405	168800	169196	169592	169988	170385	170782	171180	171578
1128.0	171976	172375	172774	173174	173575	173975	174376	174778	175180	175583
1129.0	175985	176389	176792	177197	177601	178006	178412	178818	179225	179478
1130.0	179730	179983	180235	180644	181053	181462	181872	182283	182694	183105
1131.0	183517	183929	184342	184756	185169	185583	185998	186413	186829	187244
1132.0	187661	188078	188495	188913	189331	189750	190169	190588	191009	191429
1133.0	191850	192272	192693	193116	193539	193962	194386	194810	195235	195660
1134.0	196086	196512	196938	197366	197793	198221	198649	199078	199508	199773
1135.0	200038	200303	200568	201000	201432	201865	202298	202732	203167	203602
1136.0	204037	204473	204910	205347	205785	206223	206662	207101	207541	207981
1137.0	208422	208863	209305	209748	210191	210635	211079	211523	211969	212414
1138.0	212861	213307	213755	214203	214651	215100	215550	216000	216451	216902
1139.0	217353	217805	218258	218712	219166	219620	220075	220530	220987	221220
1140.0	221453	221686	221919	222378	222838	223297	223758	224219	224681	225143
1141.0	225605	226068	226532	226997	227462	227927	228393	228859	229327	229794

TABLE 2-01.

ALAMO LAKE -- CAPACITY TABLE

SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)

COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)

(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION (FEET)	CAPACITY (ACRE-FEET) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1142.0	230263	230731	231200	231671	232141	232612	233083	233556	234029	234502
1143.0	234976	235450	235925	236401	236876	237353	237830	238308	238786	239265
1144.0	239745	240224	240705	241186	241668	242150	242633	243116	243430	243744
1145.0	244059	244373	244687	245001	245488	245976	246465	246954	247445	247935
1146.0	248426	248918	249410	249904	250397	250891	251386	251881	252378	252874
1147.0	253372	253869	254368	254868	255367	255868	256368	256870	257373	257876
1148.0	258379	258883	259388	259893	260399	260906	261413	261921	262430	262939
1149.0	263448	263958	264469	264981	265493	266006	266520	267034	267347	267660
1150.0	267973	268286	268599	268912	269431	269950	270470	270990	271512	272033
1151.0	272556	273079	273602	274127	274652	275178	275704	276231	276759	277288
1152.0	277817	278346	278876	279408	279939	280472	281004	281538	282073	282608
1153.0	283143	283679	284216	284754	285292	285831	286371	286911	287452	287994
1154.0	288536	289078	289622	290167	290712	291257	291803	292350	292667	292984
1155.0	293300	293617	293934	294251	294803	295355	295908	296462	297017	297572
1156.0	298128	298684	299242	299800	300359	300918	301479	302039	302602	303164
1157.0	303727	304291	304855	305421	305987	306553	307121	307689	308258	308827
1158.0	309398	309969	310540	311113	311686	312260	312835	313410	313986	314563
1159.0	315140	315719	316297	316878	317458	318039	318621	319203	319524	319845
1160.0	320165	320486	320807	321128	321716	322304	322893	323483	324074	324666
1161.0	325258	325851	326444	327040	327635	328231	328827	329425	330024	330623
1162.0	331222	331823	332424	333027	333629	334233	334837	335442	336049	336655
1163.0	337262	337870	338479	339089	339700	340311	340923	341535	342149	342764
1164.0	343378	343994	344611	345229	345846	346465	347085	347705	348044	348384
1165.0	348723	349062	349402	349741	350367	350994	351621	352249	352879	353508
1166.0	354139	354770	355402	356036	356669	357304	357939	358575	359212	359850
1167.0	360488	361128	361768	362409	363051	363693	364336	364980	365626	366271
1168.0	366918	367565	368213	368863	369512	370163	370814	371466	372119	372773
1169.0	373427	374083	374739	375396	376054	376712	377372	378032	378399	378765
1170.0	379132	379498	379865	380231	380897	381563	382231	382900	383570	384240
1171.0	384911	385583	386256	386931	387605	388281	388957	389634	390313	390992
1172.0	391672	392353	393035	393718	394401	395086	395771	396457	397144	397832
1173.0	398521	399210	399901	400593	401285	401978	402672	403367	404063	404760
1174.0	405458	406156	406855	407556	408257	408959	409662	410366	410737	411109
1175.0	411480	411851	412223	412594	413303	414014	414726	415439	416153	416867
1176.0	417583	418299	419016	419735	420453	421173	421894	422615	423338	424062
1177.0	424786	425511	426237	426965	427692	428421	429151	429881	430613	431346
1178.0	432079	432813	433548	434285	435021	435759	436498	437237	437979	438720
1179.0	439462	440205	440949	441695	442441	443188	443935	444684	445078	445472
1180.0	445866	446260	446654	447048	447803	448559	449316	450074	450834	451594
1181.0	452355	453116	453879	454643	455408	456173	456940	457707	458477	459246
1182.0	460016	460787	461560	462334	463108	463883	464659	465436	466215	466994
1183.0	467773	468554	469336	470120	470903	471688	472474	473260	474049	474837
1184.0	475627	476417	477209	478002	478795	479590	480385	481181	481588	481995
1185.0	482403	482810	483217	483624	484427	485231	486036	486842	487649	488457
1186.0	489266	490076	490887	491700	492512	493326	494141	494956	495774	496592
1187.0	497410	498230	499050	499873	500695	501519	502343	503169	503996	504823
1188.0	505652	506481	507312	508144	508976	509809	510644	511479	512316	513153
1189.0	513992	514831	515671	516513	517355	518198	519043	519888	520315	520743
1190.0	521170	521597	522025	522452	523304	524157	525010	525865	526721	527578
1191.0	528435	529293	530152	531013	531874	532736	533598	534462	535328	536193
1192.0	537059	537927	538795	539665	540535	541406	542278	543151	544026	544900

TABLE 2-01.

ALAMO LAKE -- CAPACITY TABLE

SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)

COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)

(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION	CAPACITY (ACRE-FEET)									
(FEET)	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1193.0	545776	546652	547530	548409	549288	550168	551050	551932	552816	553699
1194.0	554584	555470	556356	557245	558134	559023	559913	560805	561308	561810
1195.0	562313	562815	563318	563820	564718	565617	566517	567418	568321	569223
1196.0	570127	571032	571937	572845	573753	574661	575571	576481	577394	578307
1197.0	579220	580134	581050	581967	582885	583803	584722	585643	586565	587487
1198.0	588411	589335	590260	591187	592114	593043	593972	594902	595834	596766
1199.0	597699	598633	599568	600506	601443	602381	603320	604260	604765	605270
1200.0	605774	606279	606784	607289	608235	609183	610131	611081	612032	612983
1201.0	613935	614888	615842	616798	617754	618711	619668	620627	621587	622548
1202.0	623509	624471	625434	626399	627364	628330	629297	630265	631234	632204
1203.0	633174	634146	635118	636092	637066	638041	639017	639994	640973	641952
1204.0	642931	643912	644894	645877	646861	647845	648830	649816	650381	650946
1205.0	651212	652077	652642	653207	654200	655194	656189	657185	658182	659180
1206.0	660179	661178	662179	663182	664184	665188	666193	667198	668206	669213
1207.0	669440	670442	671447	672454	673461	674469	675478	676489	677502	678515
1208.0	680364	681383	682403	683426	684448	685471	686496	687521	688549	689576
1209.0	690604	691633	692664	693696	694728	695762	696796	697831	698869	699906
1210.0	700080	701119	702160	703202	704245	705288	706333	707378	708426	709474
1211.0	710523	711572	712623	713676	714729	715783	716838	717894	718953	720011
1212.0	721070	722131	723192	724256	725319	726384	727449	728516	729585	730654
1213.0	731724	732794	733866	734941	736015	737090	738166	739244	740323	741403
1214.0	742483	743565	744647	745732	746817	747903	748990	750078	751168	752258
1215.0	753190	754283	755376	756472	757568	758665	759763	760863	761965	763066
1216.0	764169	765274	766379	767487	768595	769704	770814	771925	773039	774153
1217.0	775268	776384	777501	778621	779741	780862	781984	783107	784233	785359
1218.0	786486	787614	788743	789875	791007	792140	793274	794409	795547	796685
1219.0	797824	798964	800106	801250	802394	803539	804685	805832	806983	808132
1220.0	809220	810371	811525	812681	813837	814994	816153	817313	818475	819637
1221.0	820801	821966	823132	824301	825469	826639	827810	828982	830157	831332
1222.0	832508	833686	834864	836045	837227	838409	839593	840778	841965	843153
1223.0	844341	845531	846722	847916	849110	850305	851501	852699	853899	855099
1224.0	856300	857503	858707	859914	861120	862328	863537	864747	865960	867173
1225.0	868387	869602	870818	872038	873256	874476	875697	876920	878145	879369
1226.0	880595	881822	883050	884281	885512	886743	887976	889210	890447	891683
1227.0	892921	894159	895399	896642	897884	899128	900372	901618	902866	904115
1228.0	905364	906614	907866	909121	910375	911630	912886	914144	915404	916664
1229.0	917925	919188	920451	921718	922984	924251	925519	926789	928061	929333
1230.0	930210	931483	932759	934037	935314	936593	937873	939154	940437	941720
1231.0	943004	944290	945576	946865	948154	949444	950735	952027	953322	954616
1232.0	955911	957208	958505	959806	961105	962406	963709	965012	966318	967623
1233.0	968930	970237	971546	972858	974169	975481	976794	978109	979426	980743
1234.0	982060	983379	984699	986022	987345	988668	989993	991318	992647	993975
1235.0	995300	996634	997966	999301	1000635	1001971	1003308	1004647	1005989	1007330
1236.0	1008673	1010017	1011363	1012712	1014060	1015410	1016761	1018114	1019469	1020825
1237.0	1022181	1023539	1024899	1026262	1027624	1028988	1030353	1031719	1033089	1034458
1238.0	1035829	1037201	1038575	1039951	1041328	1042706	1044085	1045465	1046849	1048232
1239.0	1049617	1051003	1052391	1053782	1055172	1056564	1057957	1059352	1060750	1062147
1240.0	1063500	1064900	1066301	1067705	1069108	1070513	1071919	1073325	1074735	1076144
1241.0	1077554	1078965	1080377	1081792	1083207	1084622	1086039	1087456	1088877	1090297
1242.0	1091718	1093140	1094563	1095989	1097414	1098841	1100268	1101697	1103129	1104559
1243.0	1105991	1107425	1108859	1110296	1111732	1113170	1114608	1116048	1117490	1118932

TABLE 2-01.

ALAMO LAKE -- CAPACITY TABLE

SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)

COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)

(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION	CAPACITY (ACRE-FEET)									
(FEET)	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1244.0	1120375	1121819	1123265	1124713	1126160	1127609	1129058	1130509	1131963	1133416
1245.0	1134870	1136325	1137782	1139241	1140701	1142161	1143623	1145086	1146552	1148017
1246.0	1149484	1150953	1152422	1153894	1155367	1156840	1158315	1159791	1161270	1162748
1247.0	1164228	1165709	1167191	1168677	1170162	1171648	1173136	1174625	1176117	1177608
1248.0	1179101	1180595	1182091	1183589	1185087	1186587	1188087	1189589	1191094	1192599
1249.0	1194105	1195612	1197120	1198632	1200143	1201655	1203169	1204684	1206202	1207720
1250.0	1209100	1210619	1212141	1213665	1215190	1216716	1218243	1219772	1221304	1222835
1251.0	1224368	1225902	1227438	1228976	1230515	1232055	1233596	1235138	1236684	1238229
1252.0	1239776	1241324	1242874	1244427	1245979	1247533	1249088	1250644	1252204	1253763
1253.0	1255324	1256886	1258450	1260017	1261583	1263151	1264720	1266291	1267864	1269438
1254.0	1271013	1272589	1274166	1275747	1277328	1278910	1280493	1282077	1283666	1285253
1255.0	1286842	1288432	1290024	1291618	1293212	1294807	1296403	1298000	1299601	1301201
1256.0	1302801	1304404	1306007	1307613	1309219	1310826	1312434	1314043	1315656	1317267
1257.0	1318880	1320494	1322110	1323728	1325346	1326965	1328585	1330206	1331830	1333454
1258.0	1335079	1336705	1338332	1339963	1341592	1343223	1344855	1346489	1348125	1349761
1259.0	1351398	1353036	1354675	1356318	1357959	1359602	1361247	1362892	1364541	1366188
1260.0	1367400	1369050	1370702	1372356	1374010	1375665	1377321	1378978	1380639	1382299
1261.0	1383960	1385622	1387285	1388951	1390617	1392284	1393952	1395621	1397294	1398966
1262.0	1400638	1402313	1403988	1405666	1407344	1409023	1410703	1412384	1414069	1415752
1263.0	1417437	1419123	1420810	1422501	1424191	1425882	1427574	1429267	1430963	1432659
1264.0	1434356	1436054	1437753	1439456	1441158	1442861	1444565	1446270	1447979	1449687
1265.0	1451300									

TABLE 2-02.

ALAMO LAKE -- AREA TABLE

SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)

COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)

(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION (FEET)	AREA (ACRES) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
990.0	0	0	0	0	0	0	0	0	0	0
991.0	0	0	0	0	0	0	0	0	0	0
992.0	0	0	0	0	0	0	0	0	0	0
993.0	0	0	0	0	0	0	0	0	0	0
994.0	0	0	0	0	0	0	0	0	0	0
995.0	0	0	0	0	0	0	0	0	0	0
996.0	0	0	0	0	0	0	0	0	0	0
997.0	0	0	0	0	0	0	0	0	0	0
998.0	0	0	0	0	0	0	0	0	0	0
999.0	0	0	0	0	0	0	0	0	0	0
1000.0	0	0	0	0	0	0	0	0	0	0
1001.0	0	0	0	0	0	0	0	0	0	0
1002.0	0	0	0	0	0	0	0	0	0	0
1003.0	0	0	0	0	0	0	0	0	0	0
1004.0	0	0	0	0	0	0	0	0	0	0
1005.0	0	0	0	0	0	0	0	0	0	0
1006.0	0	0	0	0	0	0	0	0	0	0
1007.0	0	0	0	0	0	0	0	0	0	0
1008.0	0	0	0	0	0	0	0	0	0	0
1009.0	0	0	0	0	0	0	0	0	0	0
1010.0	0	0	0	0	0	1	1	1	1	1
1011.0	1	1	1	1	1	1	1	2	2	2
1012.0	2	2	2	2	2	2	2	2	2	2
1013.0	2	3	3	3	3	3	3	3	3	3
1014.0	3	3	3	3	3	4	4	4	4	4
1015.0	4	4	4	4	4	4	4	4	4	5
1016.0	5	5	5	6	6	6	7	7	7	8
1017.0	8	8	9	9	10	10	10	11	11	12
1018.0	12	13	14	15	16	16	17	18	19	20
1019.0	21	22	23	24	25	26	27	28	30	31
1020.0	32	34	35	37	39	40	42	44	46	48
1021.0	49	51	53	55	57	60	62	64	66	68
1022.0	71	73	75	78	80	82	85	87	90	92
1023.0	95	98	100	103	106	109	111	114	117	120
1024.0	123	124	125	126	127	129	130	131	132	133
1025.0	134	135	136	138	139	140	141	142	143	145
1026.0	146	146	147	148	149	149	150	151	152	153
1027.0	153	154	155	156	156	157	158	159	160	160
1028.0	161	162	162	162	163	163	164	164	165	165
1029.0	166	166	167	167	168	168	169	169	169	170
1030.0	170	171	172	173	174	175	175	176	177	178
1031.0	179	180	181	181	182	183	184	185	186	187
1032.0	187	188	189	190	191	192	193	194	195	196
1033.0	197	198	199	199	200	201	202	203	204	205
1034.0	206	208	210	211	213	215	217	218	220	222
1035.0	224	225	227	229	231	233	235	236	238	240
1036.0	242	244	247	249	251	254	256	259	261	263
1037.0	266	268	271	273	276	278	281	283	286	288
1038.0	291	293	296	298	301	304	306	309	311	314
1039.0	317	319	322	325	327	330	333	336	338	341

TABLE 2-02.

ALAMO LAKE -- AREA TABLE

SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)

COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)

(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION (FEET)	AREA (ACRES) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1040.0	344	346	347	349	351	353	355	357	358	360
1041.0	362	364	366	368	369	371	373	375	377	379
1042.0	381	383	386	388	391	393	396	399	401	404
1043.0	406	409	412	414	417	420	422	425	428	430
1044.0	433	435	438	440	443	445	447	450	452	455
1045.0	457	460	462	464	467	469	472	474	477	479
1046.0	482	484	485	487	489	491	493	494	496	498
1047.0	500	502	504	506	507	509	511	513	515	517
1048.0	519	520	521	522	523	524	525	527	528	529
1049.0	530	531	532	534	535	536	537	538	539	541
1050.0	542	543	545	547	548	550	551	553	555	556
1051.0	558	560	561	563	564	566	568	569	571	573
1052.0	574	576	579	581	583	586	588	590	593	595
1053.0	597	600	602	604	607	609	611	614	616	618
1054.0	621	623	626	629	632	634	637	640	643	645
1055.0	648	651	654	656	659	662	665	668	670	673
1056.0	676	678	681	683	686	688	690	693	695	698
1057.0	700	703	705	707	710	712	715	717	720	722
1058.0	725	728	732	735	739	743	746	750	754	757
1059.0	761	765	768	772	776	779	783	787	791	794
1060.0	798	801	804	807	810	813	816	819	822	825
1061.0	829	832	835	838	841	844	847	850	853	856
1062.0	860	863	867	870	874	877	881	885	888	892
1063.0	896	899	903	906	910	914	917	921	925	929
1064.0	932	935	938	942	945	948	951	954	957	961
1065.0	964	967	970	973	977	980	983	986	990	993
1066.0	996	1000	1003	1007	1011	1015	1018	1022	1026	1029
1067.0	1033	1037	1041	1045	1048	1052	1056	1060	1063	1067
1068.0	1071	1075	1079	1083	1087	1091	1095	1099	1103	1107
1069.0	1111	1115	1119	1123	1127	1131	1135	1139	1143	1147
1070.0	1151	1155	1159	1164	1168	1172	1176	1181	1185	1189
1071.0	1194	1198	1202	1207	1211	1215	1220	1224	1228	1233
1072.0	1237	1241	1246	1250	1254	1259	1263	1268	1272	1276
1073.0	1281	1285	1289	1294	1298	1303	1307	1312	1316	1321
1074.0	1325	1329	1333	1337	1341	1346	1350	1354	1358	1362
1075.0	1366	1370	1375	1379	1383	1387	1391	1396	1400	1404
1076.0	1408	1413	1417	1421	1426	1430	1435	1439	1444	1448
1077.0	1453	1457	1462	1466	1470	1475	1479	1484	1489	1493
1078.0	1498	1502	1507	1512	1517	1522	1527	1532	1537	1542
1079.0	1547	1551	1556	1561	1566	1571	1576	1581	1586	1591
1080.0	1596	1601	1606	1611	1615	1620	1625	1630	1635	1640
1081.0	1645	1650	1654	1659	1664	1669	1674	1679	1684	1689
1082.0	1694	1699	1703	1708	1713	1718	1723	1728	1733	1737
1083.0	1742	1747	1752	1757	1762	1767	1772	1777	1782	1786
1084.0	1791	1797	1803	1809	1814	1820	1826	1832	1837	1843
1085.0	1849	1855	1861	1866	1872	1878	1884	1890	1896	1901
1086.0	1907	1913	1918	1924	1930	1935	1941	1946	1952	1958
1087.0	1963	1969	1974	1980	1986	1991	1997	2003	2008	2014
1088.0	2020	2026	2032	2037	2043	2049	2055	2061	2067	2073
1089.0	2079	2085	2091	2097	2103	2109	2115	2121	2127	2133

TABLE 2-02.

ALAMO LAKE -- AREA TABLE

SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)

COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)

(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION (FEET)	AREA (ACRES) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1090.0	2139	2144	2149	2154	2160	2165	2170	2176	2181	2186
1091.0	2192	2197	2202	2208	2213	2218	2224	2229	2235	2240
1092.0	2245	2250	2254	2259	2263	2268	2272	2277	2281	2286
1093.0	2291	2295	2300	2304	2309	2313	2318	2322	2327	2332
1094.0	2336	2341	2345	2350	2355	2359	2364	2369	2373	2378
1095.0	2382	2387	2392	2396	2401	2406	2410	2415	2420	2424
1096.0	2429	2433	2438	2442	2446	2450	2455	2459	2463	2467
1097.0	2472	2476	2480	2484	2489	2493	2497	2502	2506	2510
1098.0	2515	2519	2523	2527	2531	2536	2540	2544	2548	2553
1099.0	2557	2561	2566	2570	2574	2578	2583	2587	2591	2596
1100.0	2600	2604	2608	2613	2617	2622	2626	2630	2635	2639
1101.0	2643	2648	2652	2657	2661	2665	2670	2674	2678	2683
1102.0	2687	2692	2696	2700	2705	2709	2713	2718	2722	2727
1103.0	2731	2735	2740	2744	2748	2753	2757	2762	2766	2770
1104.0	2775	2779	2784	2789	2793	2798	2803	2807	2812	2817
1105.0	2821	2826	2831	2835	2840	2845	2849	2854	2859	2863
1106.0	2868	2873	2878	2883	2888	2893	2898	2903	2908	2913
1107.0	2918	2923	2928	2933	2939	2944	2949	2954	2959	2964
1108.0	2969	2975	2981	2986	2992	2998	3004	3010	3015	3021
1109.0	3027	3033	3039	3045	3051	3056	3062	3068	3074	3080
1110.0	3086	3091	3097	3102	3108	3113	3119	3124	3130	3135
1111.0	3141	3146	3152	3157	3163	3168	3174	3179	3185	3191
1112.0	3196	3202	3207	3213	3219	3224	3230	3235	3241	3247
1113.0	3252	3258	3264	3269	3275	3281	3286	3292	3298	3303
1114.0	3309	3314	3319	3324	3329	3334	3338	3343	3348	3353
1115.0	3358	3363	3368	3373	3378	3383	3388	3392	3397	3402
1116.0	3407	3412	3417	3421	3426	3431	3436	3440	3445	3450
1117.0	3455	3459	3464	3469	3474	3478	3483	3488	3493	3497
1118.0	3502	3507	3512	3518	3523	3528	3533	3538	3544	3549
1119.0	3554	3559	3564	3570	3575	3580	3585	3591	3596	3601
1120.0	3606	3611	3616	3621	3626	3631	3636	3641	3646	3651
1121.0	3656	3660	3665	3670	3675	3680	3685	3690	3695	3700
1122.0	3705	3710	3715	3720	3725	3730	3735	3740	3745	3750
1123.0	3755	3760	3765	3770	3775	3780	3785	3790	3795	3800
1124.0	3805	3810	3815	3820	3825	3830	3835	3840	3846	3851
1125.0	3856	3860	3864	3869	3873	3877	3882	3886	3890	3895
1126.0	3899	3903	3908	3912	3917	3921	3925	3930	3934	3938
1127.0	3943	3947	3951	3956	3960	3965	3969	3973	3978	3982
1128.0	3987	3991	3995	4000	4004	4009	4013	4017	4022	4026
1129.0	4031	4035	4040	4044	4048	4053	4057	4062	4066	4071
1130.0	4075	4080	4084	4089	4093	4098	4102	4107	4111	4116
1131.0	4120	4125	4130	4134	4139	4143	4148	4152	4157	4161
1132.0	4166	4171	4175	4180	4184	4189	4194	4198	4203	4207
1133.0	4212	4217	4221	4226	4230	4235	4240	4244	4249	4253
1134.0	4258	4263	4267	4272	4277	4281	4286	4290	4295	4300
1135.0	4304	4310	4315	4320	4326	4331	4336	4342	4347	4352
1136.0	4358	4363	4368	4374	4379	4384	4390	4395	4400	4406
1137.0	4411	4417	4422	4427	4433	4438	4443	4449	4454	4460
1138.0	4465	4470	4476	4481	4487	4492	4498	4503	4508	4514
1139.0	4519	4525	4530	4536	4541	4546	4552	4557	4563	4568

TABLE 2-02.
ALAMO LAKE -- AREA TABLE
SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)
COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)
(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION (FEET)	AREA (ACRES) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1140.0	4574	4579	4585	4590	4596	4601	4607	4612	4618	4623
1141.0	4629	4635	4640	4646	4651	4657	4662	4668	4673	4679
1142.0	4685	4690	4696	4701	4707	4712	4718	4724	4729	4735
1143.0	4740	4746	4752	4757	4763	4769	4774	4780	4785	4791
1144.0	4797	4802	4808	4814	4819	4825	4831	4836	4842	4848
1145.0	4853	4859	4865	4872	4878	4884	4890	4896	4902	4908
1146.0	4914	4920	4927	4933	4939	4945	4951	4957	4963	4970
1147.0	4976	4982	4988	4994	5001	5007	5013	5019	5025	5031
1148.0	5038	5044	5050	5056	5063	5069	5075	5081	5087	5094
1149.0	5100	5106	5112	5119	5125	5131	5137	5144	5150	5156
1150.0	5163	5169	5176	5182	5189	5195	5202	5208	5215	5221
1151.0	5228	5234	5241	5247	5254	5260	5267	5273	5280	5287
1152.0	5293	5300	5306	5313	5319	5326	5333	5339	5346	5352
1153.0	5359	5366	5372	5379	5385	5392	5399	5405	5412	5419
1154.0	5425	5432	5439	5445	5452	5459	5465	5472	5479	5485
1155.0	5492	5499	5506	5513	5520	5527	5535	5542	5549	5556
1156.0	5563	5570	5577	5584	5591	5599	5606	5613	5620	5627
1157.0	5634	5642	5649	5656	5663	5670	5677	5685	5692	5699
1158.0	5706	5713	5721	5728	5735	5742	5750	5757	5764	5771
1159.0	5779	5786	5793	5800	5808	5815	5822	5829	5837	5844
1160.0	5851	5859	5866	5874	5881	5889	5896	5904	5911	5919
1161.0	5926	5934	5941	5949	5956	5964	5971	5979	5987	5994
1162.0	6002	6009	6017	6024	6032	6040	6047	6055	6062	6070
1163.0	6078	6085	6093	6100	6108	6116	6123	6131	6139	6146
1164.0	6154	6162	6169	6177	6185	6192	6200	6208	6215	6223
1165.0	6231	6239	6246	6254	6262	6270	6278	6286	6294	6302
1166.0	6310	6318	6325	6333	6341	6349	6357	6365	6373	6381
1167.0	6389	6397	6405	6413	6421	6429	6437	6445	6453	6461
1168.0	6469	6477	6485	6493	6501	6509	6517	6525	6533	6541
1169.0	6549	6557	6565	6573	6582	6590	6598	6606	6614	6622
1170.0	6630	6639	6647	6656	6665	6673	6682	6691	6699	6708
1171.0	6717	6726	6734	6743	6752	6760	6769	6778	6787	6795
1172.0	6804	6813	6822	6830	6839	6848	6857	6866	6874	6883
1173.0	6892	6901	6910	6919	6927	6936	6945	6954	6963	6972
1174.0	6980	6989	6998	7007	7016	7025	7034	7043	7052	7061
1175.0	7070	7078	7087	7096	7105	7114	7123	7132	7140	7149
1176.0	7158	7167	7176	7185	7194	7203	7212	7221	7230	7239
1177.0	7248	7257	7266	7275	7283	7292	7301	7310	7319	7328
1178.0	7337	7346	7356	7365	7374	7383	7392	7401	7410	7419
1179.0	7428	7437	7446	7455	7464	7473	7482	7492	7501	7510
1180.0	7519	7528	7538	7547	7557	7566	7576	7585	7595	7604
1181.0	7614	7623	7633	7642	7652	7661	7671	7680	7690	7699
1182.0	7709	7718	7728	7738	7747	7757	7766	7776	7785	7795
1183.0	7805	7814	7824	7834	7843	7853	7862	7872	7882	7891
1184.0	7901	7911	7921	7930	7940	7950	7959	7969	7979	7988
1185.0	7998	8008	8017	8027	8037	8046	8056	8066	8076	8085
1186.0	8095	8105	8114	8124	8134	8143	8153	8163	8173	8182
1187.0	8192	8202	8212	8222	8231	8241	8251	8261	8270	8280
1188.0	8290	8300	8310	8320	8329	8339	8349	8359	8369	8379
1189.0	8389	8398	8408	8418	8428	8438	8448	8458	8468	8478

TABLE 2-02.
ALAMO LAKE -- AREA TABLE
SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)
COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)
(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION (FEET)	AREA (ACRES) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1190.0	8488	8497	8506	8515	8524	8533	8542	8551	8560	8569
1191.0	8579	8588	8597	8606	8615	8624	8633	8642	8652	8661
1192.0	8670	8679	8688	8697	8707	8716	8725	8734	8743	8753
1193.0	8762	8771	8780	8789	8799	8808	8817	8826	8836	8845
1194.0	8854	8863	8873	8882	8891	8901	8910	8919	8928	8938
1195.0	8947	8957	8966	8976	8986	8995	9005	9015	9024	9034
1196.0	9044	9054	9063	9073	9083	9092	9102	9112	9122	9131
1197.0	9141	9151	9161	9171	9180	9190	9200	9210	9219	9229
1198.0	9239	9249	9259	9269	9278	9288	9298	9308	9318	9328
1199.0	9337	9347	9357	9367	9377	9387	9397	9407	9417	9426
1200.0	9436	9445	9455	9464	9473	9482	9491	9500	9509	9518
1201.0	9527	9537	9546	9555	9564	9573	9582	9591	9600	9610
1202.0	9619	9628	9637	9646	9656	9665	9674	9683	9692	9701
1203.0	9711	9720	9729	9738	9748	9757	9766	9775	9784	9794
1204.0	9803	9812	9821	9831	9840	9849	9859	9868	9877	9886
1205.0	9896	9905	9915	9925	9935	9945	9954	9964	9974	9984
1206.0	9994	10003	10013	10023	10033	10043	10052	10062	10072	10082
1207.0	10030	10041	10053	10065	10077	10089	10101	10113	10125	10137
1208.0	10191	10200	10210	10220	10230	10240	10250	10260	10270	10280
1209.0	10290	10300	10310	10320	10330	10340	10350	10360	10370	10380
1210.0	10390	10400	10410	10421	10431	10442	10452	10463	10473	10484
1211.0	10494	10505	10515	10526	10537	10547	10558	10568	10579	10589
1212.0	10600	10610	10621	10632	10642	10653	10663	10674	10685	10695
1213.0	10706	10717	10727	10738	10748	10759	10770	10780	10791	10802
1214.0	10812	10823	10834	10845	10855	10866	10877	10887	10898	10909
1215.0	10920	10931	10943	10955	10967	10979	10991	11003	11014	11026
1216.0	11038	11050	11062	11074	11086	11098	11110	11122	11134	11146
1217.0	11158	11170	11182	11194	11206	11218	11230	11242	11254	11266
1218.0	11278	11290	11302	11314	11326	11338	11350	11362	11374	11386
1219.0	11398	11410	11422	11435	11447	11459	11471	11483	11495	11507
1220.0	11520	11532	11544	11557	11569	11582	11594	11607	11619	11632
1221.0	11644	11657	11669	11682	11694	11707	11719	11732	11744	11757
1222.0	11769	11782	11795	11807	11820	11832	11845	11858	11870	11883
1223.0	11895	11908	11921	11933	11946	11959	11971	11984	11997	12009
1224.0	12022	12035	12048	12060	12073	12086	12098	12111	12124	12137
1225.0	12150	12161	12173	12185	12196	12208	12220	12231	12243	12255
1226.0	12266	12278	12290	12302	12313	12325	12337	12349	12360	12372
1227.0	12384	12396	12407	12419	12431	12443	12455	12466	12478	12490
1228.0	12502	12514	12525	12537	12549	12561	12573	12585	12597	12609
1229.0	12620	12632	12644	12656	12668	12680	12692	12704	12716	12728
1230.0	12740	12751	12762	12773	12784	12795	12806	12817	12828	12839
1231.0	12851	12862	12873	12884	12895	12906	12917	12929	12940	12951
1232.0	12962	12973	12984	12996	13007	13018	13029	13040	13052	13063
1233.0	13074	13085	13097	13108	13119	13130	13141	13153	13164	13175
1234.0	13187	13198	13209	13220	13232	13243	13254	13266	13277	13288
1235.0	13300	13313	13327	13341	13355	13369	13383	13396	13410	13424
1236.0	13438	13452	13466	13480	13494	13508	13522	13535	13549	13563
1237.0	13577	13591	13605	13619	13633	13647	13661	13675	13689	13703
1238.0	13717	13731	13745	13759	13774	13788	13802	13816	13830	13844
1239.0	13858	13872	13886	13900	13915	13929	13943	13957	13971	13985

TABLE 2-02.

ALAMO LAKE -- AREA TABLE

SURVEYED: MAR. 1963 - MAY 1968; OCT. 1985 (ELEVATION 990-1120 FEET)

COMPUTED JUNE 1993 (SUPERSEDES ALL PREVIOUS TABLES)

(TABLE IS IN INCREMENTS OF 0.1 FOOT)

ELEVATION (FEET)	AREA (ACRES) .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1240.0	14000	14010	14021	14032	14043	14054	14065	14076	14087	14098
1241.0	14109	14120	14131	14141	14152	14163	14174	14185	14196	14207
1242.0	14218	14229	14240	14251	14262	14273	14284	14295	14306	14317
1243.0	14328	14339	14350	14361	14372	14383	14394	14405	14417	14428
1244.0	14439	14450	14461	14472	14483	14494	14505	14516	14527	14538
1245.0	14550	14562	14575	14588	14601	14614	14627	14640	14653	14665
1246.0	14678	14691	14704	14717	14730	14743	14756	14769	14782	14795
1247.0	14808	14821	14834	14847	14860	14873	14886	14899	14912	14925
1248.0	14938	14951	14964	14977	14990	15003	15016	15029	15042	15055
1249.0	15068	15081	15095	15108	15121	15134	15147	15160	15173	15186
1250.0	15200	15213	15227	15241	15255	15269	15283	15297	15310	15324
1251.0	15338	15352	15366	15380	15394	15408	15422	15436	15450	15464
1252.0	15478	15492	15506	15520	15534	15548	15562	15576	15590	15604
1253.0	15618	15632	15646	15660	15674	15688	15702	15716	15730	15744
1254.0	15758	15772	15786	15801	15815	15829	15843	15857	15871	15885
1255.0	15900	15911	15923	15935	15947	15959	15971	15983	15995	16007
1256.0	16019	16031	16042	16054	16066	16078	16090	16102	16114	16126
1257.0	16138	16150	16162	16174	16186	16198	16210	16222	16234	16246
1258.0	16258	16270	16282	16294	16306	16318	16330	16342	16354	16367
1259.0	16379	16391	16403	16415	16427	16439	16451	16463	16475	16487
1260.0	16500	16511	16523	16535	16547	16559	16571	16583	16595	16607
1261.0	16619	16631	16643	16654	16666	16678	16690	16702	16714	16726
1262.0	16738	16750	16762	16774	16786	16798	16810	16822	16834	16846
1263.0	16858	16870	16882	16894	16906	16918	16930	16942	16955	16967
1264.0	16979	16991	17003	17015	17027	17039	17051	17063	17075	17087
1265.0	17100									

Table 4-01

ALAMO DAM, ARIZONA

Period of Record: 1 July 1975 to 31 December 1998

Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	64.9	70.1	75.6	84.8	93.4	104.3	107.7	105.9	100.0	89.1	74.9	65.6	86.4
Average Min. Temperature (F)	36.4	40.3	44.9	51.5	60.2	69.1	76.6	75.9	68.3	55.8	43.0	35.8	54.8
Average Total Precipitation (in.)	1.22	1.18	1.06	0.28	0.19	0.03	0.61	1.50	1.06	0.56	0.69	0.81	9.19
Average Total SnowFall (in.)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 99.3% Min. Temp.: 99.4% Precipitation: 99.6% Snowfall: 99.6% Snow Depth: 99.6%

T4-1

Heating Degree Days

Heating Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
65	445	278	172	50	5	0	0	0	0	17	196	444	1606
60	291	154	72	16	1	0	0	0	0	3	96	289	921
57	203	95	36	6	0	0	0	0	0	1	56	202	598
55	150	64	21	3	0	0	0	0	0	0	36	150	425
50	53	20	3	0	0	0	0	0	0	0	8	53	137

*Heating degree days at or below specified base temperature.

Cooling Degree Days

Cooling Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
55	15	70	184	397	676	952	1150	1113	874	541	156	17	6144
57	6	44	137	341	614	892	1088	1051	814	480	115	7	5587
60	1	19	80	260	522	802	995	958	724	389	65	1	4814
65	0	2	25	144	371	652	840	803	574	247	15	0	3672
70	0	0	4	62	232	502	685	648	426	129	1	0	2689

Precipitation Exceedance Probability

Probability Levels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.05	3.87	3.53	3.24	1.25	0.77	0.22	1.83	5.02	4.59	1.80	2.54	3.26
0.10	2.89	2.99	2.86	1.06	0.54	0.16	1.39	3.79	2.69	1.60	1.62	2.92
0.20	2.08	1.67	2.08	0.40	0.33	0.03	1.01	2.09	1.88	1.11	1.17	1.25
0.30	1.53	1.19	1.38	0.30	0.23	0.00	0.87	1.63	1.66	0.68	0.99	0.81
0.40	1.07	1.10	1.04	0.21	0.13	0.00	0.72	1.39	0.76	0.49	0.77	0.48
0.50	0.77	0.89	0.88	0.12	0.07	0.00	0.50	1.25	0.44	0.32	0.39	0.39
0.60	0.59	0.84	0.23	0.04	0.04	0.00	0.30	0.99	0.22	0.16	0.26	0.27
0.70	0.39	0.71	0.14	0.01	0.02	0.00	0.16	0.69	0.13	0.07	0.19	0.16
0.80	0.25	0.27	0.10	0.00	0.00	0.00	0.05	0.40	0.07	0.02	0.13	0.07
0.90	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.22	0.01	0.00	0.00	0.03
0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00

Monthly Precipitation (inches)

Table 4-01

CHINO VALLEY, ARIZONA

Period of Record: 1 July 1948 to 31 December 1998

Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	52.1	56.0	62.0	69.7	78.0	88.4	92.2	89.6	85.5	75.3	63.5	54.4	72.2
Average Min. Temperature (F)	21.2	23.4	27.9	33.7	41.0	49.4	58.6	56.8	48.9	37.9	27.0	20.9	37.2
Average Total Precipitation (in.)	1.01	0.95	0.99	0.58	0.40	0.34	1.93	2.09	1.24	0.86	0.66	0.97	12.04
Average Total SnowFall (in.)	2.5	1.6	1.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.8	8.0
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 89.3% Min. Temp.: 89.4% Precipitation: 96.1% Snowfall: 97.2% Snow Depth: 96.3%

Heating Degree Days

Heating Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
65	878	715	622	399	188	30	0	1	36	267	593	849	4578
60	723	574	467	254	88	7	0	0	8	141	443	694	3399
57	630	489	375	178	51	2	0	0	3	88	353	601	2770
55	568	433	315	135	34	1	0	0	1	62	295	539	2382
50	414	294	180	57	9	0	0	0	0	23	166	384	1528

*Heating degree days at or below specified base temperature.

Cooling Degree Days

Cooling Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
55	15	70	184	397	676	952	1150	1113	874	541	156	17	6144
57	6	44	137	341	614	892	1088	1051	814	480	115	7	5587
60	1	19	80	260	522	802	995	958	724	389	65	1	4814
65	0	2	25	144	371	652	840	803	574	247	15	0	3672
70	0	0	4	62	232	502	685	648	426	129	1	0	2689

*Cooling degree days at or above specified base temperature.

Precipitation Exceedance Probability

Probability Levels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.05	2.93	2.79	3.54	2.25	1.35	1.46	4.96	4.53	4.37	2.03	2.05	2.96
0.10	2.28	2.28	2.22	1.21	1.01	1.18	3.69	4.03	3.62	1.84	1.56	2.23
0.20	1.79	1.84	1.72	1.03	0.63	0.66	2.96	3.56	1.85	1.24	1.23	1.80
0.30	1.36	1.42	1.28	0.72	0.52	0.33	2.37	2.77	1.50	1.01	0.72	1.21
0.40	1.01	1.06	0.78	0.41	0.44	0.21	1.99	2.44	1.35	0.87	0.57	0.97
0.50	0.77	0.69	0.70	0.30	0.28	0.13	1.79	2.04	0.96	0.51	0.51	0.60
0.60	0.50	0.57	0.56	0.23	0.11	0.05	1.32	1.71	0.62	0.41	0.38	0.39
0.70	0.39	0.35	0.38	0.13	0.02	0.00	0.95	1.33	0.26	0.32	0.18	0.22
0.80	0.16	0.14	0.15	0.07	0.00	0.00	0.80	0.98	0.13	0.15	0.07	0.15
0.90	0.02	0.00	0.00	0.00	0.00	0.00	0.53	0.46	0.00	0.00	0.01	0.01
0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.14	0.00	0.00	0.00	0.00

Monthly Precipitation (inches)

Table 4-01

KINGMAN, ARIZONA

Period of Record: 1 May 1901 to 31 July 1967

Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	55.8	60.1	65.8	74.2	82.7	92.6	97.8	95.3	90.3	79.0	66.5	56.8	76.4
Average Min. Temperature (F)	31.0	33.5	36.8	43.2	49.7	58.0	67.1	65.4	58.0	47.6	37.8	32.2	46.7
Average Total Precipitation (in.)	1.11	1.30	1.06	0.66	0.25	0.15	0.91	1.45	0.94	0.65	0.71	1.18	10.36
Average Total SnowFall (in.)	1.3	0.3	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.0	3.7
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 91.8% Min. Temp.: 92.2% Precipitation: 96.3% Snowfall: 96.3% Snow Depth: 95.9%

Heating Degree Days

Heating Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
65	669	514	423	208	67	5	0	0	6	115	386	637	3032
60	514	374	275	105	25	1	0	0	1	47	246	482	2070
57	422	293	195	63	12	0	0	0	0	25	173	390	1575
55	362	241	150	42	7	0	0	0	0	16	131	330	1280
50	221	130	64	13	2	0	0	0	0	4	56	191	680

*Heating degree days at or below specified base temperature.

Cooling Degree Days

Cooling Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
55	3	10	37	154	354	610	850	786	575	273	47	3	3700
57	1	5	21	114	298	550	788	724	515	220	28	1	3264
60	0	1	7	66	217	461	695	631	426	149	11	0	2664
65	0	0	0	20	105	316	540	476	281	62	1	0	1800
70	0	0	0	3	35	185	385	322	152	16	0	0	1097

*Cooling degree days at or above specified base temperature.

Precipitation Exceedance Probability

Probability Levels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.05	2.86	4.40	3.29	2.35	1.17	0.78	2.26	3.86	3.43	2.64	2.68	3.53
0.10	2.20	3.01	2.92	1.85	0.87	0.27	2.07	3.12	1.88	1.65	1.85	2.79
0.20	1.84	2.27	1.90	1.15	0.34	0.19	1.50	2.06	1.28	1.15	1.29	2.15
0.30	1.62	1.77	1.23	0.69	0.25	0.11	1.05	1.49	0.97	0.68	0.90	1.73
0.40	1.28	1.25	0.88	0.57	0.14	0.07	0.84	1.21	0.66	0.56	0.46	1.18
0.50	0.97	0.78	0.71	0.30	0.05	0.00	0.60	1.02	0.40	0.37	0.18	0.85
0.60	0.57	0.53	0.55	0.17	0.00	0.00	0.43	0.88	0.26	0.20	0.11	0.58
0.70	0.35	0.15	0.33	0.06	0.00	0.00	0.27	0.62	0.14	0.04	0.00	0.31
0.80	0.16	0.05	0.03	0.00	0.00	0.00	0.10	0.27	0.00	0.00	0.00	0.03
0.90	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Monthly Precipitation (inches)

Table 4-01

PARKER NE, ARIZONA

Period of Record: 1 October 1893 to 31 December 1998

Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	67.1	72.9	78.9	87.3	95.3	104.0	108.3	106.6	101.6	90.4	77.2	67.5	88.1
Average Min. Temperature (F)	35.9	40.6	45.5	51.9	59.6	68.3	77.3	76.7	68.0	55.0	42.6	36.0	54.8
Average Total Precipitation (in.)	0.73	0.57	0.50	0.19	0.07	0.03	0.33	0.63	0.48	0.30	0.35	0.63	4.84
Average Total SnowFall (in.)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 94.9% Min. Temp.: 94.9% Precipitation: 96.5% Snowfall: 96.6% Snow Depth: 96.5%

T4-4

Heating Degree Days

Heating Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
65	418	238	129	32	4	0	0	0	0	19	176	411	1428
60	267	124	49	8	1	0	0	0	0	5	82	260	795
57	185	73	22	3	0	0	0	0	0	2	44	178	507
55	139	48	12	1	0	0	0	0	0	1	27	130	358
50	55	13	2	0	0	0	0	0	0	0	6	48	124

*Heating degree days at or below specified base temperature.

Cooling Degree Days

Cooling Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
55	31	98	236	440	696	937	1173	1136	895	549	175	29	6396
57	15	66	185	382	635	877	1111	1074	835	488	132	15	5815
60	4	32	118	297	542	787	1018	981	745	398	79	4	5007
65	0	6	43	171	390	637	863	826	595	258	24	0	3814
70	0	0	9	78	248	488	708	671	447	139	3	0	2791

*Cooling degree days at or above specified base temperature.

Precipitation Exceedance Probability

Probability Levels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.05	2.89	2.52	1.76	1.28	0.30	0.22	1.21	2.51	1.75	1.48	1.42	2.39
0.10	1.70	1.99	1.44	0.55	0.18	0.10	0.99	1.56	1.06	0.90	1.00	1.83
0.20	1.34	0.85	0.86	0.32	0.07	0.01	0.58	0.95	0.83	0.51	0.56	1.15
0.30	0.90	0.46	0.57	0.16	0.03	0.00	0.36	0.67	0.38	0.24	0.41	0.71
0.40	0.52	0.32	0.30	0.07	0.00	0.00	0.21	0.43	0.25	0.13	0.25	0.51
0.50	0.25	0.19	0.24	0.01	0.00	0.00	0.10	0.26	0.13	0.05	0.14	0.24
0.60	0.14	0.04	0.09	0.00	0.00	0.00	0.03	0.11	0.04	0.00	0.05	0.10
0.70	0.08	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.01	0.02
0.80	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Monthly Precipitation (inches)

Table 4-01

PRESCOTT, ARIZONA

Period of Record: 1 May 1898 to 31 December 1998

Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	50.4	53.9	58.9	66.8	75.1	85.6	88.9	86.0	81.7	72.0	60.4	51.7	69.3
Average Min. Temperature (F)	21.0	23.9	28.0	33.8	40.3	48.6	57.1	55.8	48.2	36.9	27.1	21.8	36.9
Average Total Precipitation (in.)	1.81	1.89	1.78	0.96	0.50	0.39	2.94	3.32	1.73	1.07	1.29	1.71	19.39
Average Total SnowFall (in.)	6.3	5.1	5.3	1.4	0.2	0.0	0.0	0.0	0.0	0.2	2.3	5.0	25.9
Average Snow Depth (in.)	1	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 97.1% Min. Temp.: 96.6% Precipitation: 98% Snowfall: 97.4% Snow Depth: 94.4%

Heating Degree Days

Heating Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
65	909	737	667	442	239	48	2	4	65	331	637	76	4957
60	754	595	513	297	122	13	0	0	19	194	487	721	3715
57	661	511	420	217	73	5	0	0	8	127	397	628	3047
55	599	454	360	170	50	2	0	0	4	92	338	566	2636
50	444	316	219	79	17	0	0	0	0	36	202	412	1725

*Heating degree days at or below specified base temperature.

Cooling Degree Days

Cooling Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
55	0	0	2	29	133	365	559	493	301	74	1	0	1958
57	0	0	1	16	94	307	497	431	245	47	0	0	1639
60	0	0	0	6	49	226	404	338	166	21	0	0	1210
65	0	0	0	1	11	111	252	187	62	3	0	0	627
70	0	0	0	0	2	39	113	65	10	0	0	0	229

*Cooling degree days at or above specified base temperature.

Precipitation Exceedance Probability

Probability Levels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.05	5.61	6.34	5.57	3.45	1.54	1.53	5.90	6.67	4.01	3.39	4.01	5.13
0.10	3.95	3.51	3.86	2.16	1.20	1.07	5.33	5.74	3.36	2.64	2.70	4.42
0.20	2.64	3.01	2.83	1.38	0.86	0.77	4.55	4.69	2.66	1.69	2.14	3.24
0.30	2.10	2.33	2.24	1.07	0.69	0.44	3.40	4.05	2.27	1.21	1.45	2.25
0.40	1.83	1.70	1.68	0.82	0.55	0.25	3.08	3.53	1.87	0.98	1.18	1.54
0.50	1.32	1.31	1.16	0.56	0.37	0.16	2.80	2.82	1.50	0.73	0.95	1.03
0.60	0.86	0.90	0.91	0.36	0.20	0.10	2.30	2.35	1.20	0.49	0.73	0.73
0.70	0.60	0.65	0.60	0.22	0.09	0.00	1.91	2.11	0.77	0.36	0.44	0.48
0.80	0.35	0.43	0.38	0.08	0.00	0.00	1.50	1.82	0.25	0.13	0.12	0.31
0.90	0.12	0.07	0.05	0.00	0.00	0.00	0.48	1.00	0.03	0.00	0.00	0.01
0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.55	0.00	0.00	0.00	0.00

Monthly Precipitation (inches)

Table 4-01

WICKENBURG, ARIZONA

Period of Record: 1 March 1908 to 31 December 1998

Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	64.1	67.7	72.9	81.2	90.0	99.9	103.4	100.8	95.9	85.5	73.6	65.3	83.4
Average Min. Temperature (F)	30.8	34.1	38.0	43.1	49.9	58.2	69.2	68.3	60.1	48.1	37.4	31.4	47.4
Average Total Precipitation (in.)	1.23	1.20	1.07	0.49	0.19	0.13	1.27	1.94	1.16	0.61	0.75	1.24	11.29
Average Total SnowFall (in.)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 94.5% Min. Temp.: 94.6% Precipitation: 95.4% Snowfall: 95.5% Snow Depth: 95.3%

Heating Degree Days

Heating Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
65	544	399	301	127	28	1	0	0	1	57	291	514	2264
60	389	262	168	51	7	0	0	0	0	18	162	360	1416
57	298	187	105	26	2	0	0	0	0	8	101	270	997
55	240	142	73	16	1	0	0	0	0	4	70	213	759
50	118	59	22	3	0	0	0	0	0	1	23	98	324

*Heating degree days at or below specified base temperature.

Cooling Degree Days

Cooling Degree Days for Selected Base Temperature (F)

Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
55	6	26	87	230	465	721	970	916	690	371	85	9	4575
57	2	14	57	181	405	661	908	854	630	312	56	3	4083
60	0	4	27	116	316	571	815	761	540	230	26	0	3407
65	0	0	5	42	182	422	660	606	391	114	6	0	2428
70	0	0	0	9	80	278	505	451	247	40	2	0	1612

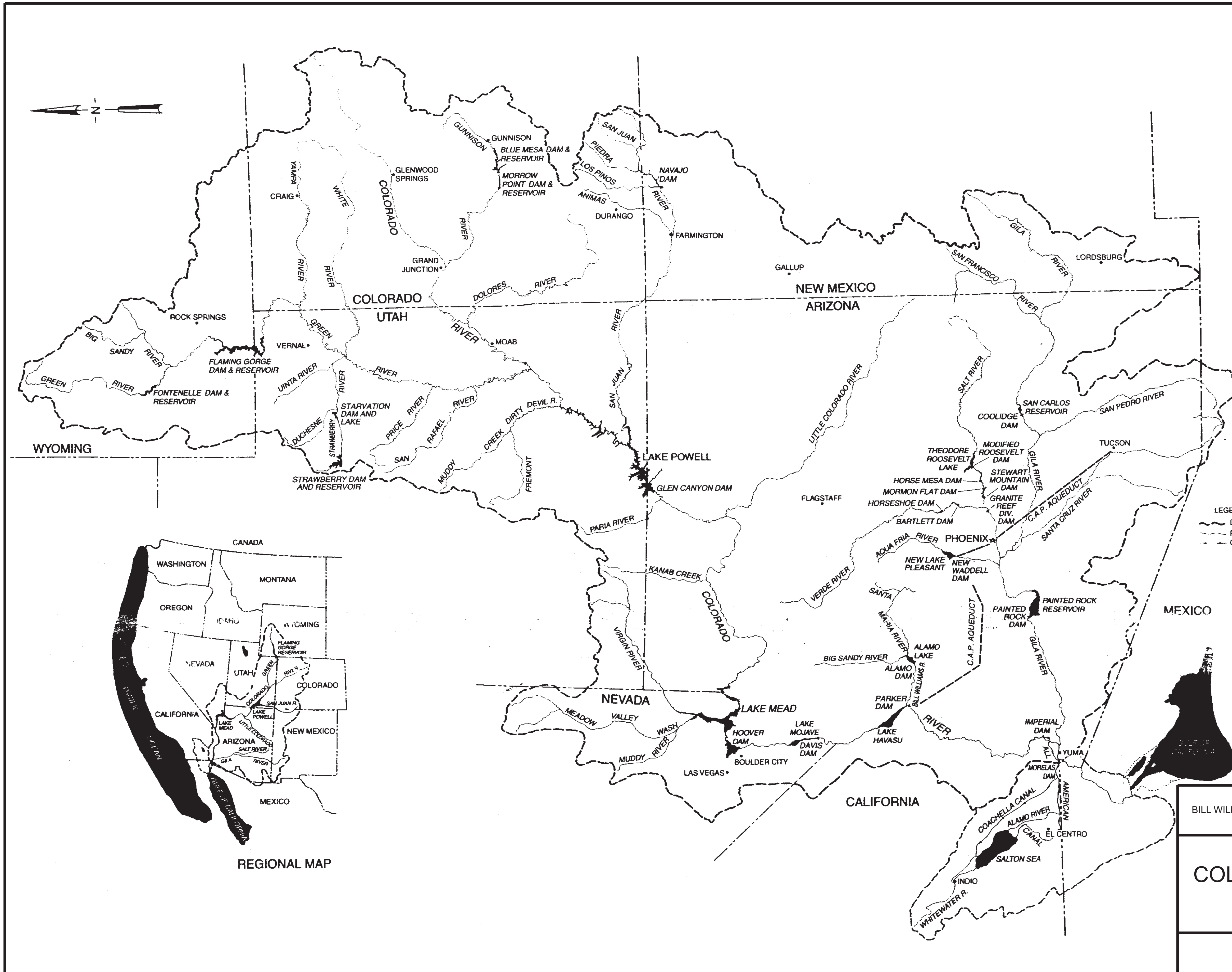
*Cooling degree days at or above specified base temperature.

Precipitation Exceedance Probability

Probability Levels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.05	3.85	3.98	3.89	2.06	0.77	0.69	3.38	4.74	3.84	2.06	2.46	4.14
0.10	2.95	2.91	2.81	1.39	0.61	0.53	2.92	3.87	2.56	1.64	2.07	3.00
0.20	2.31	1.84	1.85	0.83	0.30	0.20	2.06	2.67	2.11	0.91	1.31	2.03
0.30	1.73	1.34	1.19	0.52	0.21	0.06	1.55	1.99	1.51	0.70	1.12	1.45
0.40	1.01	0.99	0.82	0.32	0.10	0.00	1.15	1.62	0.92	0.49	0.59	1.16
0.50	0.73	0.72	0.54	0.17	0.02	0.00	0.92	1.46	0.63	0.31	0.34	0.67
0.60	0.42	0.53	0.34	0.06	0.00	0.00	0.73	1.25	0.36	0.20	0.16	0.40
0.70	0.21	0.42	0.17	0.00	0.00	0.00	0.48	1.01	0.16	0.06	0.04	0.15
0.80	0.05	0.12	0.02	0.00	0.00	0.00	0.31	0.70	0.00	0.00	0.00	0.00
0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.38	0.00	0.00	0.00	0.00
0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00

Monthly Precipitation (inches)

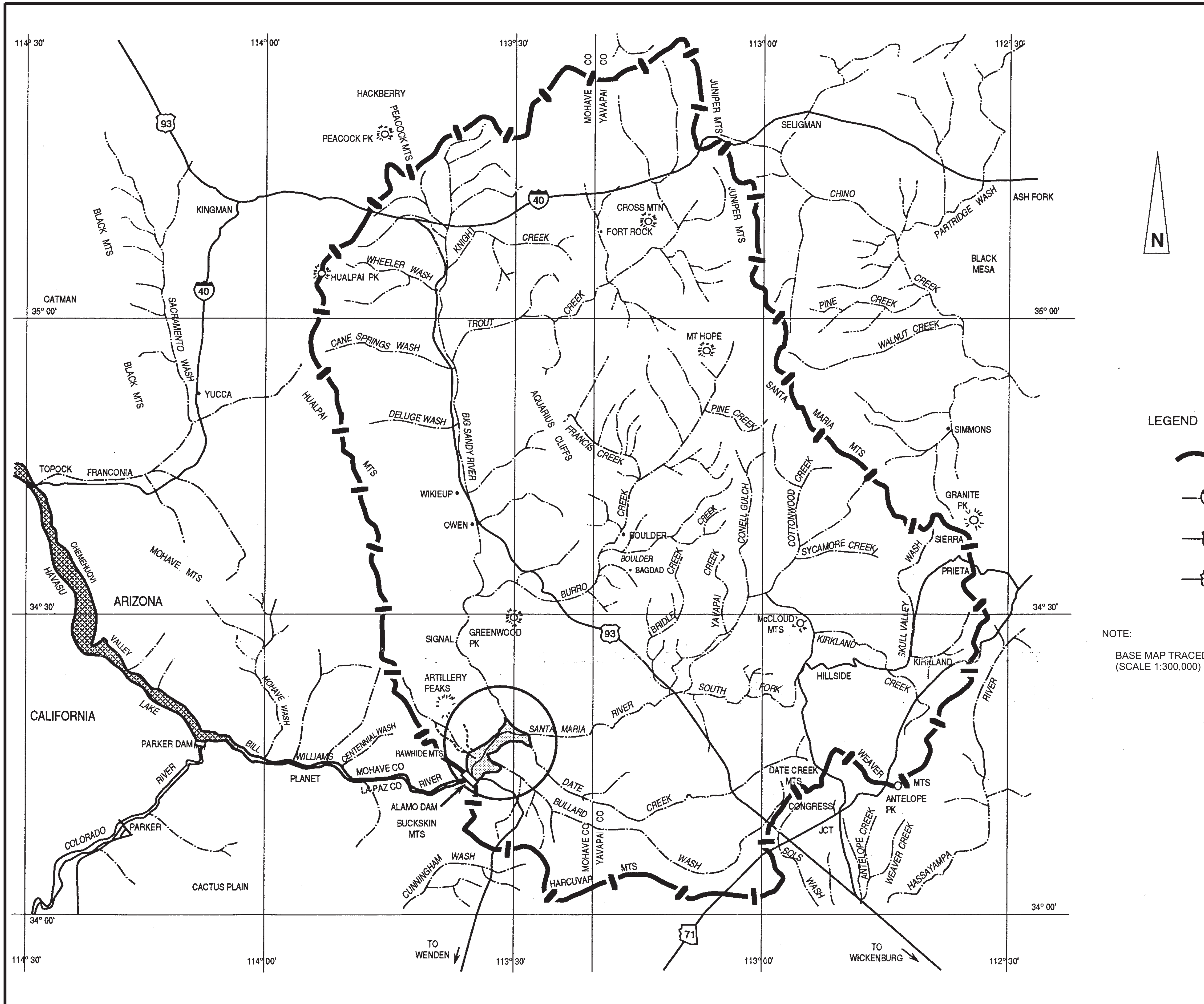
PLATES



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

COLORADO RIVER BASIN LOCATION MAP

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

PROJECT LOCATION

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

The Plate you are attempting to access (Plate 2-02) is not currently available.

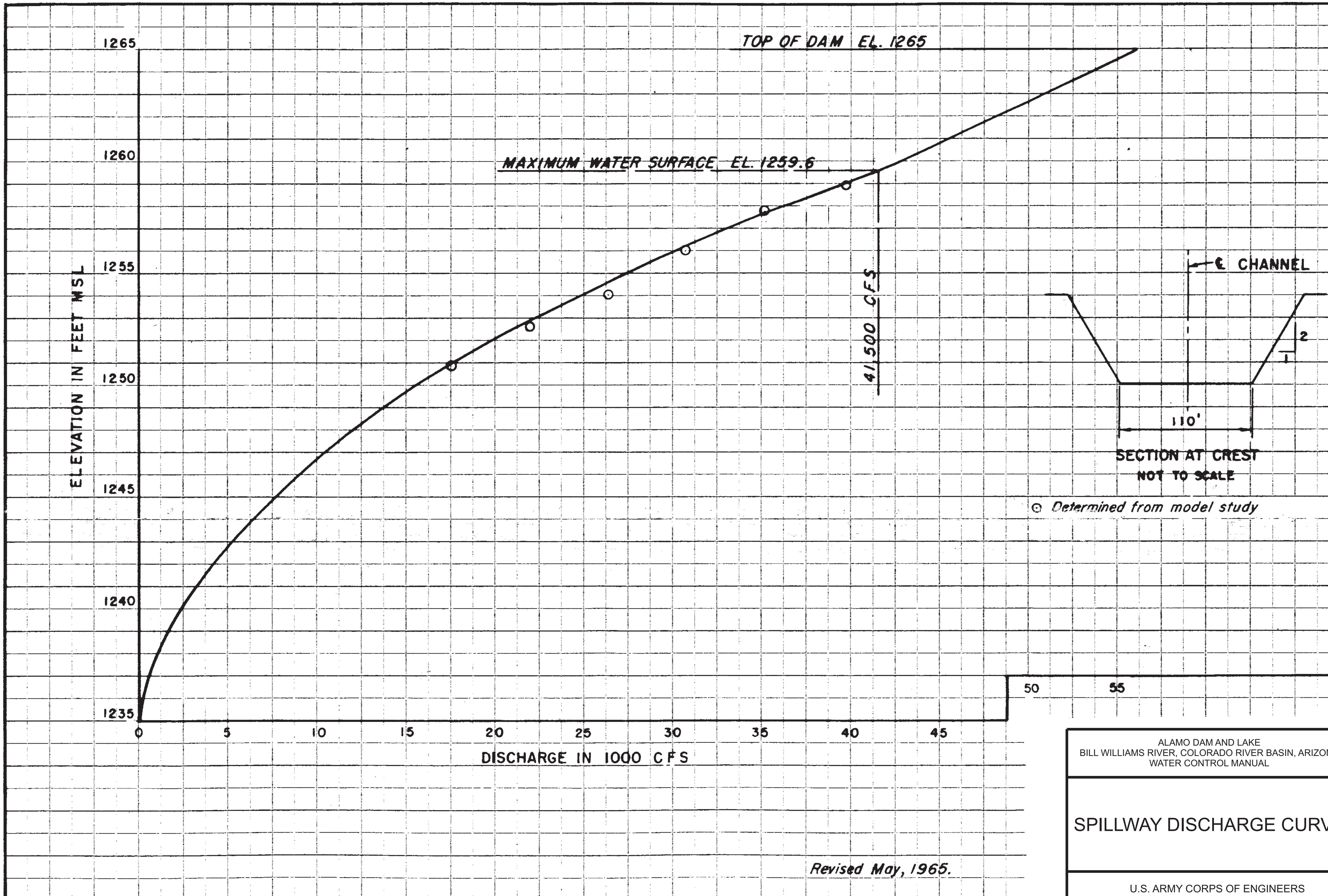
For additional information, please contact the Los Angeles District Public Affairs Office at (213) 452-3908.

The Plate you are attempting to access (Plate 2-03) is not currently available.

For additional information, please contact the Los Angeles District Public Affairs Office at (213) 452-3908.

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

SPILLWAY DISCHARGE CURVE

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

The Plate you are attempting to access (Plate 2-05) is not currently available.

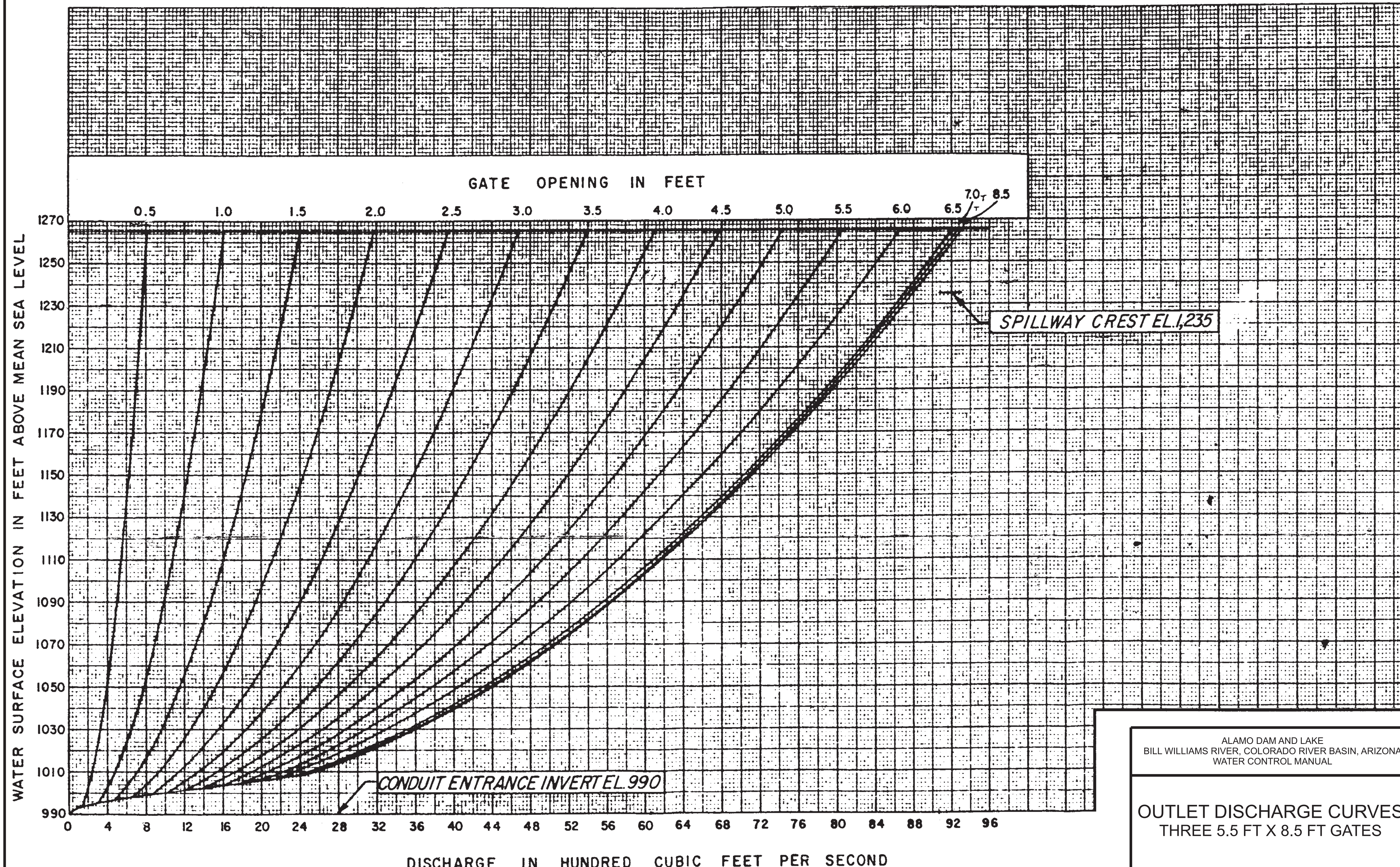
For additional information, please contact the Los Angeles District Public Affairs Office at (213) 452-3908.

The Plate you are attempting to access (Plate 2-06) is not currently available.

For additional information, please contact the Los Angeles District Public Affairs Office at (213) 452-3908.

The Plate you are attempting to access (Plate 2-07) is not currently available.

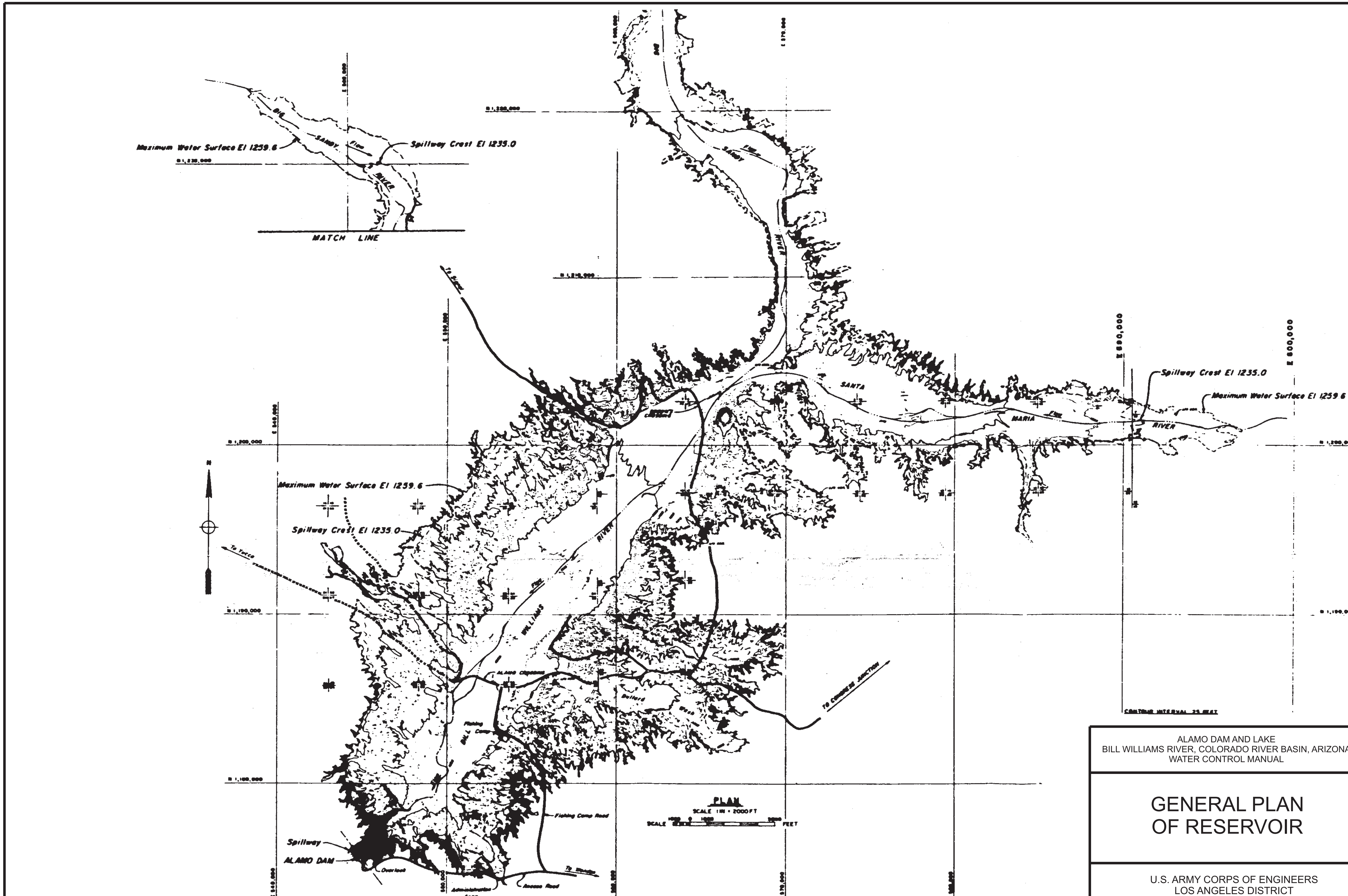
For additional information, please contact the Los Angeles District Public Affairs Office at (213) 452-3908.



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

OUTLET DISCHARGE CURVES
THREE 5.5 FT X 8.5 FT GATES

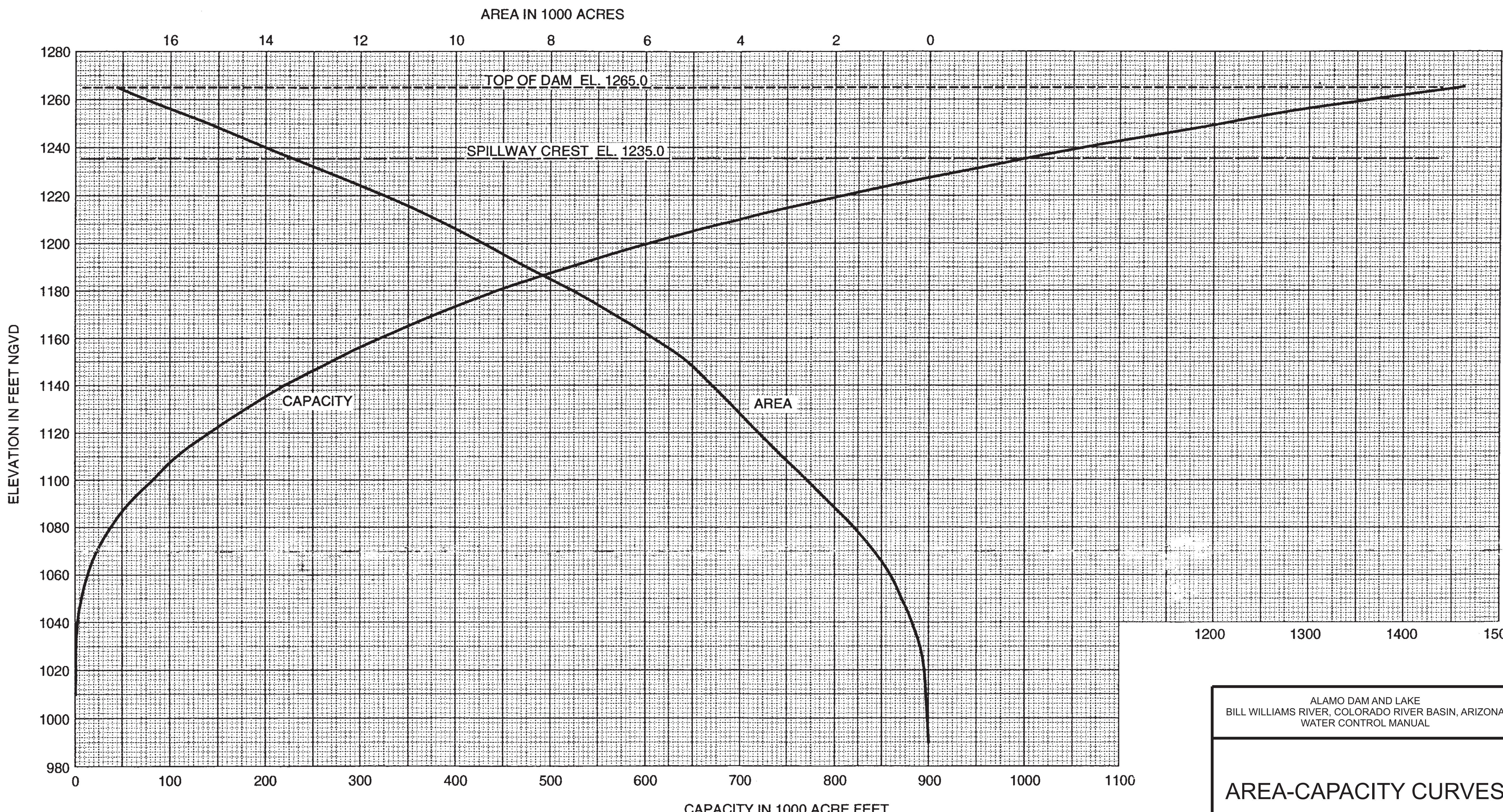
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

GENERAL PLAN OF RESERVOIR

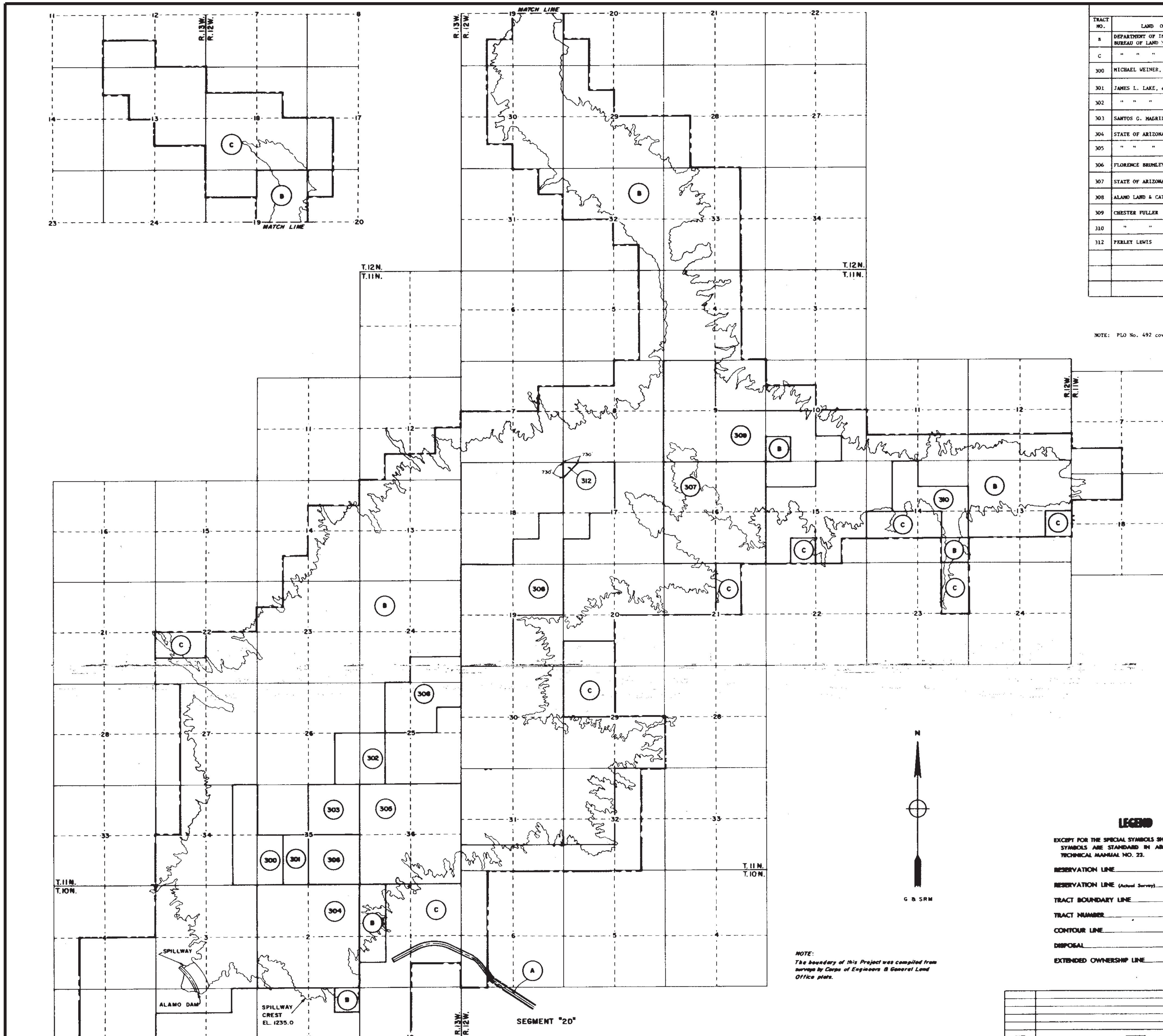
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

AREA-CAPACITY CURVES

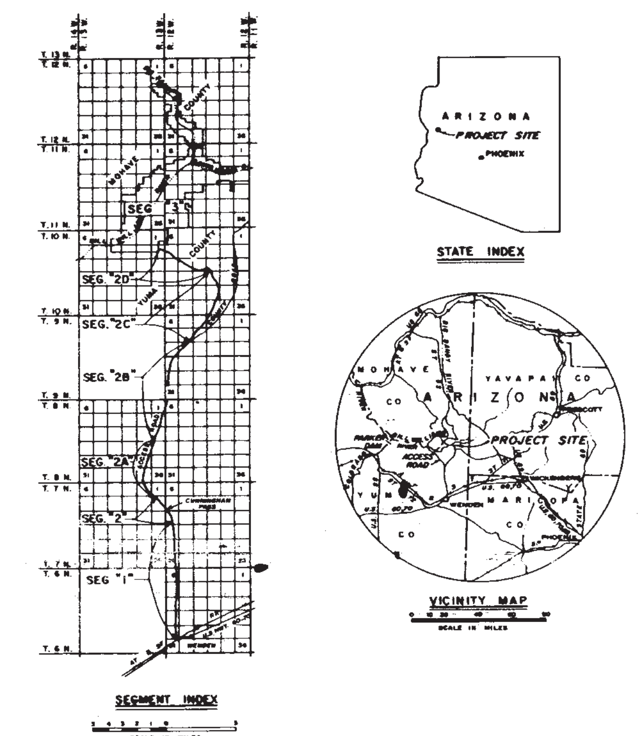
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



TRACT REGISTER

TRACT NO.	LAND OWNER	ACREAGE FEE	ACREAGE TRANSFER			REMARKS
B	DEPARTMENT OF INTERIOR BUREAU OF LAND MANAGEMENT		14,889.12			PLO No. 492 dated 2 July 1948
C	" " " "		3,488.62			Withdrawal order pending.
300	MICHAEL WEINER, et al	240.00				D/T filed 31 May 1966 - Civil #6005-PHX
301	JAMES L. LAKE, et al	80.00				" " " " "
302	" " " " "	160.00				" " " " "
303	SANTOS G. MADRILL, et ux	160.00				" " " " "
304	STATE OF ARIZONA	642.92				" " " " "
305	" " "	640.00				" " " " "
306	FLORENCE BRUMLEY	160.00				Deed dated 18 Oct 65. Formerly Lease No. DA-04-353-CIVENG-6-65-173.
307	STATE OF ARIZONA	640.00				D/T filed 31 May 1966 - Civil #6005-PHX.
308	ALAMO LAND & CATTLE CO.	1064.96				D/T filed 14 Mar 69 - Civil #69-101-PHX. Additional 6.12 acres in Tract # 312.
309	CHESTER FULLER	720.00				D/T filed 29 Sep 67 - Civil #6471-PHX
310	" "	200.00				" " " " " " " "
312	PERLEY LEWIS	6.12				D/T filed 14 Mar 69 - Civil #69-101-PHX. Taken as part of Tract #308.

NOTE: PLO No. 492 covers 19,403.12 acres of which 4,514.00 acres is in private ownership.



LEGEND

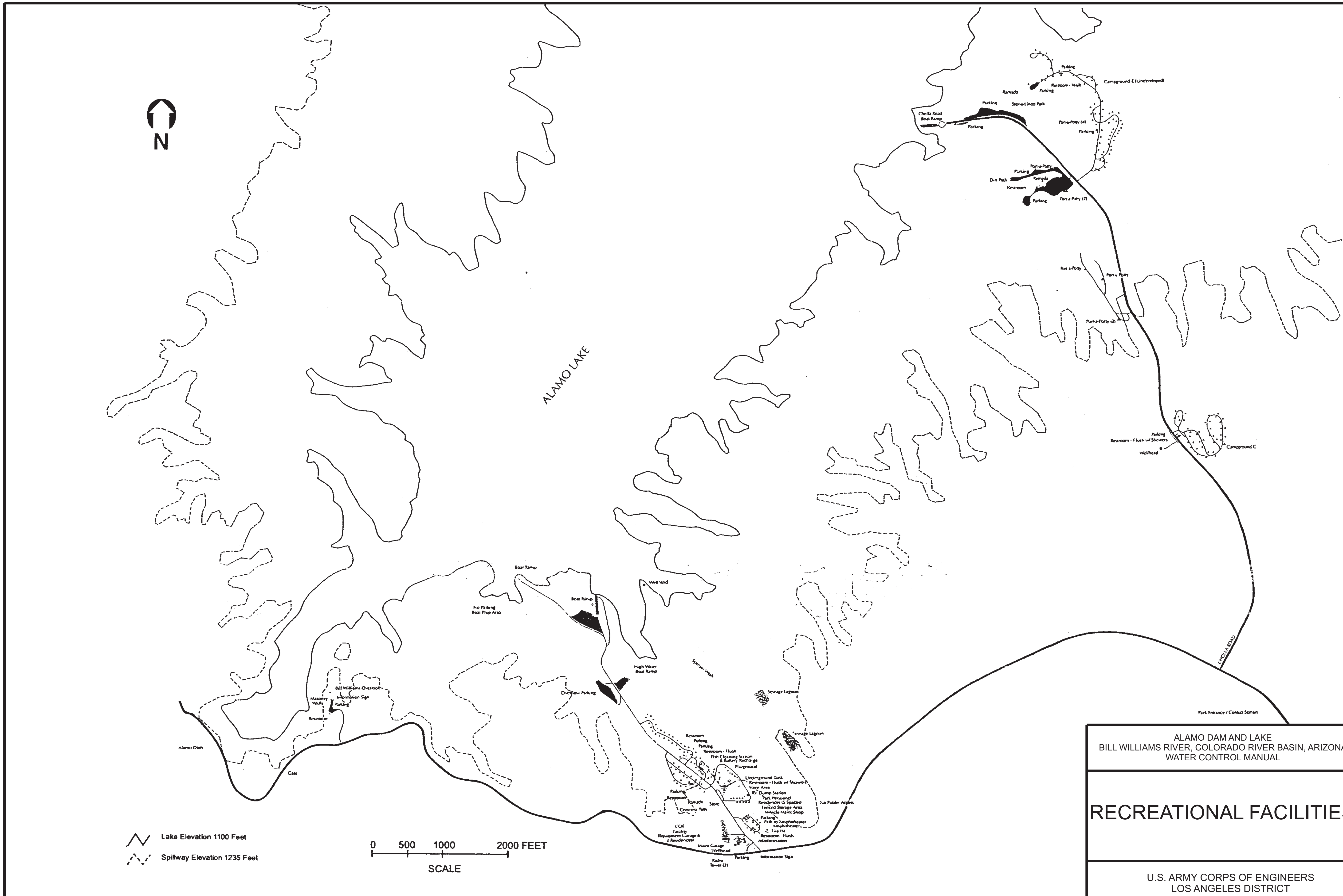
EXCEPT FOR THE SPECIAL SYMBOLS SHOWN BELOW MAP SYMBOLS ARE STANDARD IN ARMY MAP SERVICE TECHNICAL MANUAL NO. 23.

- RESERVATION LINE
- RESERVATION LINE (Actual Survey)
- TRACT BOUNDARY LINE
- TRACT NUMBER
- CONTOUR LINE
- DISPOSAL
- EXTENDED OWNERSHIP LINE

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

REAL ESTATE BOUNDARIES

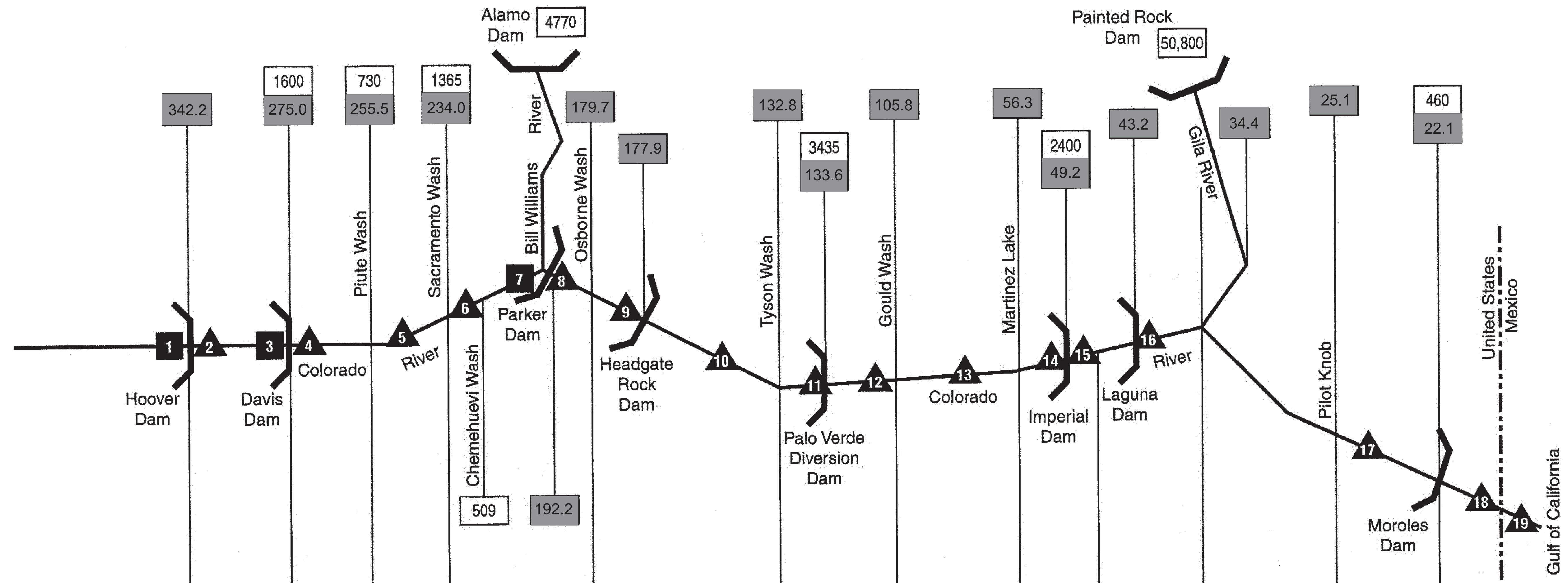
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

RECREATIONAL FACILITIES

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



Levee Design Capacity (cfs)	100,000	50,000	70,000	N/A	50,000	75,000	80,000	N/A	103,500		140,000	
River Channel Capacity (cfs)	N/A	30,000			19,000	15,000				8,000	16,000	12,000
Channel Type	Natural											

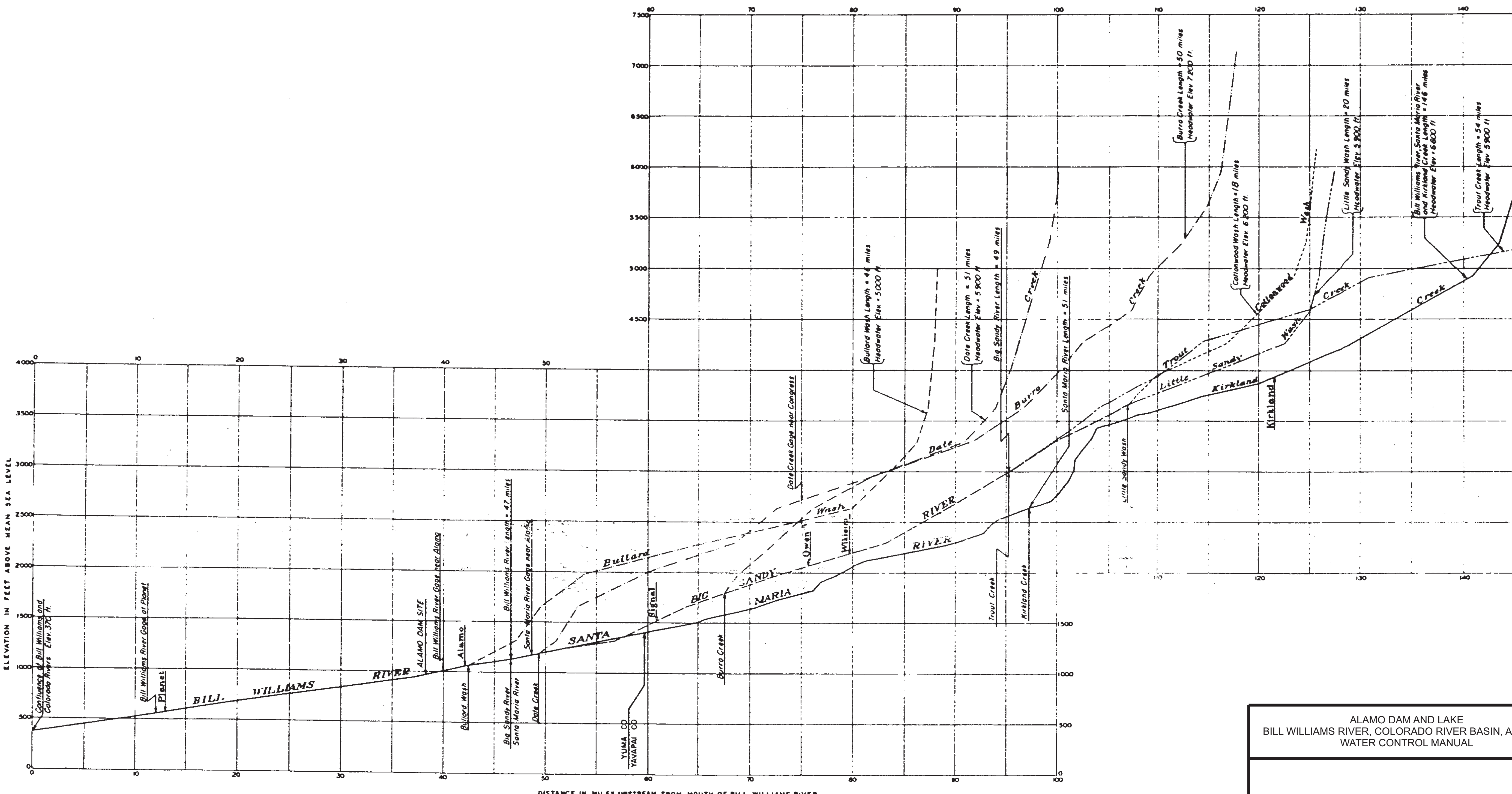
- ▲ (19) Streamflow Gage
- ■ (19) Storage Gage
- Dam
- 509 Drainage area in square miles. Unlabeled area is shown at downstream end of reach
- 345.1 Miles from Stream Mouth

Gage #	USGS Gage #	Station Location
1	09421000	Lake Mead
2	09421500	Colorado River below Hoover Dam
3	09422500	Lake Mohave
4	09423000	Colorado River below Davis Dam
5	09423500	Colorado River at Needles
6	09424000	Colorado River near Topock
7	09427500	Lake Havasu
8	09427520	Colorado River below Parker Dam
9	09428500	Colorado River at Indian Reservation Main Canal
10	N/A	Colorado River at Water Wheel
11	09429010	Colorado River at Palo Verde Dam
12		Colorado River at Taylor Ferry
13	09429300	Colorado River below Cibola Valley (Adobe Ruin)
14	09429490	Colorado River above Imperial Dam
15	09429500	Colorado River below Imperial Dam
16	09429600	Colorado River below Laguna Dam
17	09521100	Colorado River below Yuma Main Canal Wasteway
18	09522000	Colorado River at Northerly International Boundary
19	09522200	Colorado River at Southerly International Boundary

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

LOWER COLORADO RIVER CHANNEL SCHEMATIC

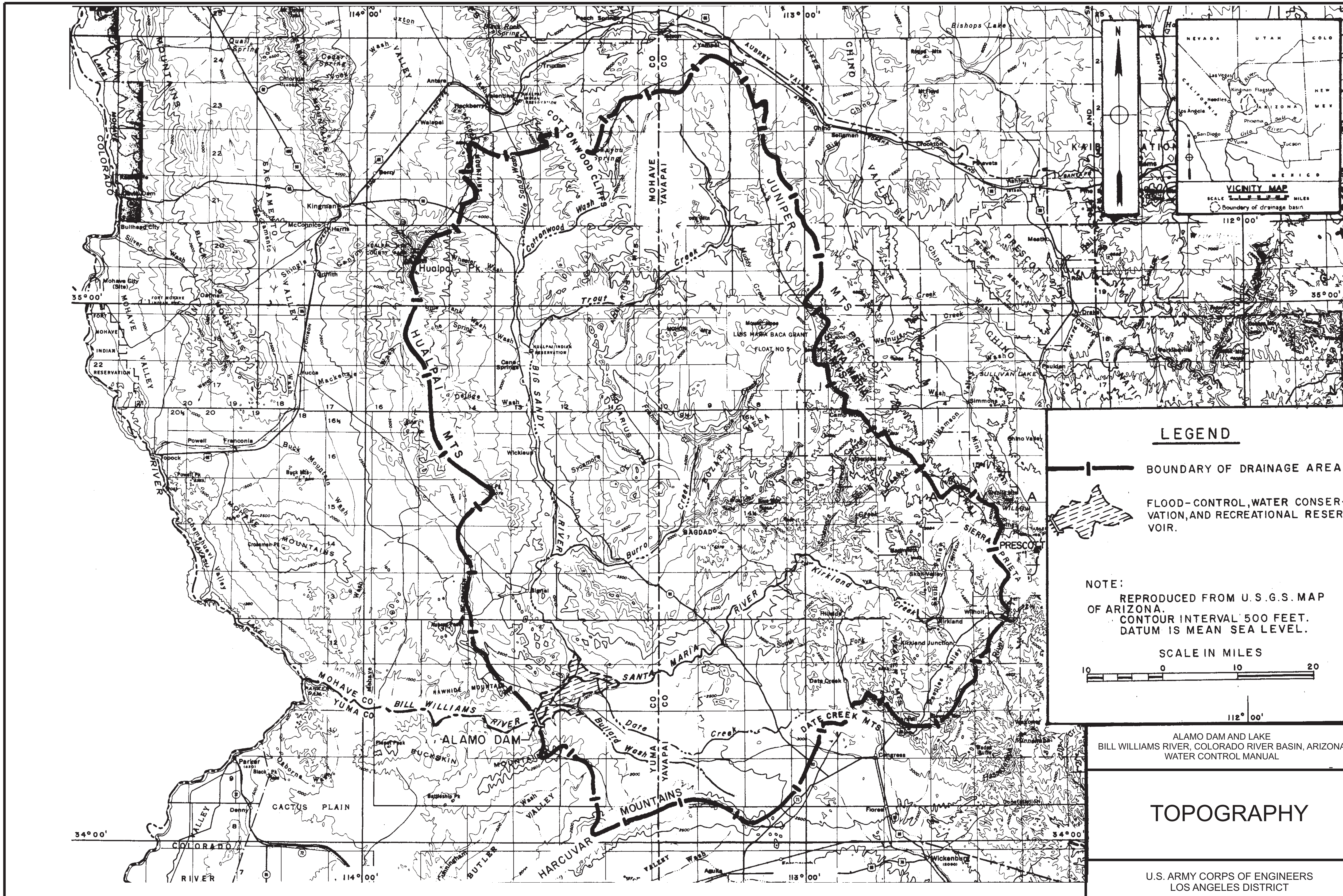
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

STREAMBED PROFILES

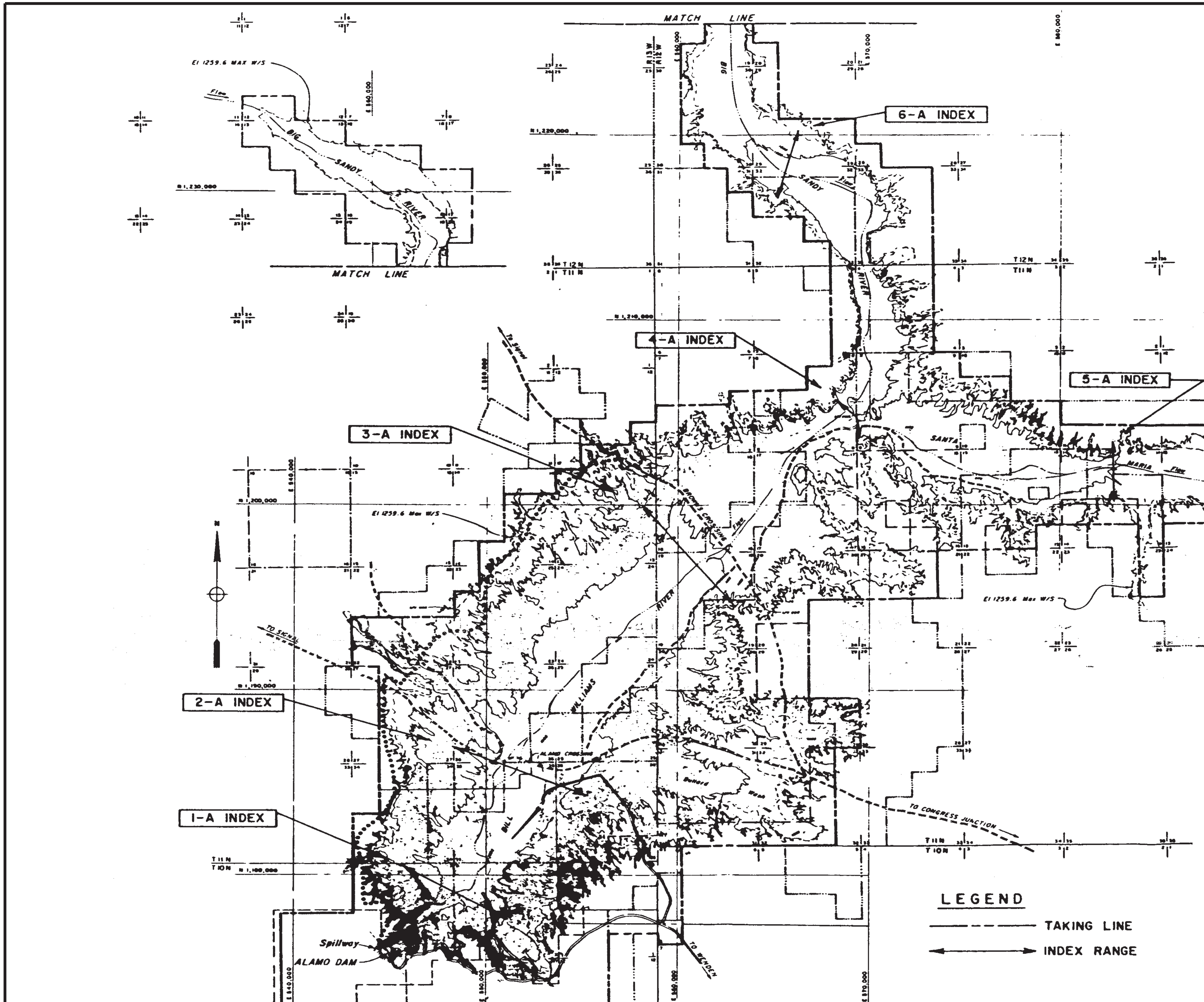
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

TOPOGRAPHY

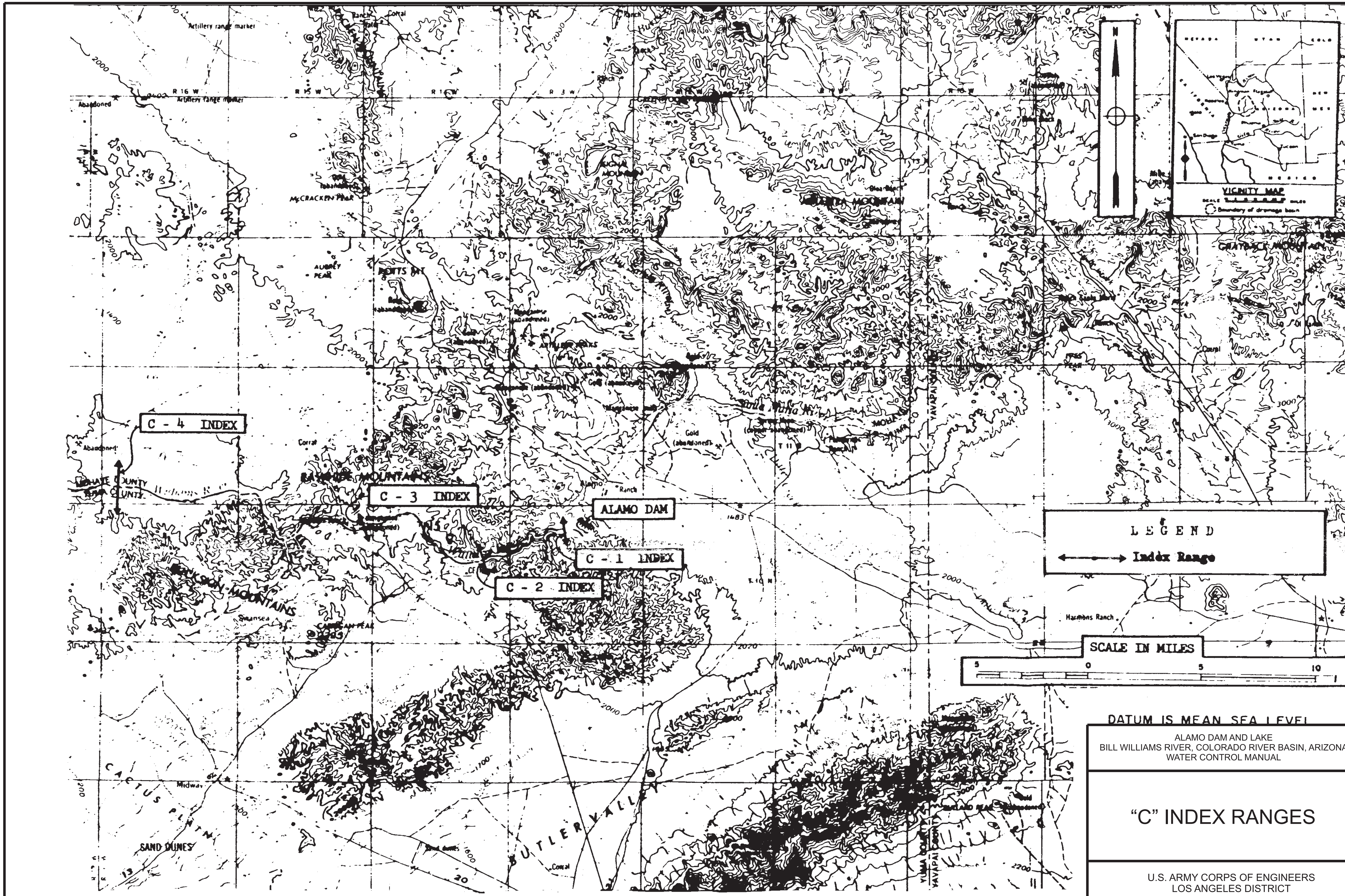
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

"A" INDEX RANGES

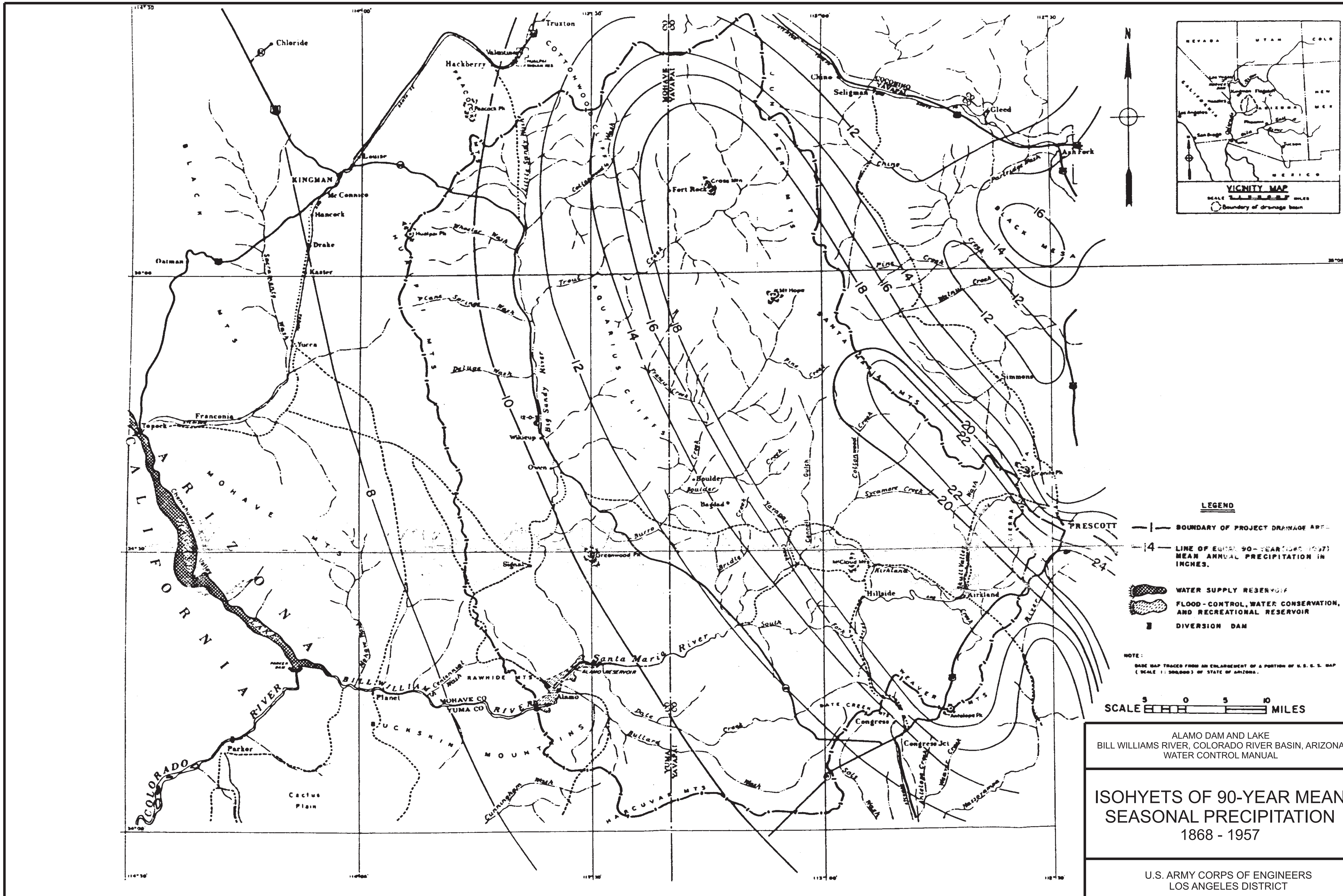
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

"C" INDEX RANGES

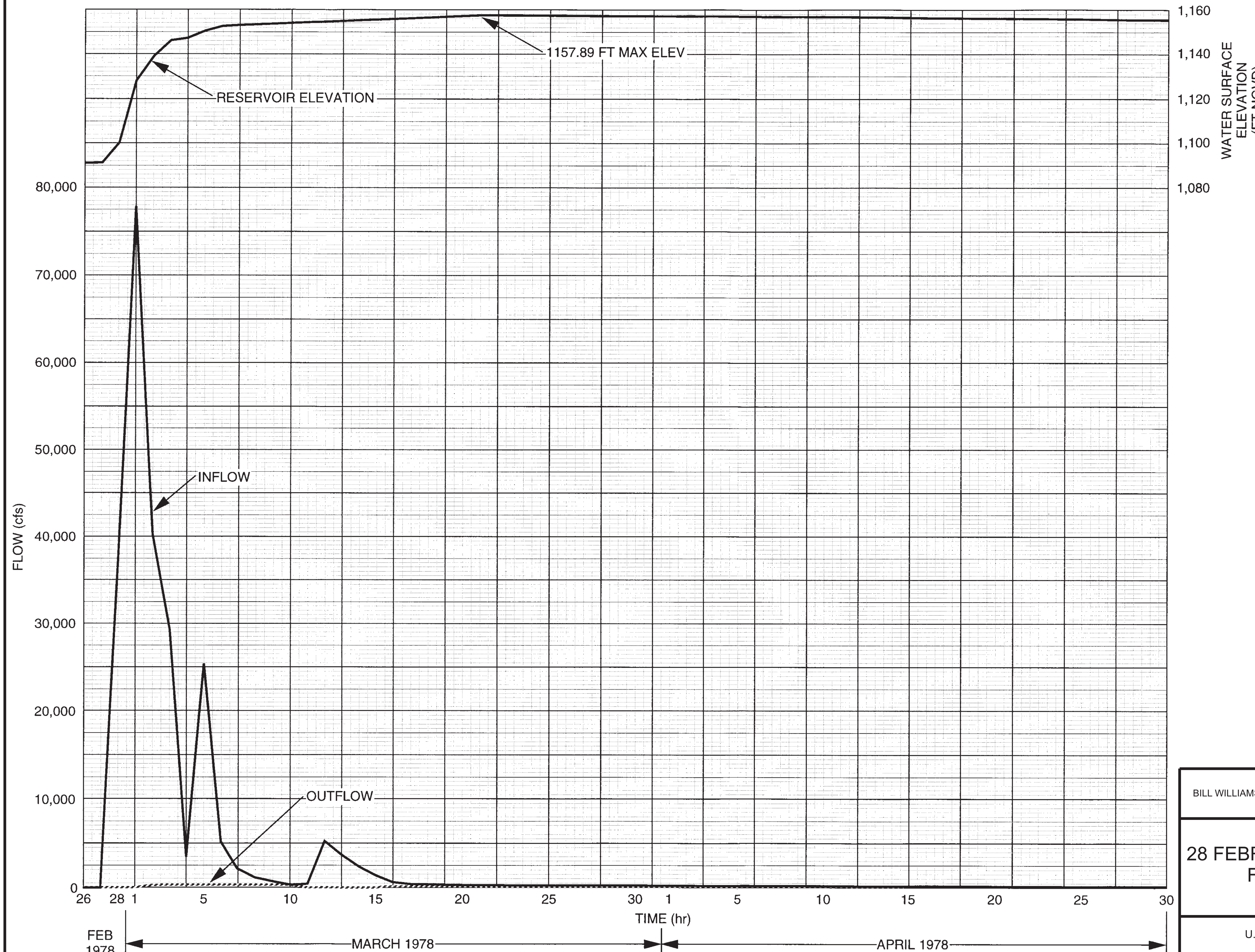
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

ISOHYETS OF 90-YEAR MEAN SEASONAL PRECIPITATION
1868 - 1957

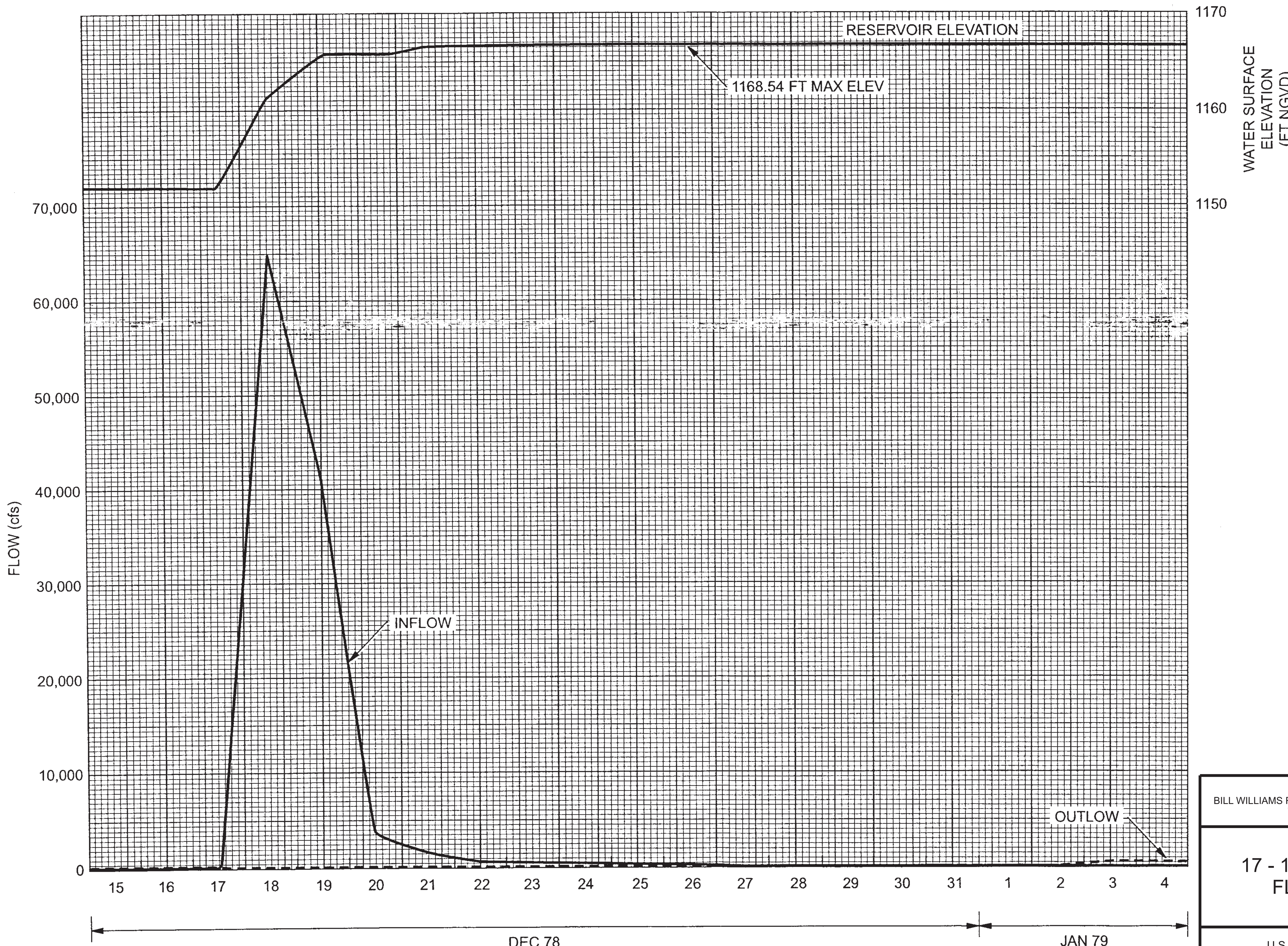
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

28 FEBRUARY - 3 MARCH 1978 FLOOD ROUTING

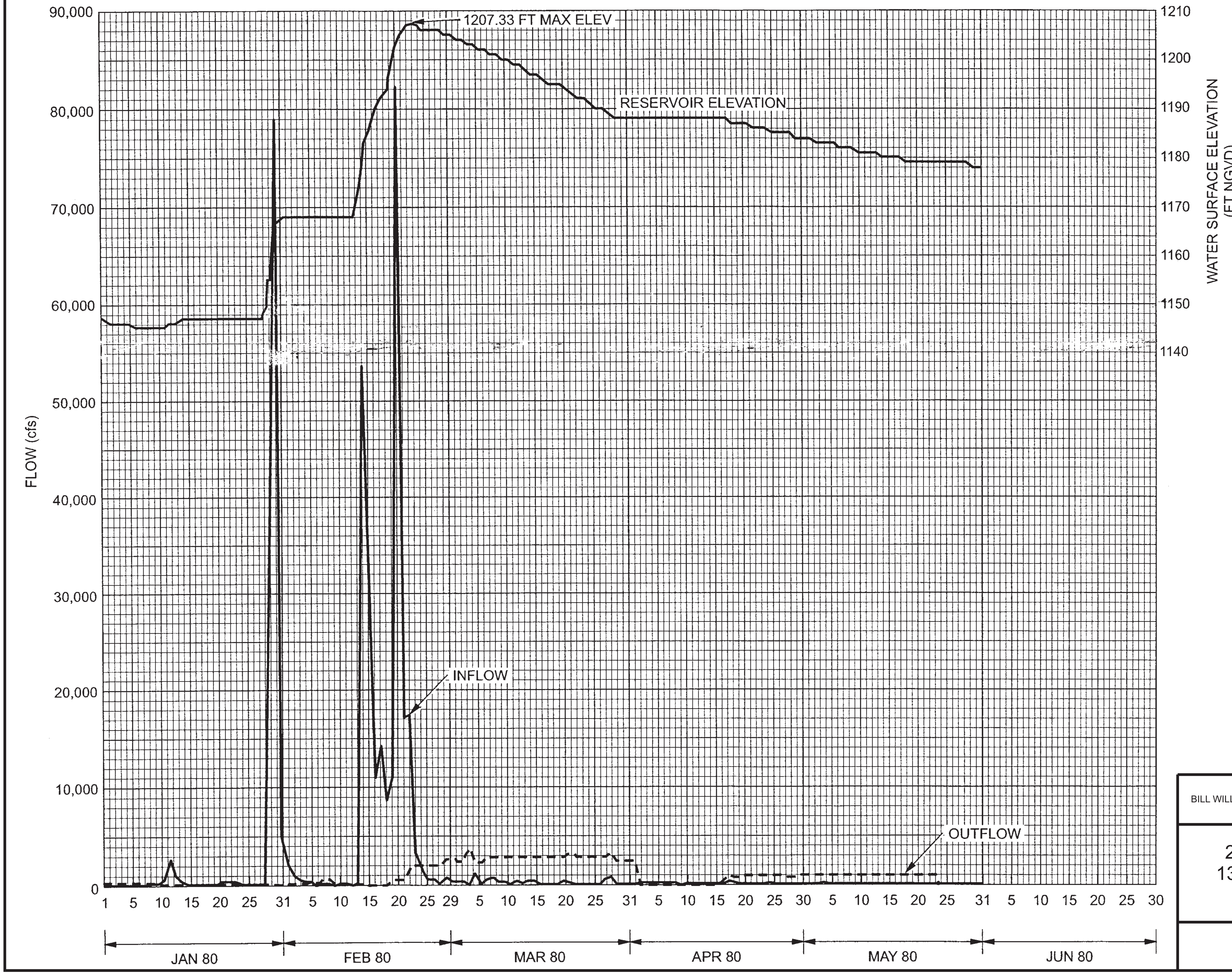
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

17 - 19 DECEMBER 1978 FLOOD ROUTING

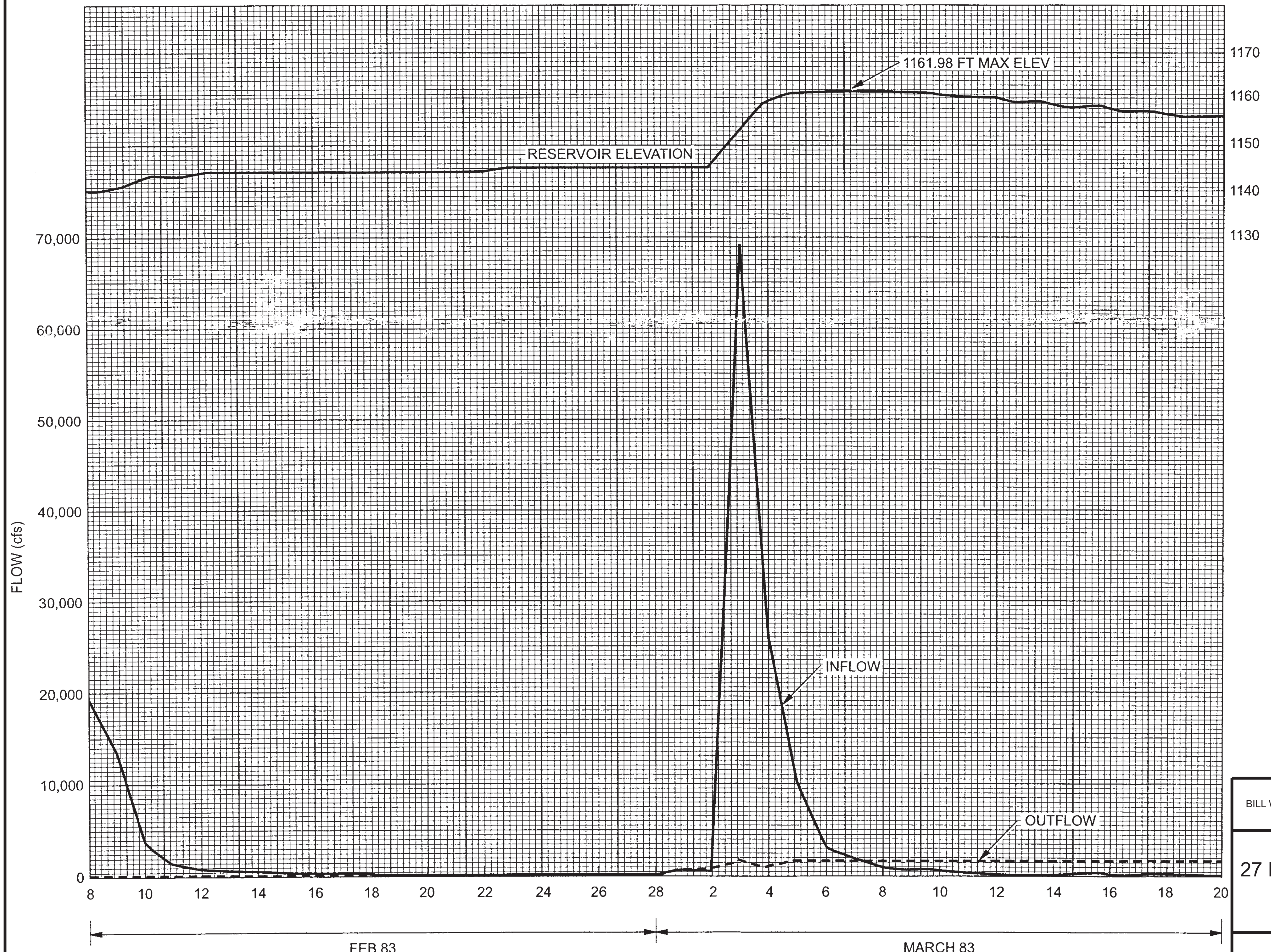
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

28 - 30 JANUARY AND 13 - 22 FEBRUARY 1980 FLOOD ROUTING

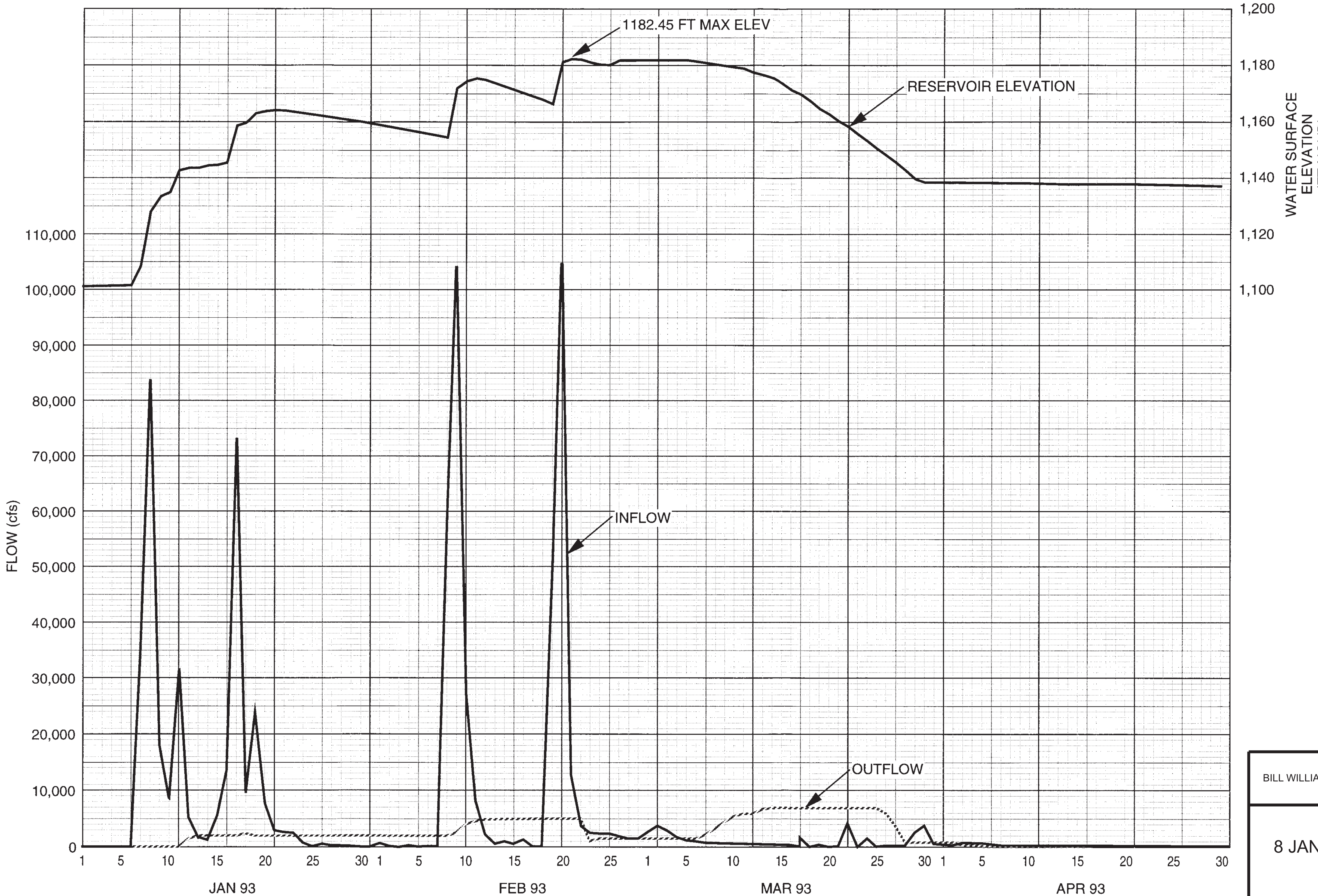
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

27 FEBRUARY - 4 MARCH 1983 FLOOD ROUTING

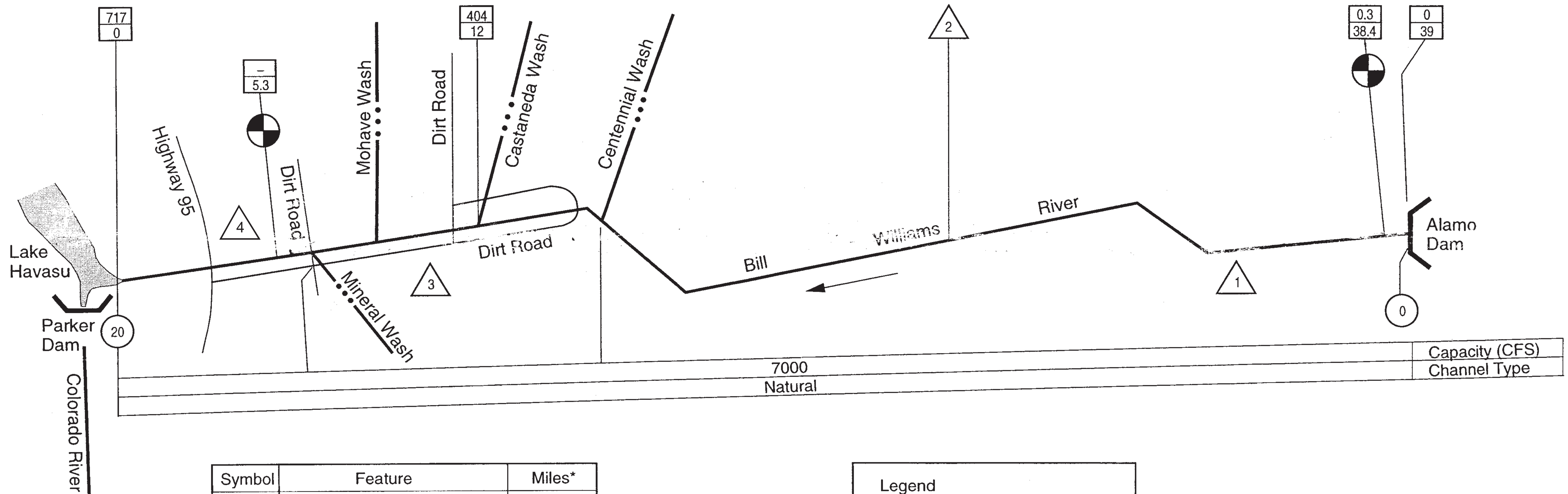
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

8 JANUARY - 28 FEBRUARY 1993
FLOOD ROUTING

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



Symbol	Feature	Miles*
Stream gage symbol	Bill Williams River below Alamo Dam	38.4
Triangle 1	Lincoln Ranch	32.4
Triangle 2	El Paso Natural Gas above-ground pipeline crossing (suspension bridge)	25.5
Triangle 3	Planet Ranch	11.3 - 16.3
Triangle 4	Bill Williams River National Wildlife Refuge	0 - 11.3
Stream gage symbol	Bill Williams River near Parker	5.3

* Miles from Stream Mouth

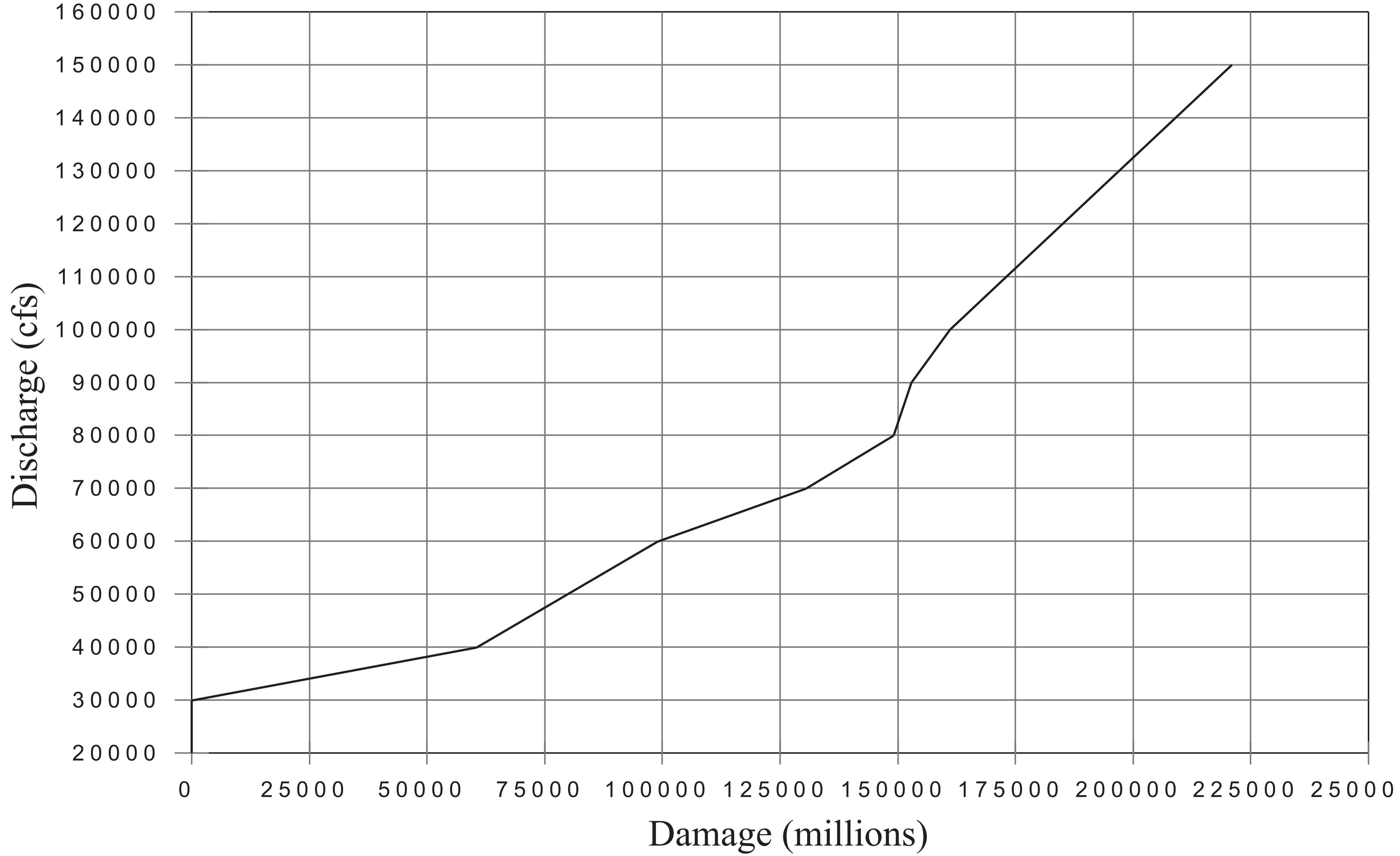
Legend

- Stream Gage
- Drainage Area
- Miles from Stream Mouth
- Miscellaneous Feature

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

BILL WILLIAMS RIVER CHANNEL SCHEMATIC

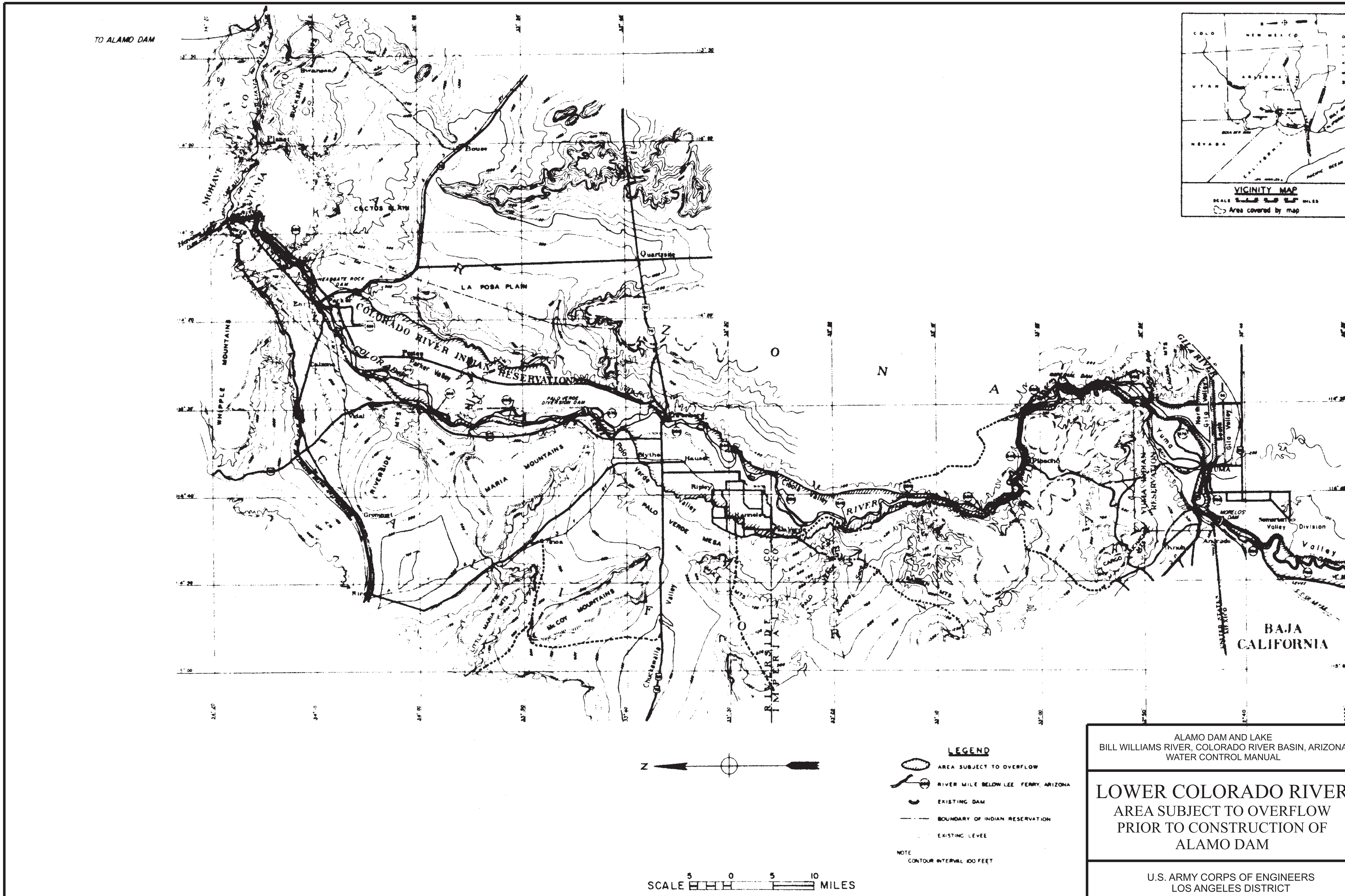
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

DAMAGE vs. DISCHARGE CURVE

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

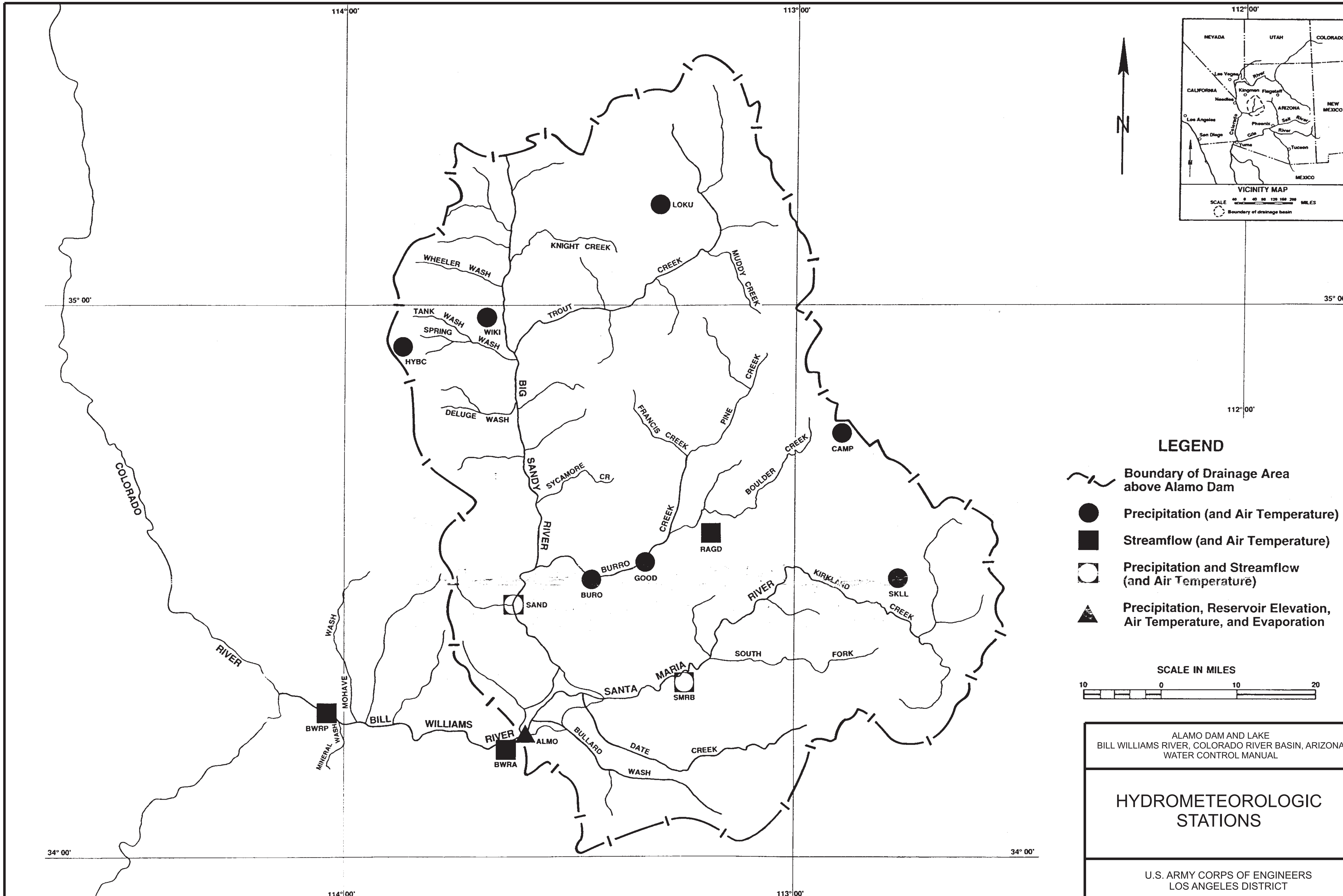


ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

LOWER COLORADO RIVER

AREA SUBJECT TO OVERFLOW PRIOR TO CONSTRUCTION OF ALAMO DAM

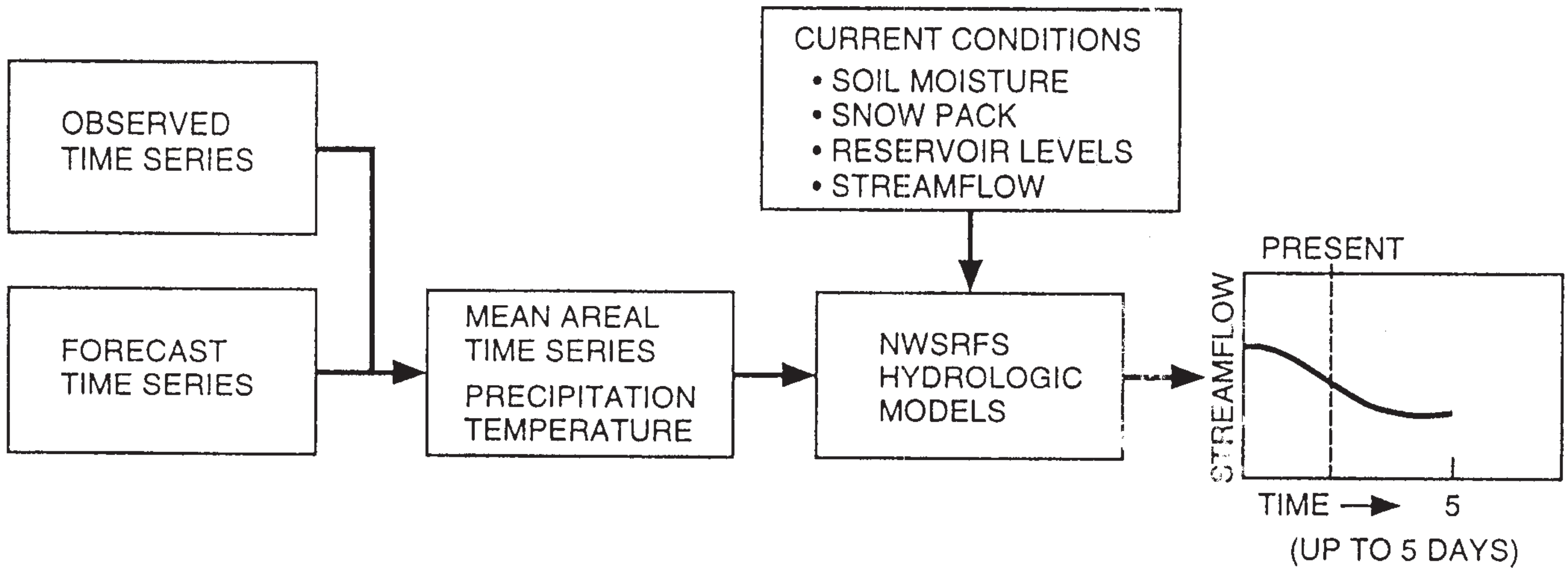
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

HYDROMETEOROLOGIC STATIONS

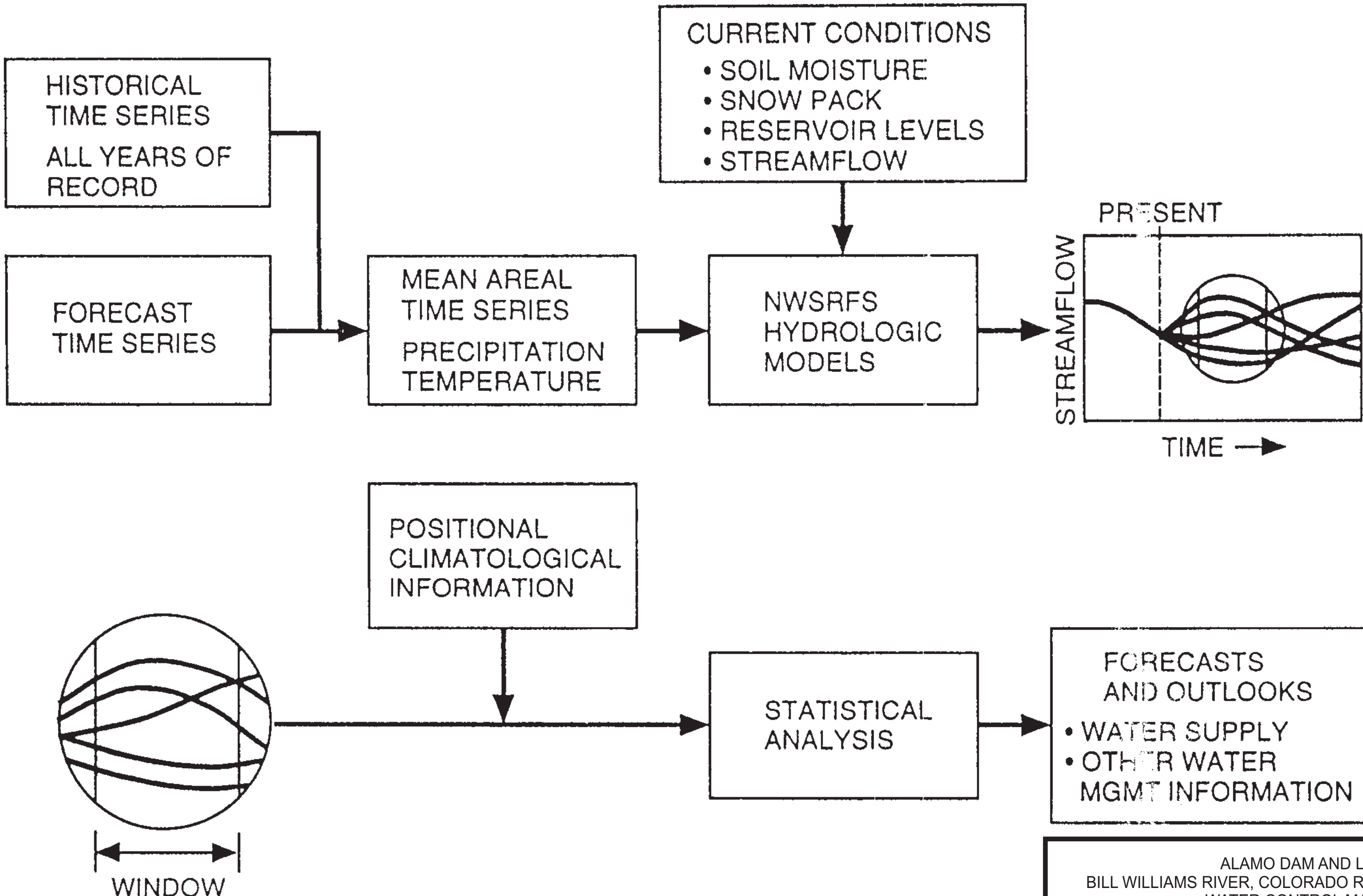
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

NATIONAL WEATHER SERVICE FLOOD FORECAST METHODOLOGY

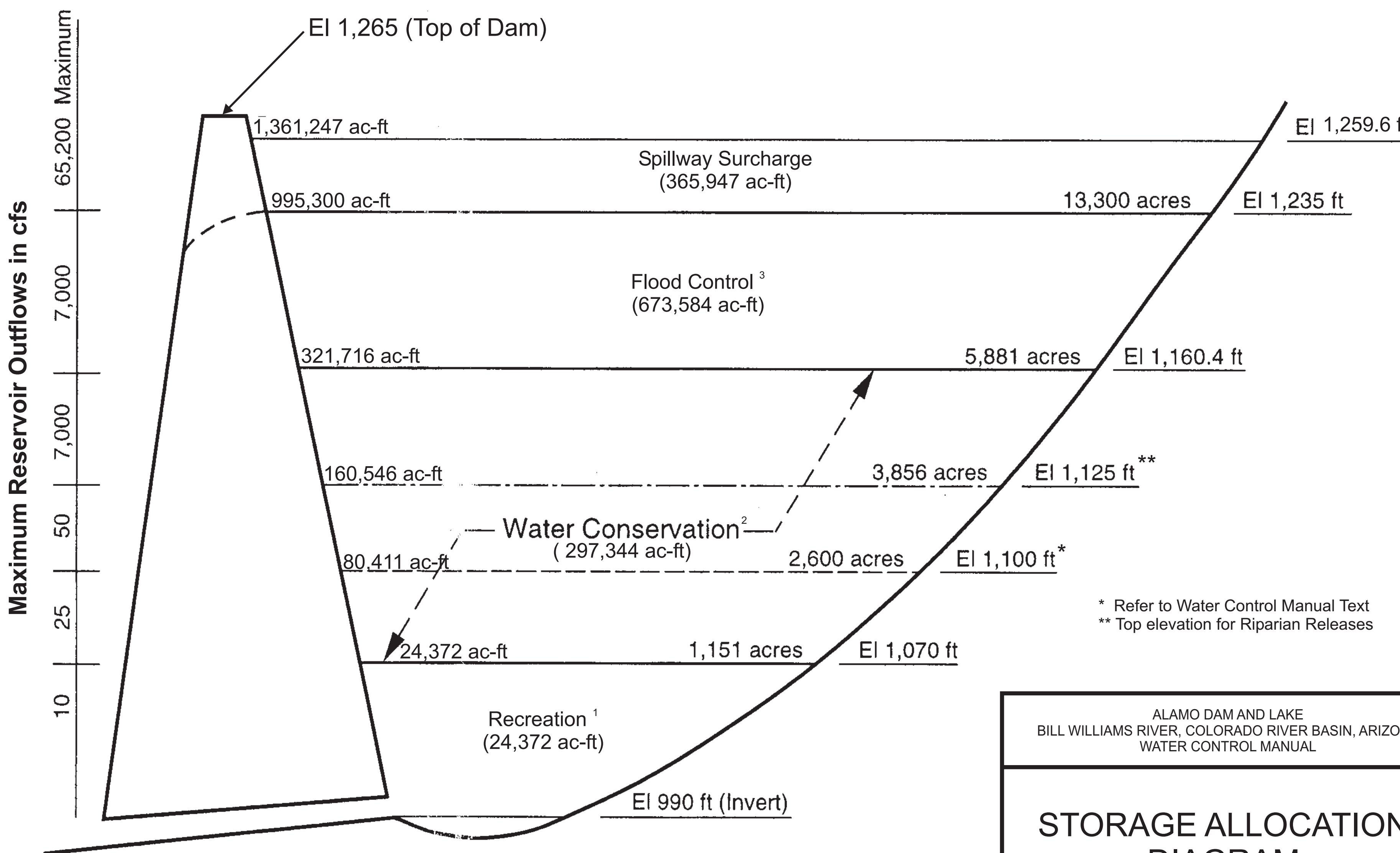
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

NATIONAL WEATHER SERVICE EXTENDED STREAMFLOW PREDICTION METHODOLOGY

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



Notes:
1. Of the 24,372 ac-ft net storage, 5,000 ac-ft is allocated for Recreation.
2. Of the 297,344 ac-ft net storage, 230,000 ac-ft is allocated for Water Conservation.
3. Of the 673,584 ac-ft net storage, 608,369 ac-ft is allocated for Flood Control.

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

STORAGE ALLOCATION DIAGRAM

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

Release Schedule

Lake Water Surface Elevation (ft, NGVD)	Spillway Discharge (cfs)	Non-Spillway Flow Transfer Option[9]			Spillway Flow Transfer Option[6]		
		Outlet Works Discharge (cfs)	Total Discharge (cfs)	Recommended Gate Setting (ft)	Outlet Works Discharge (cfs)	Total Discharge (cfs)	Recommended Gate Setting (ft)
1250 - 1265[1]	15,625 - 56,000	9,198	24,604 - 65,198	6.8	8,979 - 9,198	24,604 - 65,198	6.8 (3 gates)
1244.3 - 1250	7,000 - 15,625	8,979	15,899 - 24,604	6.8	0	7,000 - 15,625	0.0
1244.3	7,000	8,874	15,899	6.8	0	7,000	0.0
1244	6,650	8,869	15,519	6.8	350	7,000	0.7 (1 gate)
1243	5,400	8,850	14,250	6.8	1,600	7,000	1.0 (3 gates)
1242	4,350	8,832	13,182	6.8	2,650	7,000	1.7 (3 gates)
1241	3,300	8,814	12,114	6.8	3,700	7,000	2.5 (3 gates)
1240	2,500	8,795	11,295	6.8	4,500	7,000	3.0 (3 gates)
1239	1,700	8,779	10,479	6.8	5,300	7,000	3.6 (3 gates)
1238	1,200	8,763	9,963	6.8	5,800	7,000	4.0 (3 gates)
1237	700	8,747	9,447	6.8	6,300	7,000	4.4 (3 gates)
1236	350	8,731	9,081	6.8	6,650	7,000	4.7 (3 gates)
1235 (Spillway crest)	0	8,715	8,715	6.8	7,000	7,000	5.0 (3 gates)

	Discharge (cfs)	Recommended Gate Setting (ft)
1148.4[2] - 1235	7,000	6.80 - 5.0 (3 gates)
1132 - 1148.4	6,621[3] - 7,000	6.80 (3 gates)
1131 - 1132	6,000	5.75 (3 gates)
1130 - 1131	5,000	4.65 (3 gates)
1129 - 1130	4,000	3.65 (3 gates)
1128 - 1129	3,000	2.70 (3 gates)
1127 - 1128	2,000	1.75 (3 gates)
1126 - 1127	1,000	1.30 (2 gates)
1125 - 1126	Transition up to 1,000 cfs	0 - 1.3 (2 gates)

	Oct 1 - Nov 1	Nov 1 - Feb 1	Feb 1 - May 1[4,5]	May 1 - Sep 30
1100 - 1125[4]	40 cfs	25 cfs	40 cfs	50 cfs
1070 - 1100[4]	15 cfs	10 cfs	25 cfs	25 cfs
990 - 1070	10 cfs	10 cfs	10 cfs	10 cfs

Season of Year applies to riparian base flows only (shaded area).

Notes:

1. Top of dam
2. Minimum elevation at which 7,000 cfs can be released (3 gaes at 6.90 feet opening).
3. Maximum outflow at elevation 1132 feet (3 gates at 6.80 feet opening).
4. Riparian release shown in the shaded area that are above 10 cfs are maximum. Smaller releases can be made with agreement by the Bill Williams River National Wildlife Refuge Manager.
5. Riparian releases could be temporarily interrupted to allow inspection and/or maintenance. Compensatory releases should be made to maintain the scheduled daily average release rate. Coordination with the resource agencies and other interested parties should be made.
6. Refer to section 7-05 for a discussion of when to use Spillway Flow Transfer Option.
7. Total flow (Spillway + Outlets)
8. Outlet Works only
9. To arrive at recommended gate setting, use 3 gate changes, one per hour apart: 1.7, 3.4, 5.1, then 6.8 feet.

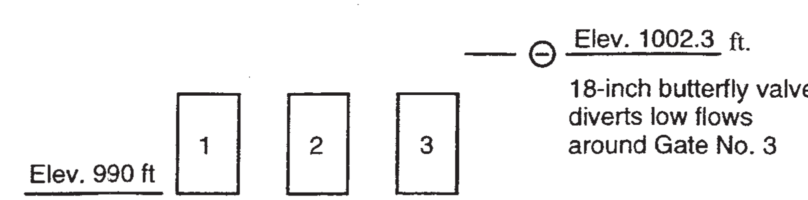
AGENCIES WITH WHOM TO COORDINATE RELEASES

(1) U.S. Bureau of Reclamation in Boulder City, Nevada
(2) U.S. Fish and Wildlife Service, Bill Williams River National Wildlife Refuge in Parker, Arizona
(3) U.S. Bureau of Land Management in Lake Havasu City, Arizona
(4) Arizona Department of Water Resources in Phoenix, Arizona
(5) Arizona Department of Game and Fish in Phoenix, Arizona
(6) Arizona State Parks Department in Lake Havasu City, Arizona

Maximum Rate of Release Increase

Release Range (cfs)[7]	Rate of Increase (cfs/hr)[8]
0 - 500	250
500 - 1,000	500
1,000 - 3,000	1,000
3,000 - 7,000	2,000

OUTLET WORKS DIAGRAM
(Looking Downstream)



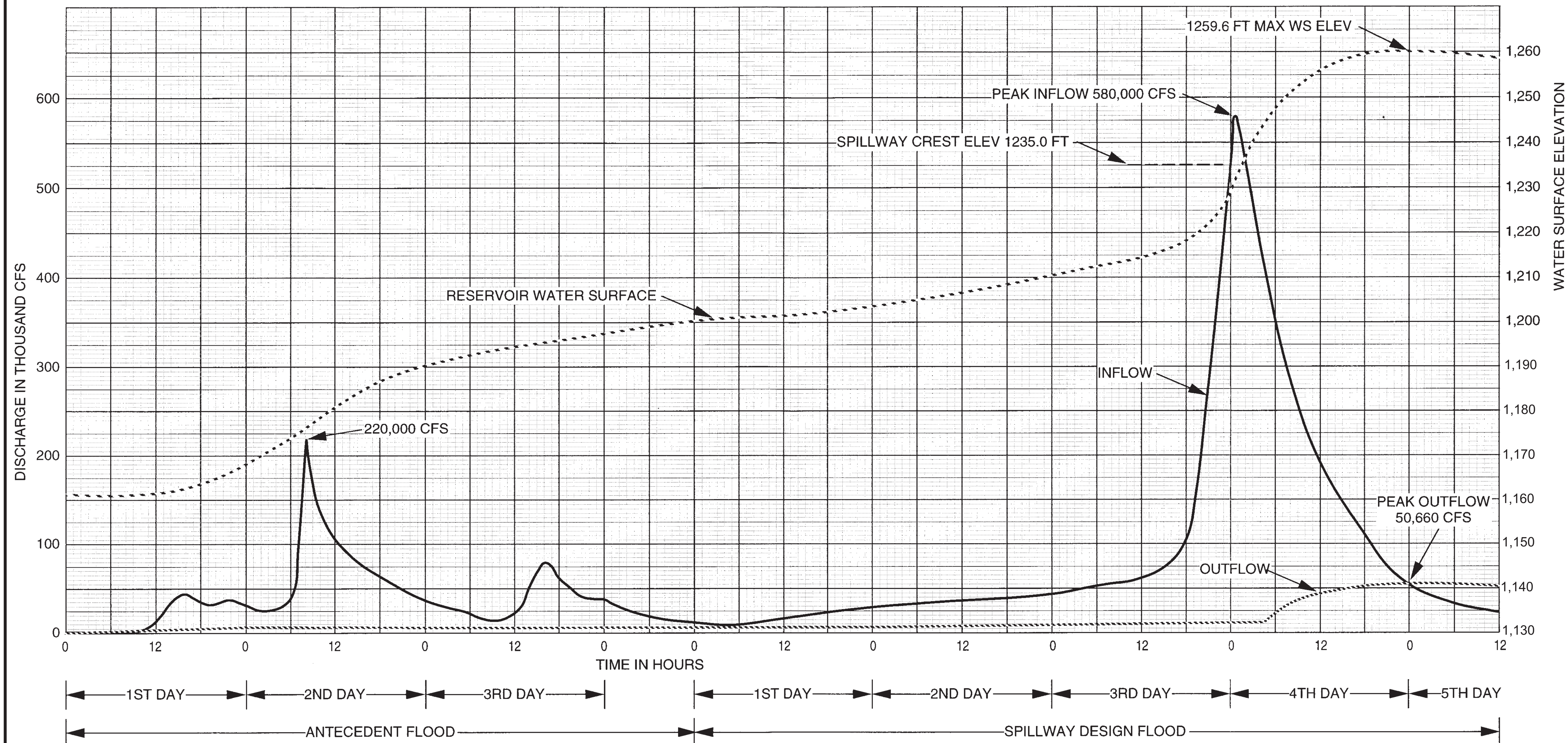
All outlet gates 5.5 ft W x 8.5 ft H

When service gates are in use, butterfly valve is closed

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

RESERVOIR OPERATION SCHEDULE

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

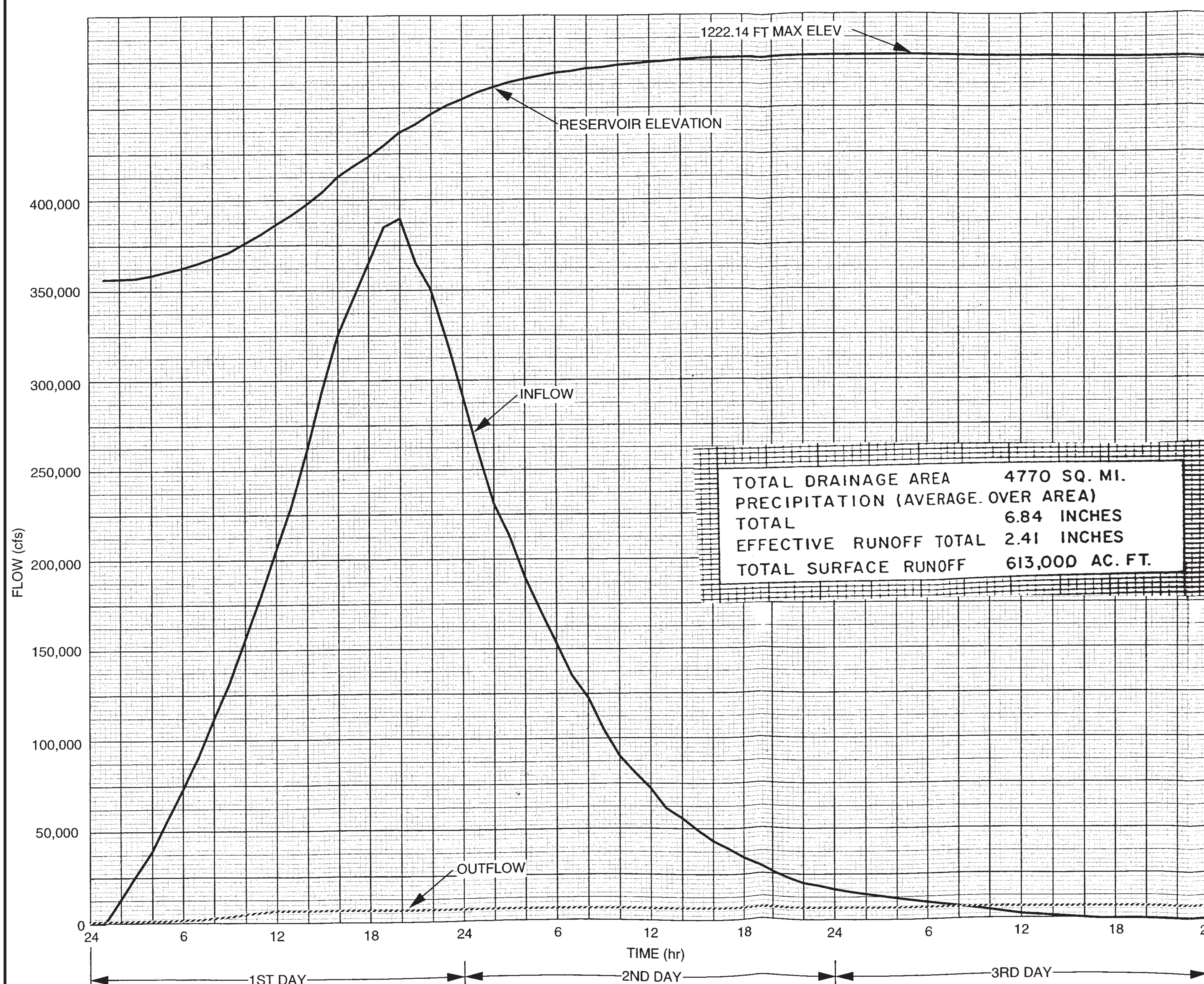


TOTAL DRAINAGE AREA	4,770 SQ MI
AVERAGE RAINFALL DEPTH OVER AREA:	
TOTAL (72 HOURS)	12.0 INCHES
EFFECTIVE TOTAL (SURFACE RUNOFF)	3.1 INCHES
TOTAL RUNOFF FOR PERIOD OF SURFACE	
RUNOFF (INCLUDING BASE FLOW)	893,000 AC-FT
	3.5 INCHES

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

SPILLWAY DESIGN FLOOD ROUTING

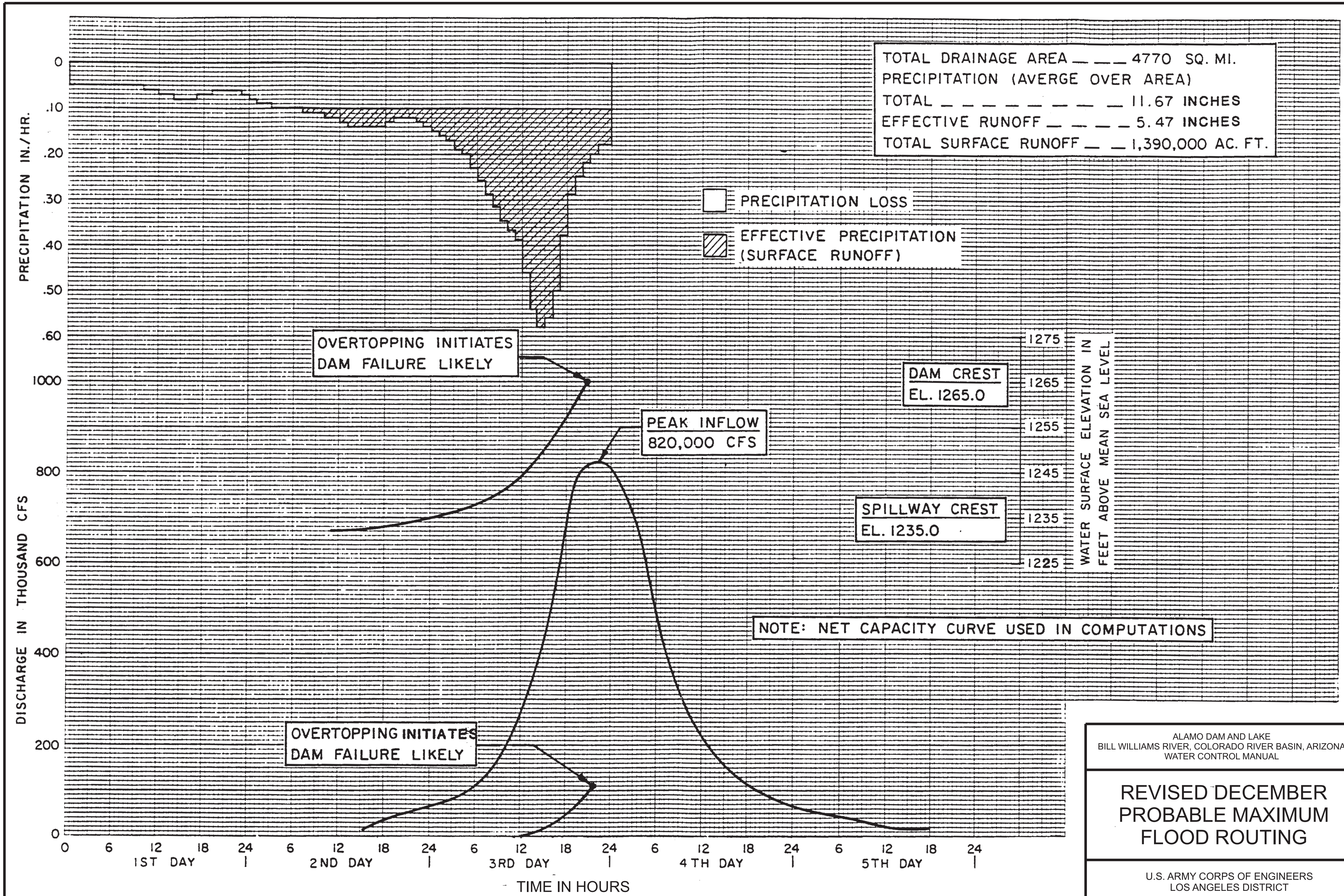
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

REVISED STANDARD PROJECT FLOOD ROUTING

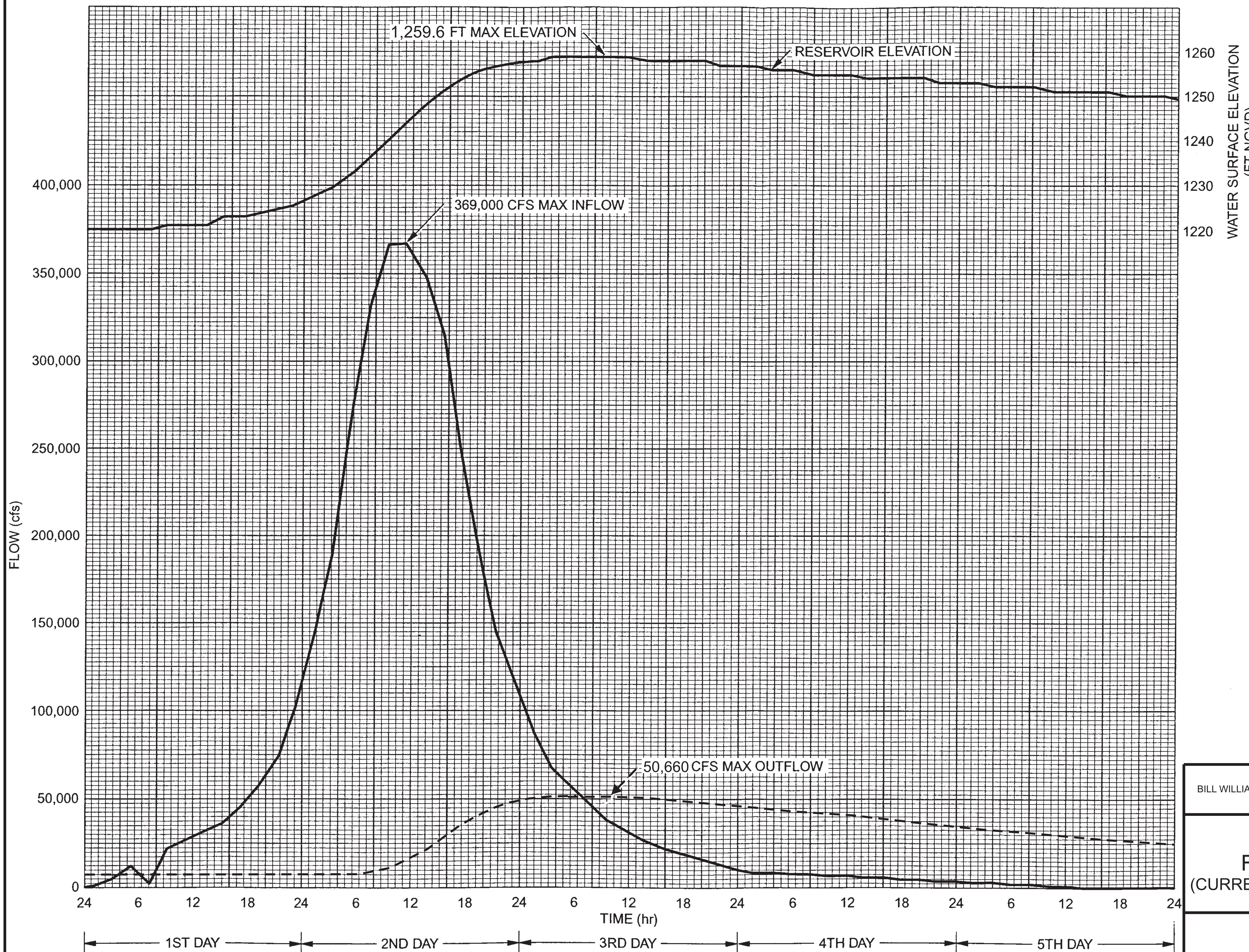
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

REVISED DECEMBER
PROBABLE MAXIMUM
FLOOD ROUTING

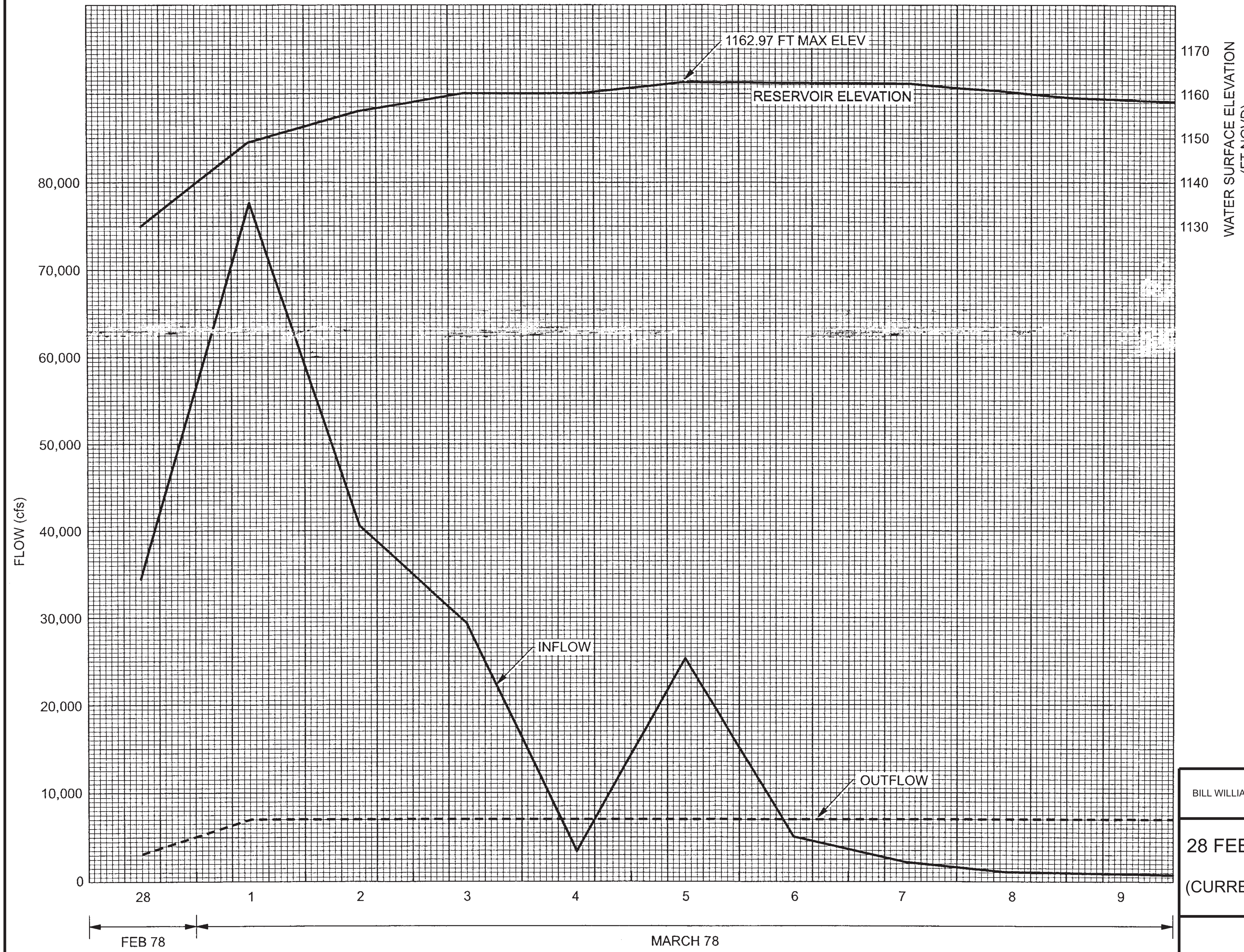
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

THRESHOLD FLOOD ROUTING
(CURRENT WATER CONTROL PLAN)

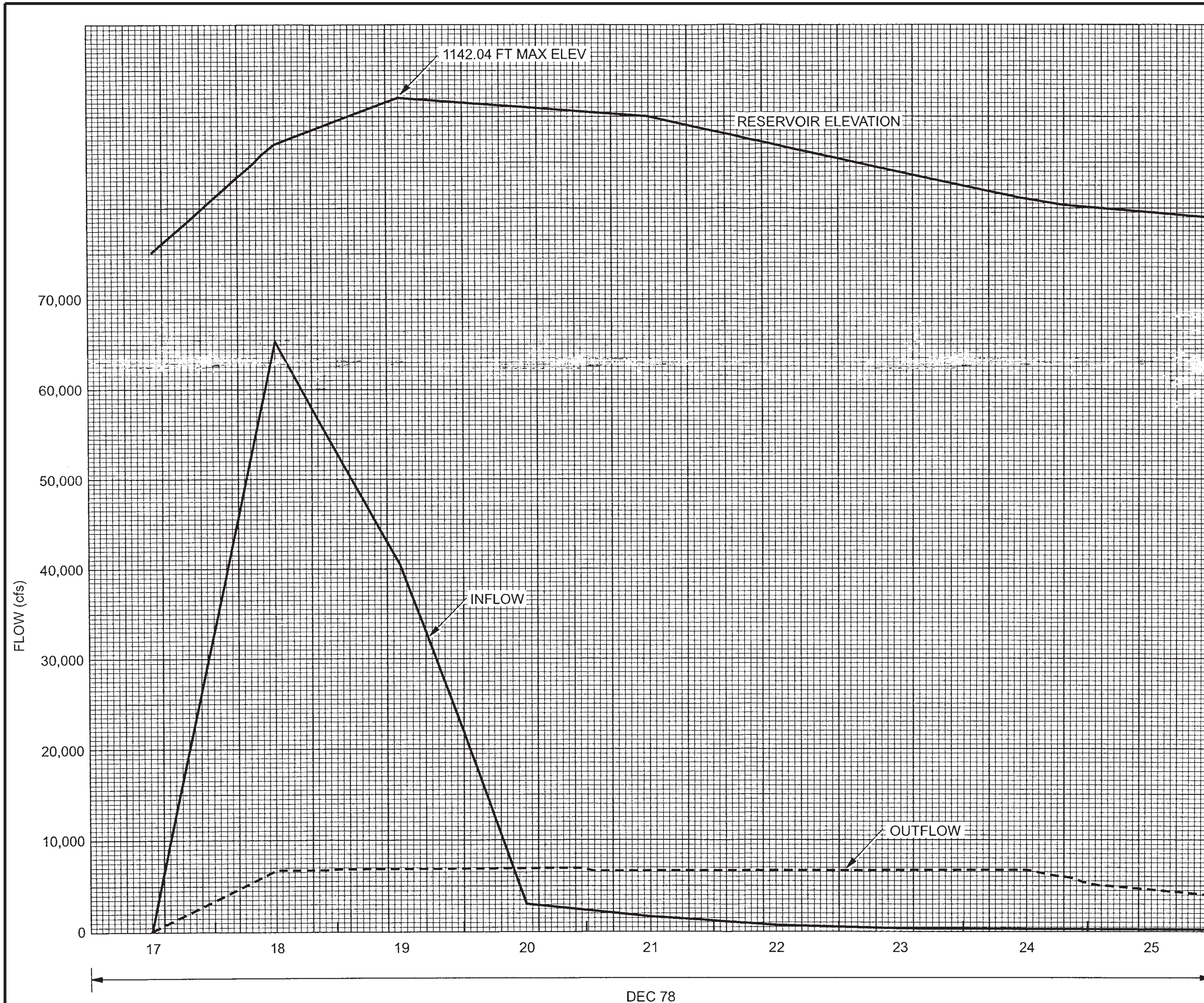
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

28 FEBRUARY - 3 MARCH 1978
FLOOD ROUTING
(CURRENT WATER CONTROL PLAN)

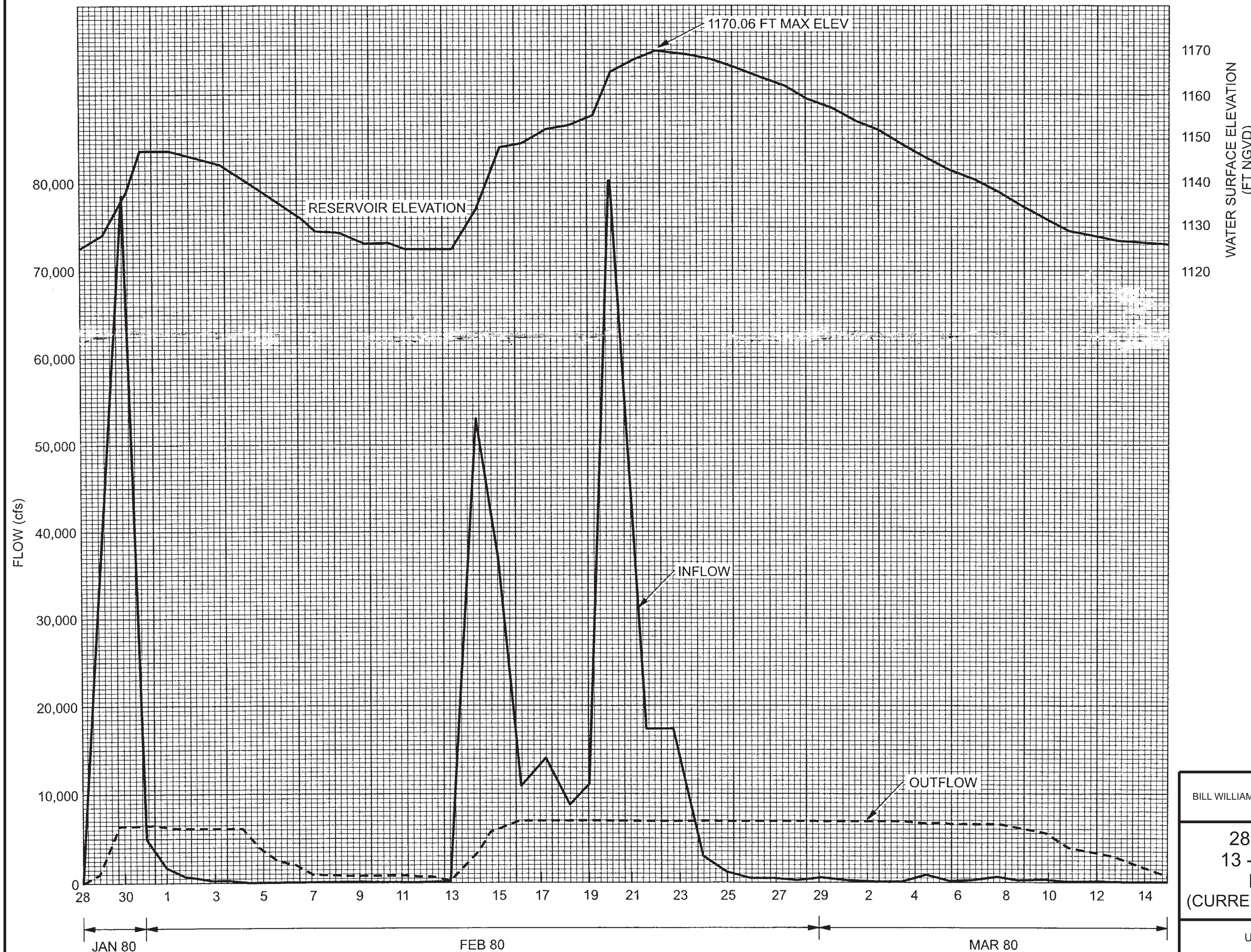
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

17 - 19 DECEMBER 1978
FLOOD ROUTING
(CURRENT WATER CONTROL PLAN)

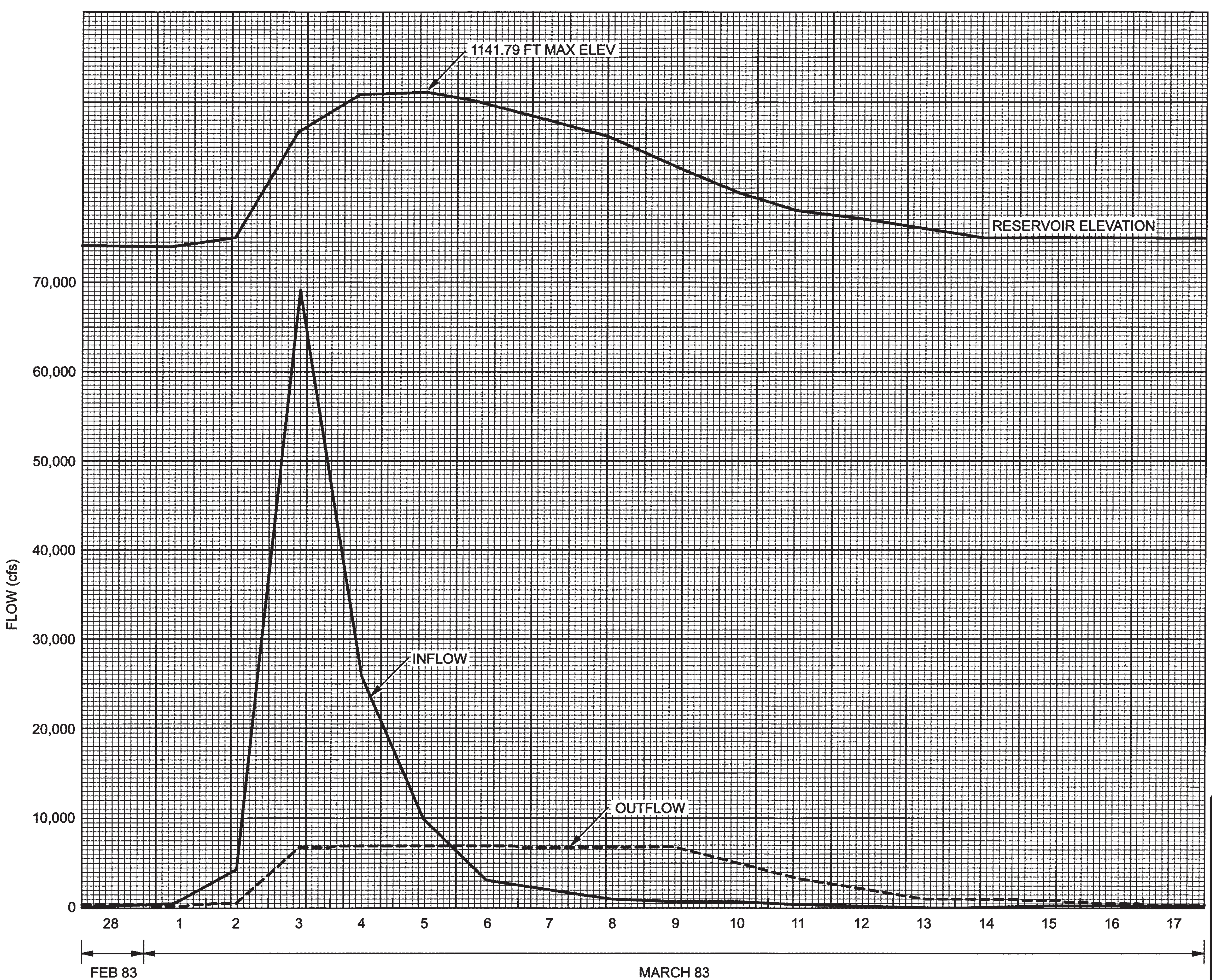
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

28 - 30 JANUARY AND
13 - 22 FEBRUARY 1980
FLOOD ROUTING
(CURRENT WATER CONTROL PLAN)

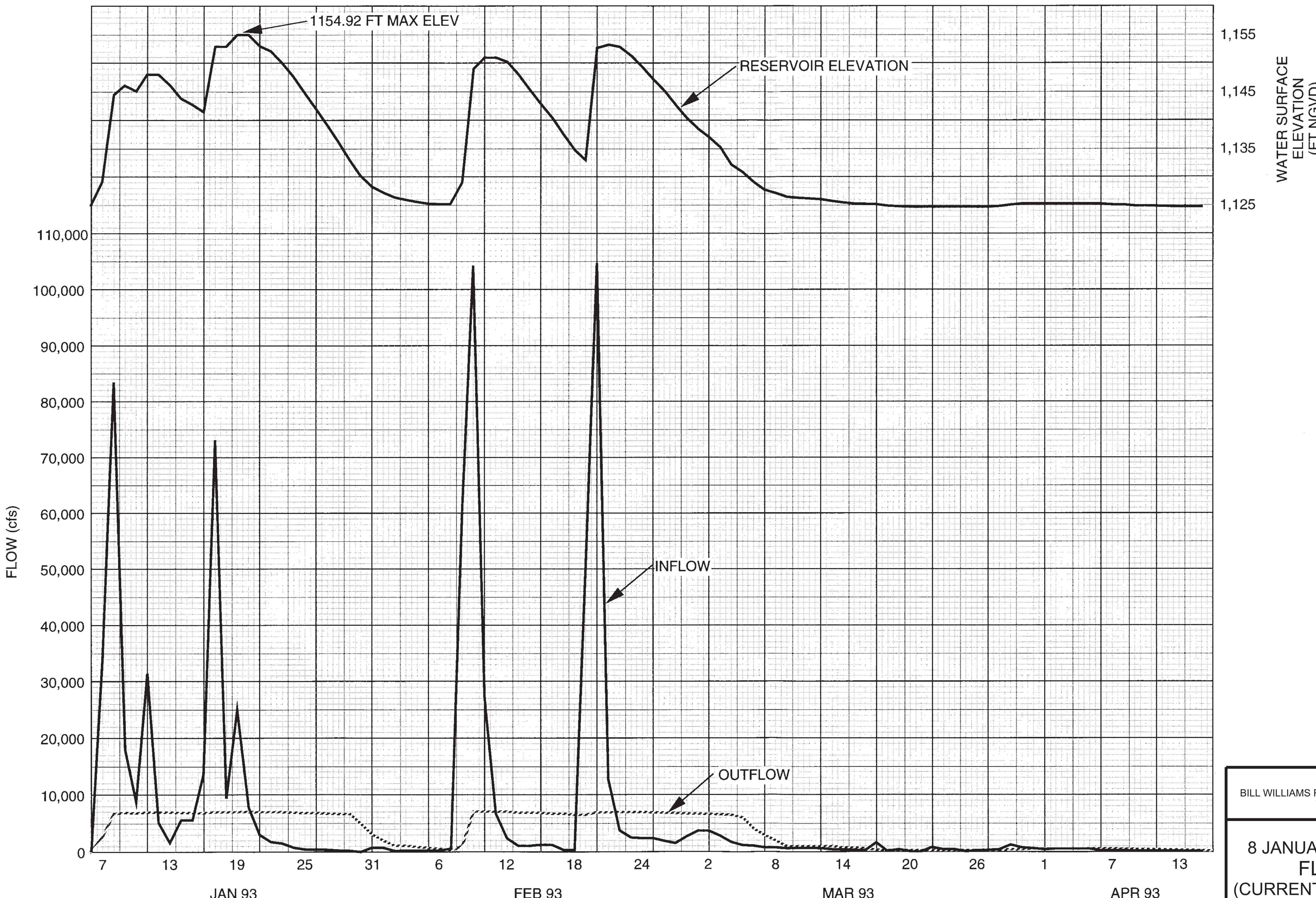
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

27 FEBRUARY - 4 MARCH 1983
FLOOD ROUTING
(CURRENT WATER CONTROL PLAN)

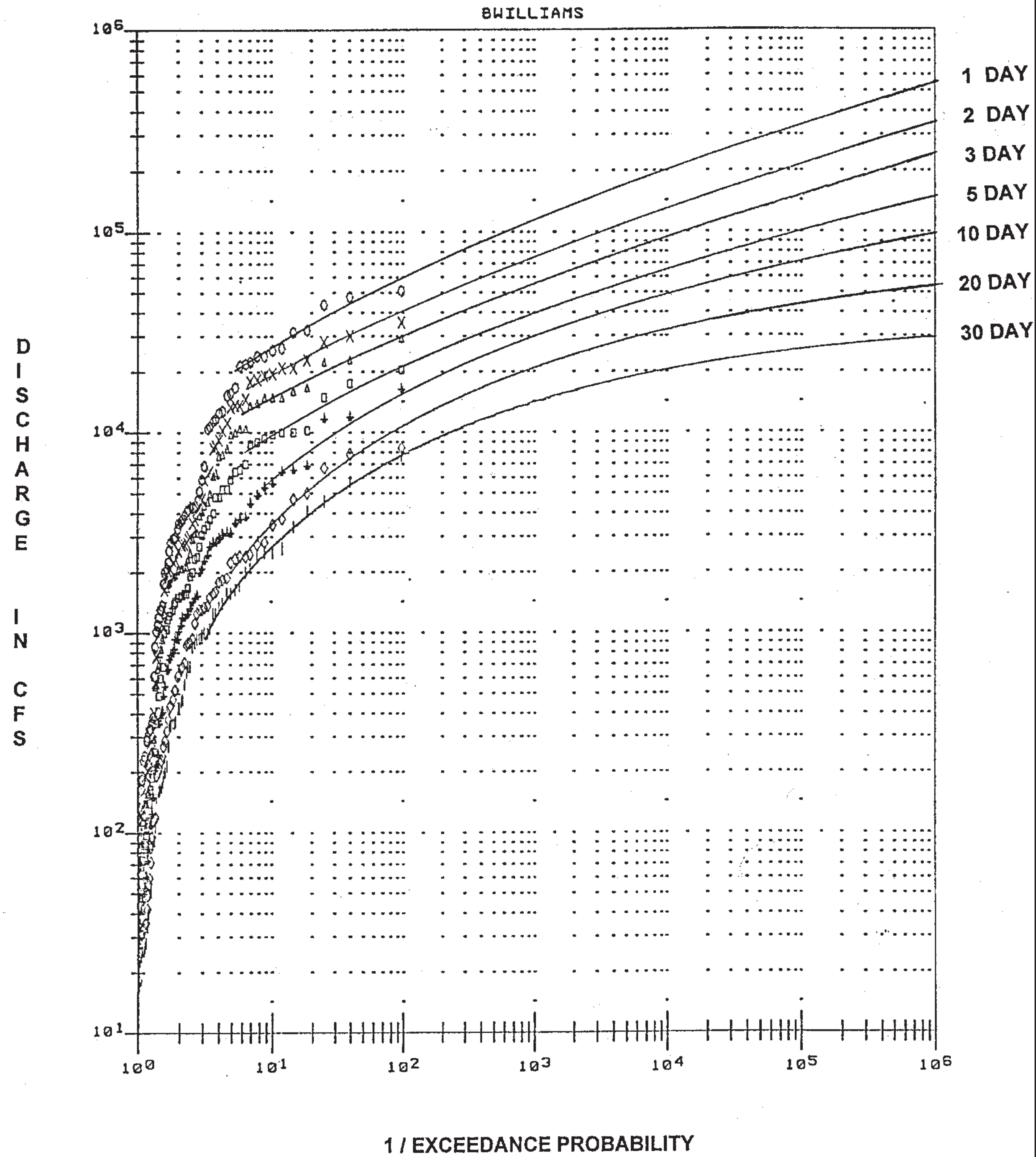
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

8 JANUARY - 28 FEBRUARY 1993
FLOOD ROUTING
(CURRENT WATER CONTROL PLAN)

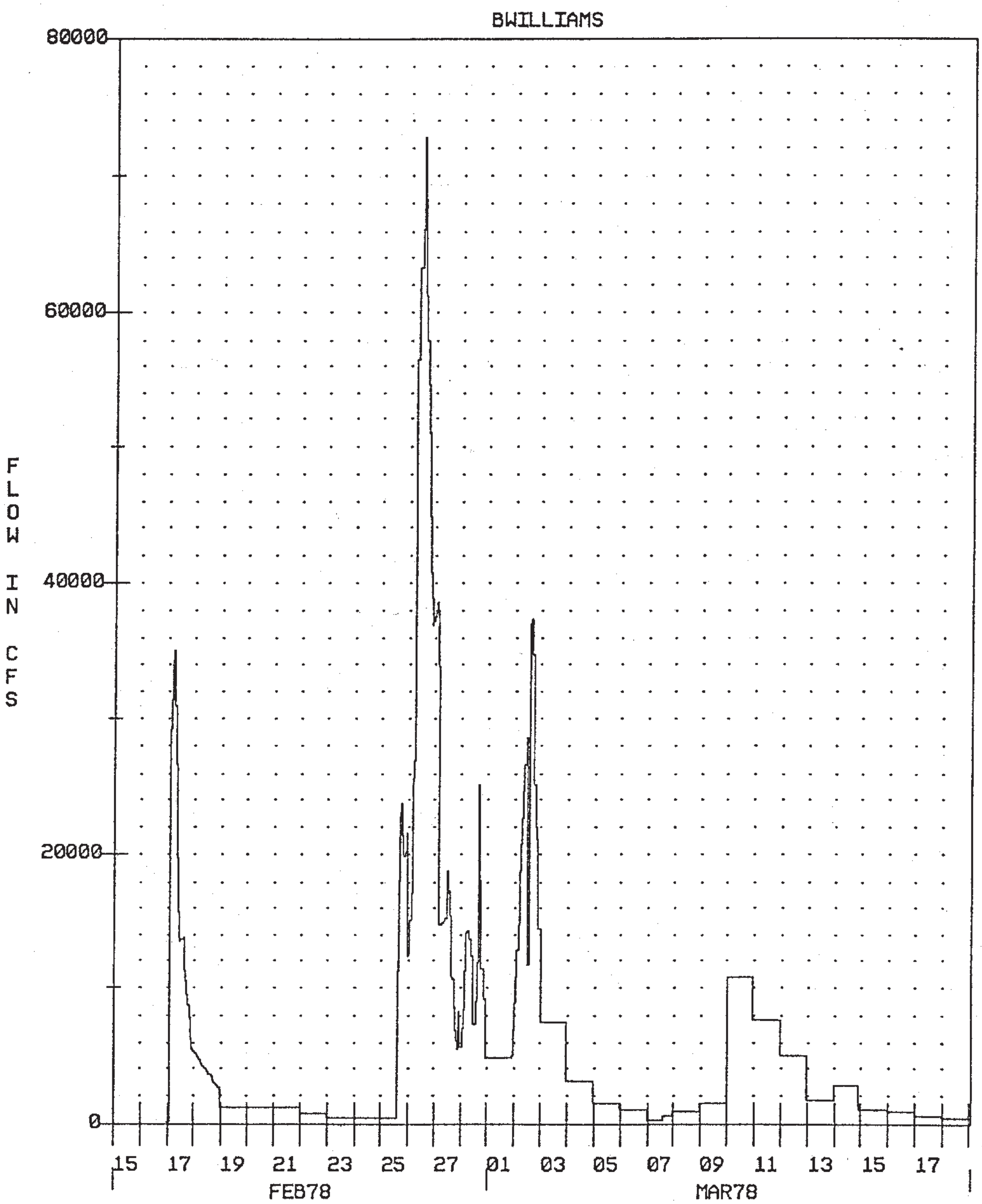
U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

RISK ASSESSMENT INFLOW VOLUME FREQUENCY CURVES

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

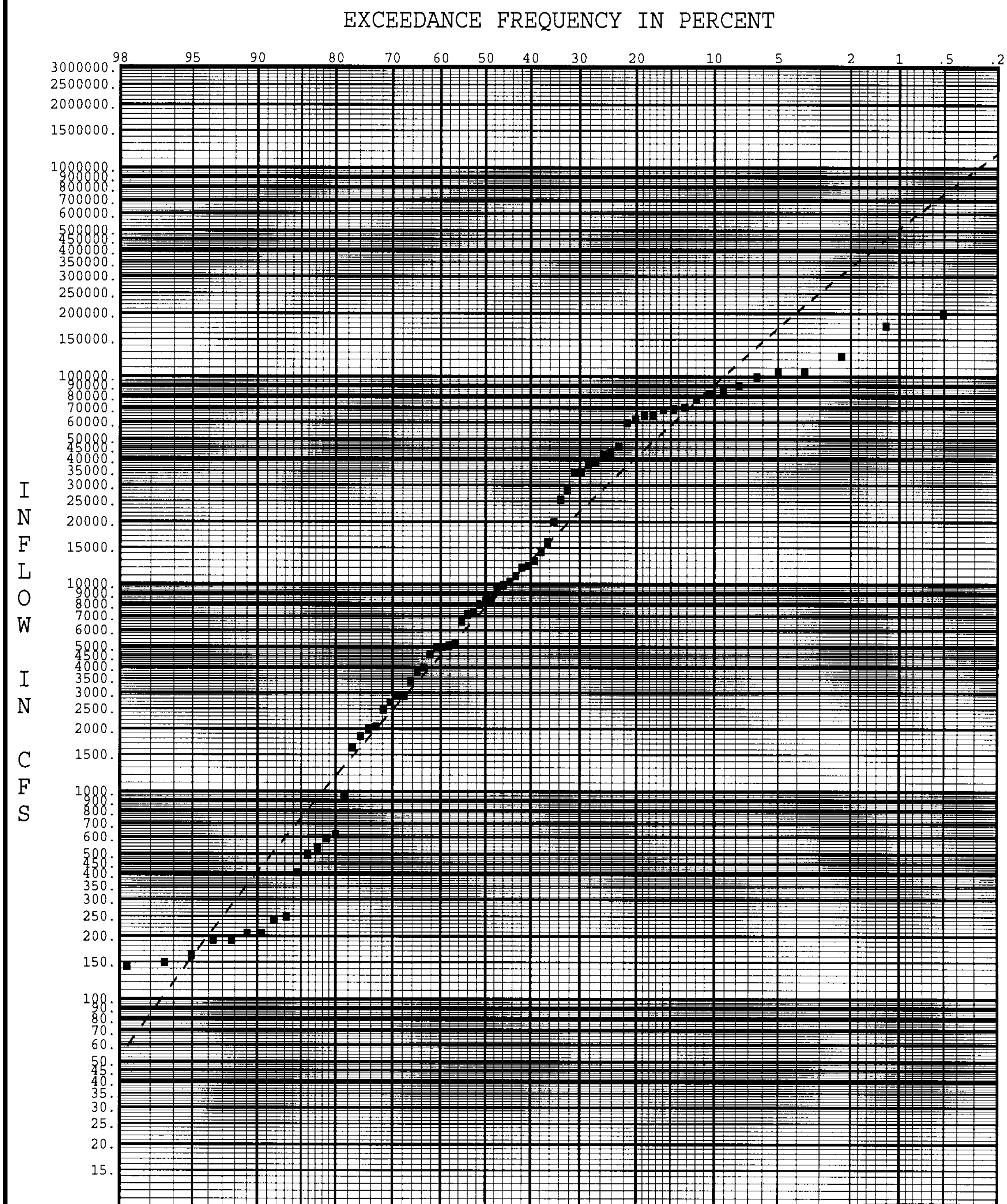


NOTE:
Information is from the Alamo Dam Risk Assessment Demonstration Study, dated 1998. The period of record spans from 1929 to 1998.

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

50-YEAR BALANCED HYDROGRAPH

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



--- INFL Frequency (with Exp. Prob.)

■ Median Plotting Positions

FREQUENCY STATISTICS

LOG TRANSFORM OF INFLOW	CFS	NUMBER OF EVENTS	
MEAN	3.8271	HISTORIC EVENTS	2
STANDARD DEV	.9061	HIGH OUTLIERS	0
SKEW	-.4171	LOW OUTLIERS	0
REGIONAL SKEW	-.4600	ZERO OR MISSING	0
ADOPTED SKEW	-.4000	SYSTEMATIC EVENTS	72
		HISTORIC PERIOD(1861-1999)	138

WATER YEARS IN RECORD: 1891, 1916, 1927, 1929-1999

BASIN DRAINAGE AREA: 4,770 SQUARE MILES

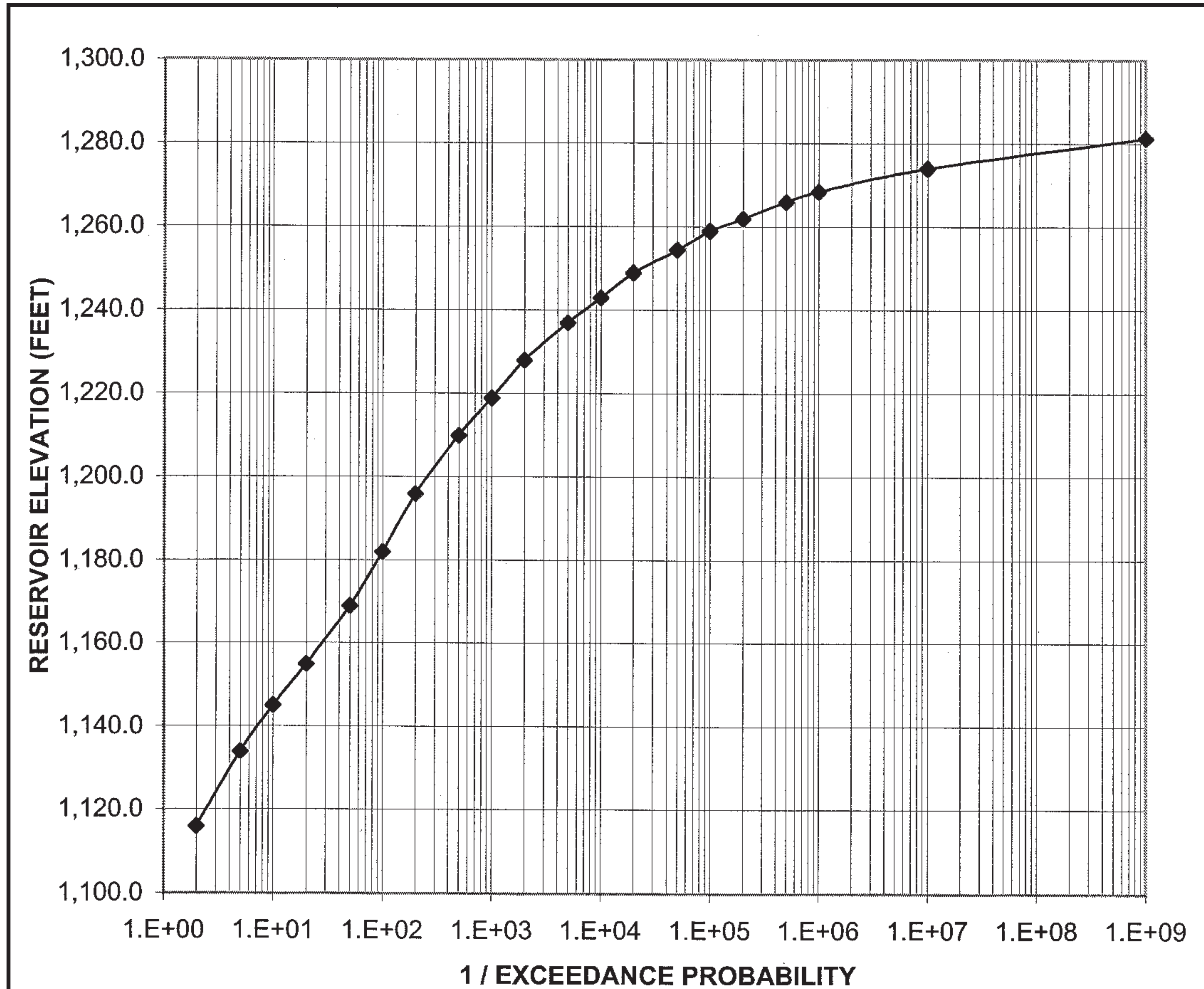
ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

PEAK ANNUAL INFLOW FREQUENCY

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

Alamo Dam Risk Assessment Demostration Study - 2000

Average Return Interval ARI (yr)	Annual Exceedance Probability AEP (%)	Maximum Reservoir Stage (feet)	Maximum Reservoir Outflow (cfs)
2	50	1,116.0	5,000
5	20	1,134.0	5,000
10	10	1,145.0	5,000
20	5	1,155.0	5,000
50	2	1,169.0	5,000
100	1	1,182.0	5,000
200	0.5	1,196.0	5,000
500	0.2	1,210.0	5,000
1000	0.1	1,219.0	5,000
2000	0.05	1,228.0	5,000
5000	0.02	1,237.0	7,000
10000	0.01	1,243.0	12,526
20000	0.005	1,249.0	21,311
50000	0.002	1,254.5	33,391
100000	0.001	1,259.0	45,510
200000	0.0005	1,262.0	53,560
500000	0.0002	1,266.0	68,188
1000000	0.0001	1,268.5	85,596
10000000	0.00001	1,274.0	157,107
1000000000	0.0000001	1,281.3	282,142



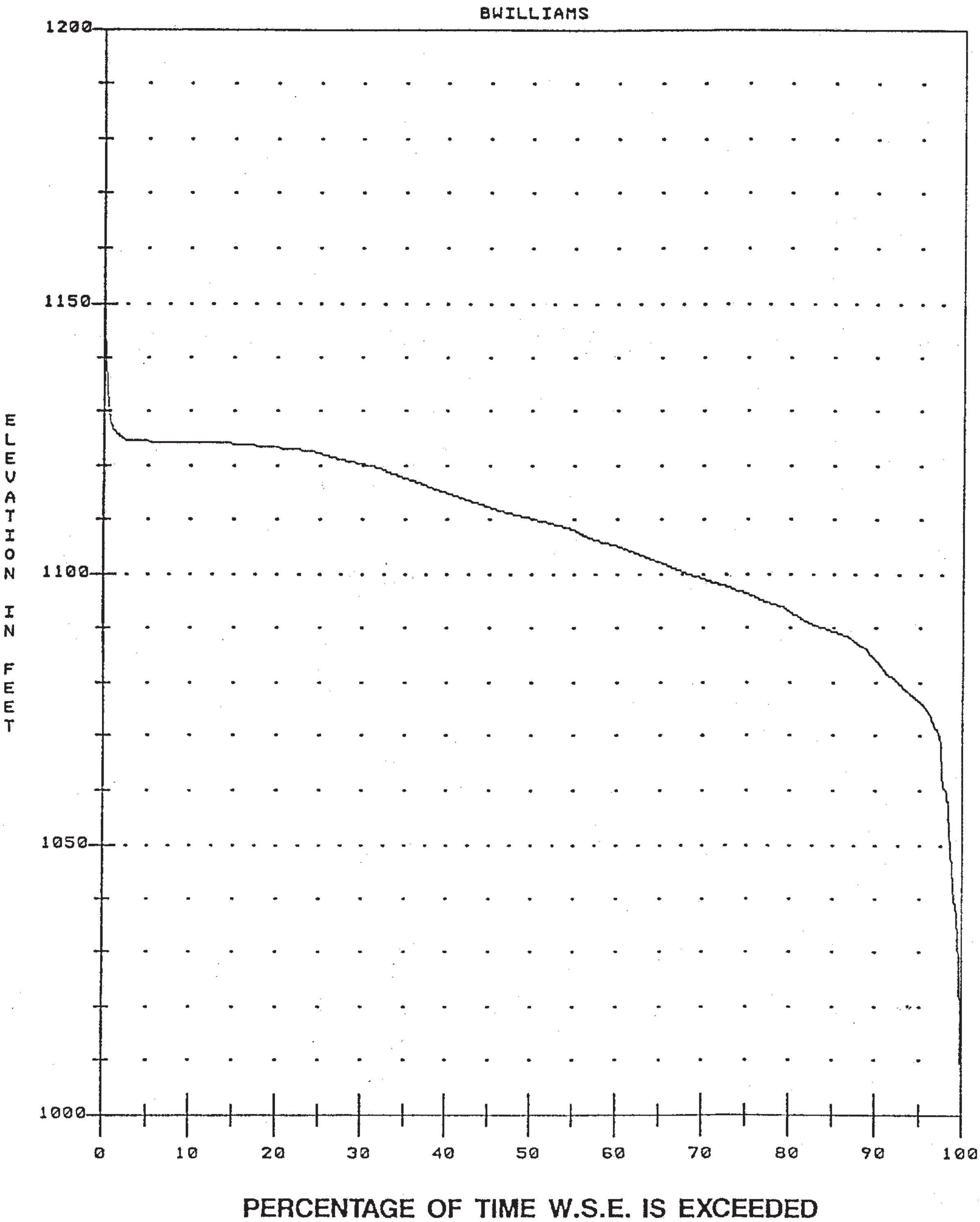
NOTES:

- Maximum reservoir outflow is a combination of discharge through the dam outlet works, spillway, and over or through the embankment (in the case of dambreak)
- Values assume no embankment failure regardless of extent of overtopping
- The period of record spans from 1929 to 1998.

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

RESERVOIR STAGE FREQUENCY AND OUTFLOW FREQUENCY RELATIONSHIPS FOR CURRENT WATER CONTROL PLAN

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT



NOTE:
Information is from the Alamo Dam Risk Assessment Demonstration Study, dated 1998. The period of record spans from 1929 to 1998.

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

ELEVATION-DURATION FREQUENCY CURVE

FOR PERIOD OF RECORD (1929-1998)

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

EXHIBIT A.

STANDING INSTRUCTIONS TO PROJECT OPERATOR (DAM TENDER) FOR WATER CONTROL

Exhibit A

Standing Instructions To The Project Operator For Water Control

Alamo Dam and Lake
Bill Williams River Basin

Lower Colorado River System

Los Angeles District Office
U.S. Army Corps Of Engineers

February 2002

EXHIBIT A

STANDING INSTRUCTIONS TO THE PROJECT OPERATOR

FOR WATER CONTROL

ALAMO DAM

1. BACKGROUND AND RESPONSIBILITIES

1.01 General Information.

(1) This exhibit is prepared in accordance with instructions contained in EM 1110-2-3600, paragraph 9-2, (Standing Instructions to Project Operators for Water Control), and ER 1110-2-240. The exhibit pertains to the duties and responsibilities of the Project Operator, in connection with the operation of Alamo Dam and the reporting of required hydrologic data.

Operational instructions to the project operator are outlined with specific emphasis on flood emergencies when communication facilities between the project operator and the Reservoir Operation Center (ROC) have been disrupted. This exhibit is designed to be used independently as a flood control guide or in conjunction with the rest of the water control manual. To facilitate independent use of this exhibit, a chart required for normal and emergency flood control operation of Alamo Dam is included. This chart is shown on Plate A-01.

The project operator is required to have available at the dam site, this exhibit and other manuals that complement these standing instructions. These manuals are: The current year's "Instructions for Reservoir Operations Center Personnel" (the "Orange Book") and the "Operation and Maintenance Manual for Alamo Dam". Any deviation from the Standing instructions will require the approval of the District Commander.

(2) The authorized purposes of Alamo Dam and Lake are flood control, water conservation, recreation, and fish and wildlife conservation.

(3) Reservoir operations at Alamo Dam and other Corps of Engineers facilities are conducted by the Reservoir Regulation Unit of the Reservoir Regulation Section of the Los Angeles District. Plate A-02 is an organizational chart depicting the chain of command for the reservoir operation decisions.

(4) Alamo Dam is located on the Bill Williams River, 39 miles upstream from its confluence with the Colorado River at Lake Havasu. The dam is on the border of the La Paz and Mohave Counties, Arizona, about 2.5 miles downstream from the Alamo Crossing (Refer to Plate 2-01 in the Water Control Manual). Main access is from the town of Wenden, on U.S. Highway 60, approximately 36 miles south of the reservoir. The geographic coordinates of the dam are 34°13’55”N latitude and 113°36’29”W longitude.

Alamo Dam is a zoned earthfill embankment structure with a detached spillway located in the right abutment. The outlet works, located near the left abutment of the dam, consist of a concrete-lined tunnel 12 feet in diameter, and 3 pairs of slide gates installed in tandem.

(5) Major constraints and issues concerning operation of Alamo Dam are 1) downstream streambed crossing inundation, and 2) hydrogen-sulfide in the outlet works gate chamber.

(6) Alamo Dam is owned, operated, and maintained by the U.S. Army Corps of Engineers, Los Angeles District, which has complete regulatory responsibility.

1.02 Role of the project Operator.

(1) Normal Conditions (Dependent Day-to-Day Instructions).

The Project Operator (dam tender) will be directed by the Reservoir Operations Center (ROC), as necessary, for water control actions under normal hydrometeorological conditions. The Project Operator is responsible for the project works to ensure that all the equipment is in good operating condition, and that the gates and electrical facilities in the control house are periodically inspected and tested according to the pre-established schedule.

(2) Emergency Conditions (Flood or Drought).

The Project Operator will be directed by the ROC for water control actions during flood events and other emergency conditions. The Project Operator responsibilities are:

1) Be present at the Dam when rainfall or runoff occurs, as instructed by the Operations Branch.

2) Operate the gates in accordance with instruction from the ROC.

3) Notify the ROC when a gate change will be required according to Plate A-01, Alamo Dam Reservoir Regulation Schedule.

4) Notify the ROC if unable to set the gates as instructed.

5) Follow the Water Control Diagram provided in Plate A-01 in this exhibit during any period of extended communication (longer than 24 hours) disruption. During short-term communication (less than 24 hours) disruptions, follow the most recent instructions

from the ROC. Make every possible effort to re-establish communications with the ROC before undertaking any independent action.

6) Assist engineers dispatched by the ROC during flood emergencies in every way possible.

7) Maintain routine records such as water surface elevation, outflow gate heights, precipitation amounts, gate openings, and a daily log on prescribed forms.

8) Notify local authorities and interested agencies of anticipated releases from the reservoir when instructed to do so by the ROC or if communications are interrupted.

9) Obtain hydrologic and hydraulic data from other agencies upon request of the ROC.

2. DATA COLLECTION AND REPORTING.

2.01 Normal Conditions.

During normal operations, the following items are recorded by the Project Operator on a daily basis: reservoir water surface elevation (both staff and tape readings), the gage height from USGS Gage No. 09426000 (both staff and tape readings), incremental precipitation, the hook gage reading (used to compute reservoir evaporation), gate settings, flow through the 18-inch low flow valve, and current, minimum and maximum daily evaporation pan temperatures.

The Project Operator maintains the record of measurements and logs all radio and telephone communication on the following forms: Flood Control Basin Operation Report (SPL 19) prepared by each Project Operator; Rainfall Record (SPL 31) from manual glass readings of glass tube rain gages; and Record of Calls (SPL 188) for both radio and telephone communiqués. Examples of these forms are shown on Figures A-1, A-2, and A-3, respectively.

2.02 Emergency Conditions.

During flood operations the Project Operator should follow instructions, as issued by the ROC. Measurements of the reservoir water surface and USGS gage readings may be required at a specified time interval.

When reporting to the ROC, the Project Operator should clearly describe any wave action on the reservoir water surface, and any silt and debris situation at the downstream gage. When instruments are not working or are stuck in silt, the Project Operator should not report the erroneous reading, but should rather state the instrument or staff problem.

2.03 Regional Hydrometeorological Conditions.

The Project Operator will be informed by the ROC of regional hydrometeorological conditions that may impact the project.

3. WATER CONTROL ACTION AND REPORTING.

3.01 Normal Conditions.

During normal hydrometeorological conditions, the Project Operator will be instructed by the ROC for the appropriate water control action. The Project Operator should:

(1) Establish communication with the ROC.

(2) Implement instructions.

(3) Notify the ROC on the status of the water control action.

The Project Operator may not independently implement any gate change, even if the change will have no effect on the reservoir operation. The Project Operator may request gate-setting changes (e.g. for purposes of maintenance), however, they need to be approved in advance by the ROC.

3.02 Emergency Conditions.

During emergency conditions, the Project Operator will be instructed by the ROC to take the necessary water control action. During flood conditions, the Project Operator will be instructed by the ROC for upcoming gate changes. The Project Operator should:

(1) Establish communication with the ROC.

(2) Implement the instructions.

(3) Notify the ROC on the status of the water control action.

(4) If communications are disrupted between the ROC and the Project Operator, the Project Operator must follow the procedures in step 5) of Section 1.02(2) within this Exhibit.

3.03 Inquiries.

All significant inquiries received by the Project Operator from citizens, constituents or interested groups regarding water control procedures or actions must be referred directly to the ROC, without attempting to answer such inquiries.

3.04 Water Control Problems.

The ROC must be contacted immediately by the most rapid means available in the event that an operational malfunction, erosion, or other incident occurs that could impact project integrity, in general, or water control capability, in particular.

Emergency departures from the regulation instructions issued by the ROC may be required, because of water control equipment failures, accidents, or other emergencies requiring immediate action. Under these situations, the Project Operator should contact the ROC via radio or telephone for instructions. When communications are broken, or the situation demands immediate action, the Project Operator may proceed independently. The ROC should be notified of such action as soon as possible. All other non-emergency deviations from procedures covered by this water control manual must be approved in advance by the Division Engineer, South Pacific Division, U.S. Army Corps of Engineers.

The Project Operator should immediately alert the ROC whenever a requested gate change cannot be fully implemented due to mechanical or physical problems. The ROC will evaluate the problem and provide further instructions to the Project Operator.

3.05 Communication Outage.

The ROC maintains close contact with the Project Operator at Alamo Dam. During flood periods, communication between the Project Operator and ROC may break down. The project Operator should try to re-establish communication through the radio network or by any other means available.

If the Project Operator is unsuccessful in re-establishing communications with the ROC, the Project Operator should not make any changes in gate settings for 24 hours, should the communication outage last that length of time, or longer.

Emergency notifications are normally made by the ROC. However, if the Project Operator loses communication with the ROC and an emergency notification situation arises, such as an imminent dam failure or spillway flow, the Project Operator should make the necessary notifications, if possible. The emergency evacuation notification list is contained in the "Instructions for Reservoir Operations Center Personnel" (the "Orange Book"). The notifications should include:

(1) description of the type and extent of existing or impending emergency.

(2) advisement for evacuation from the flood plain.

(3) information on the time of initial release of hazardous amounts of water.

(4) the reservoir water surface elevation

(5) the project Operator's name and telephone number.

Upon completing the above notifications, attempt to re-establish communications with the ROC. Document all notifications made, and refer to the "Orange Book" for more information on additional emergency notifications. The Project Operator should be not leave the dam unless his/her safety is in jeopardy. The Project Operator's safety is presumed to be in jeopardy if the reservoir water surface elevation rises above 1259.6 feet.

U. S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS

FLOOD CONTROL BASIN OPERATION REPORT

Name **Month** **Year**

Day	Reservoir W.S. Elev			Outlet channel		Gate operation																	OPERATOR
	Time	Type of Gage	Gage reading in feet	Time	Gage height in feet	Time	Gate opening in feet																
							No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16	

REMARKS: Bypass flow in c.f.s.

FIGURE A-1

RAINFALL RECORD

STATION					☐ HOURLY ☐ DAILY		DATE
HR	DAY	TIME OF READING	GAGE READING	STORM TOTAL	SEASON TOTAL	OBSERVER	REMARK (SNOW, TEMP, ETC.)
0000	1						
0100	2						
0200	3						
0300	4						
0400	5						
0500	6						
0600	7						
0700	8						
0800	9						
0900	10						
1000	11						
1100	12						
1200	13						
1300	14						
1400	15						
1500	16						
1600	17						
1700	18						
1800	19						
1900	20						
2000	21						
2100	22						
2200	23						
2300	24						
2400	25						
	26						
	27						
	28						
	29						
	30						
	31						
TOTAL							

SPL FORM 31
OCT 66

FIGURE A-2

RECORD OF CALLS ☐ Radio ☐ Telephone						Date
Local Time	From		To		Check Repeatable calls	Message or Remarks
	Person and/or Call Sign	Telephone and City	Person and/or Call Sign	Telephone and City		

*Reportable telephone calls include collect calls, charge calls and long distance calls that can not be dialed without a code number.

FIGURE A-3

Release Schedule

Lake Water Surface Elevation (ft, NGVD)	Spillway Discharge (cfs)	Use Non-Spillway Flow Transfer Option		
		Outlet Works Discharge (cfs)	Total Discharge (cfs)	Recommended Gate Setting (ft)
1250 - 1265[1]	15,625 - 56,000	9,198	24,604 - 65,198	6.8
1244.3 - 1250	7,000 - 15,625	8,979	15,899 - 24,604	6.8
1244.3	7,000	8,874	15,899	6.8
1244	6,650	8,869	15,519	6.8
1243	5,400	8,850	14,250	6.8
1242	4,350	8,832	13,182	6.8
1241	3,300	8,814	12,114	6.8
1240	2,500	8,795	11,295	6.8
1239	1,700	8,779	10,479	6.8
1238	1,200	8,763	9,963	6.8
1237	700	8,747	9,447	6.8
1236	350	8,731	9,081	6.8
1235 (Spillway crest)	0	8,715	8,715	6.8

	Discharge (cfs)	Recommended Gate Setting (ft)
1148.4[2] - 1235	7,000	6.80 - 5.0 (3 gates)
1132 - 1148.4	6,621[3] - 7,000	6.80 (3 gates)
1131 - 1132	6,000	5.75 (3 gates)
1130 - 1131	5,000	4.65 (3 gates)
1129 - 1130	4,000	3.65 (3 gates)
1128 - 1129	3,000	2.70 (3 gates)
1127 - 1128	2,000	1.75 (3 gates)
1126 - 1127	1,000	1.30 (2 gates)
1125 - 1126	Transition up to 1,000 cfs	0 - 1.3 (2 gates)

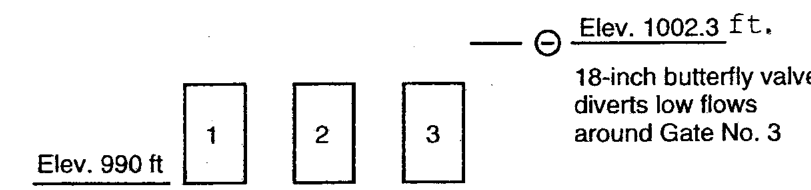
	Oct 1 - Nov 1	Nov 1 - Feb 1	Feb 1 - May 1	May 1 - Oct 1
1100 - 1125 [4]	40 cfs	25 cfs	40 cfs	50 cfs
1070 -1100 [4]	15 cfs	10 cfs	25 cfs	25 cfs
990 - 1070	10 cfs	10 cfs	10 cfs	10 cfs

Season of Year applies to riparian base flows only (shaded area). [4, 5]

Maximum Rate of Release Increase

Release Range (cfs)	Rate of Increase (cfs/hr)
0 - 500	250
500 - 1,000	500
1,000 - 3,000	1,000
3,000 - 7,000	2,000

OUTLET WORKS DIAGRAM
(Looking Downstream)



All outlet gates 5.5 ft W x 8.5 ft H

When service gates are in use, butterfly valve is closed

Notes:

1. Top of dam.
2. Minimum elevation at which 7,000 cfs can be released (3 gates at 6.80 feet opening).
3. Maximum outflow at elevation 1132 feet (3 gates at 6.80 feet opening).
4. Riparian release shown in shaded area that are above 10 cfs are maximum. Smaller releases can be made with agreement by the Bill Williams River National Wildlife Refuge Manager.
5. Riparian releases could be temporarily interrupted to allow inspection and/or maintenance. Compensatory releases should be made to maintain the scheduled daily average release rate. Coordination with the resource agencies and other interested parties should be made.

General Notes:

1. Project Operator is to maintain the last gate settings provided by the Reservoir Operations Center (ROC) for a period of 24 hours following loss of communication with the ROC. If Project Operator is unable to reestablish communication with the ROC for 24 hours, then the Project Operator shall use this reservoir operation schedule for project gate settings.

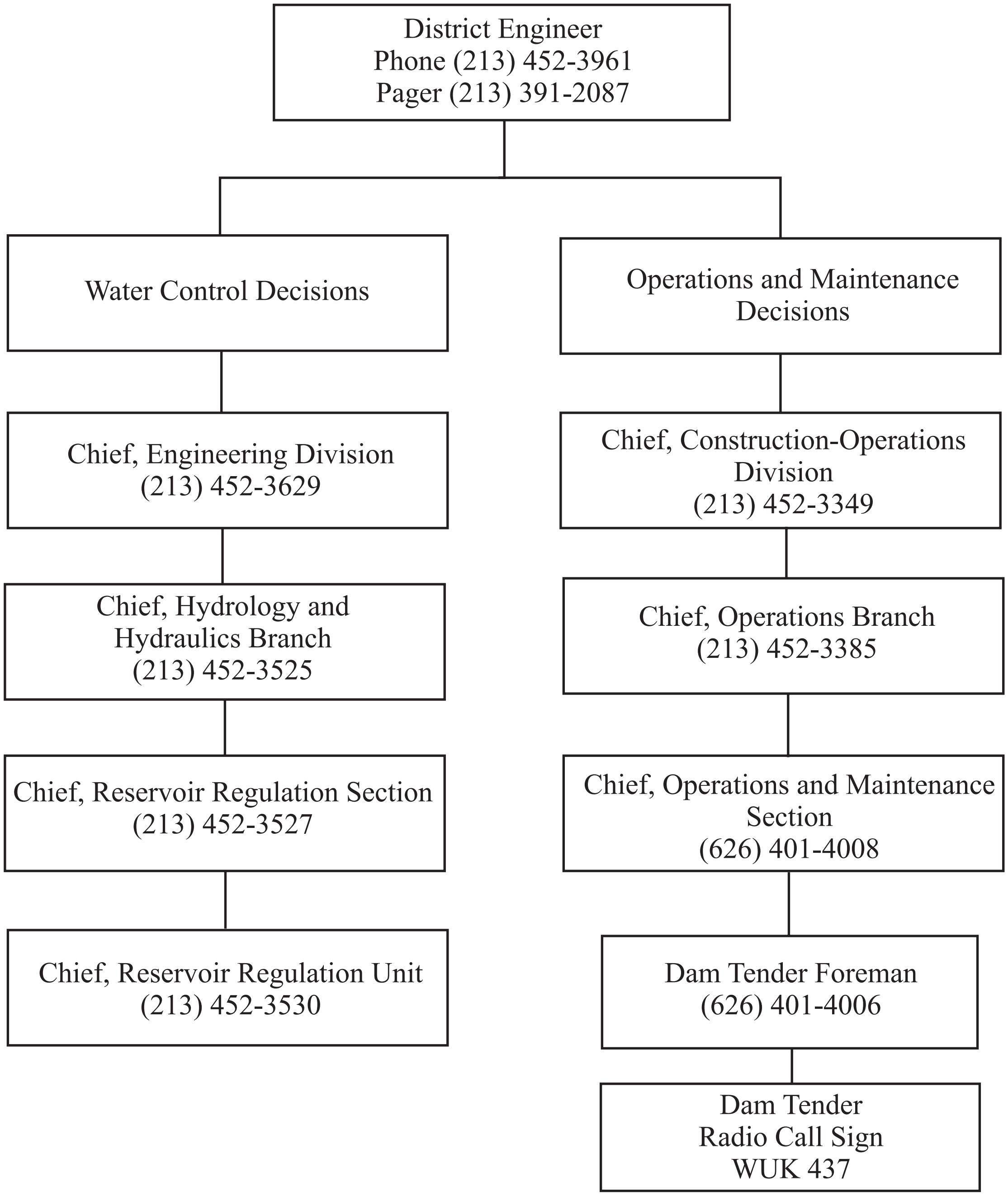
2. **When reservoir water surface exceeds elevation 1259.6 feet, Project Operators are to leave dam for their safety.**

ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

RESERVOIR OPERATION SCHEDULE
(DURING LOSS OF COMMUNICATION BETWEEN ROC AND DAMTENDER)

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

U.S. Army Corps of Engineers
Los Angeles District



ALAMO DAM AND LAKE
BILL WILLIAMS RIVER, COLORADO RIVER BASIN, ARIZONA
WATER CONTROL MANUAL

CHAIN OF COMMAND FOR RESERVOIR OPERATION DECISIONS

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

EXHIBIT B.

PERTINENT DATA FOR OTHER DAMS
AFFECTING ALAMO DAM AND LAKE OPERATION

EXHIBIT B

HOOVER DAM AND LAKE MEAD
COLORADO RIVER
PERTINENT DATA

COLORADO RIVER DRAINAGE AREAS

Location	Drainage Areas (sq mi)[1] Total	Incremental
Glen Canyon Dam	107,740	
Lee Ferry[2]	108,040	300
Hoover Dam	167,740	59,700
Davis Dam	169,340	1,600
Parker Dam	178,740	9,400
Imperial Dam	184,540	5,800
Southerly International Boundary	242,740	58,200

Notes:
1. USGS Water Resources Data less 3,959 square miles in Great Divide Basin.
2. Compact Point

REPRESENTATIVE STREAMFLOWS AND VOLUMES AT HOOVER DAM

Mean Annual Natural Runoff (1906-80) ....15,135,000 ac-ft
Maximum Mean Daily Recorded Inflow[1] ....220,000 cfs
Standard Project Rain Flood
Maximum Mean Daily Inflow ....112,000 cfs
Total Volume ....1,079,000 ac-ft
Probable Maximum Rain Flood
Maximum Mean Daily Inflow ....194,600 cfs
Total Volume ....2,760,000 ac-ft
Probable Maximum Snowmelt Flood
Maximum Month... 14,800,000 ac-ft
Total Volume, Jan-Aug .... 25,900,000 ac-ft

NOTES:
[1]Colorado River near Grand Canyon, June 19, 1921.

DESCRIPTIVE DATA

DAM

Type ....Concrete Gravity - Arch
Crest Elevation ....1232 ft
Parapet Elevation ....1236 ft
Structural Height ....726.4 ft
Crest Length ....1244 ft
Crest Width...45 ft
Freeboard Above Maximum
Design Flood Pool...3 ft

SPILLWAY

Description Two side-channel, gated spillways discharging through 50-ft dia. concrete lined tunnel through abutments, one on each side.
Total Crest Length ....800 ft
Gates
Description Four floating drum gates on each spillway activated by filling float chambers.
Length, Each...100 ft
Maximum Height...16 ft

POWERPLANT

Operating Head ....440 to 590 ft
Number of Units 19
Capacity (1980 Configuration) .... 1345 MW
Penstocks[1] Two 30-ft dia. steel conduit through concrete lined tunnels each abutment.

OUTLETS AND POWER PENSTOCKS

Intakes
Description Four towers, two near each abutment, one each for river outlets and power penstocks.
Sill Elevations ....lower 895 ft
....upper 1045 ft
Gates ....Two 32-ft dia. gates in each tower

RIVER OUTLETS

Conduits Two 30-ft dia. steel conduits in concrete lined tunnels, one on each side[1].
Valves Four 72-inch dia. needle valves on each conduit, each with an emergency ring-follower type gate immediately upstream.
Centerline Elevation of Valves (Nevada)..........................653.88 ft
(Arizona) ....652.92 ft

CANYON WALL OUTLETS

Conduit Two 30-ft dia. steel conduits in 37-ft dia. concrete lined tunnels, one through each abutment[1].
Valves Two 84-inch diameter needle valves on each penstock, each w/an emergency ring-follower type gate immediately upstream.
Centerline Elevation of Valves .... 820.0 ft

NOTES:
[1]30-ft dia. conduits used for both power penstocks and river and canyon wall releases.

AREA, STORAGE AND DISCHARGES AT CRITICAL POOL ELEVATIONS

Point	Elevation (ft)	Area (1000 ac)	Storages (1000 ac-ft) Total[2] Active	Incremental Active	Below Maximum Design Pool	Maximum Discharge (cfs) Maximum Power Plant[3]	Canyon Wall Outlets[4]	River Outlets[4]	Spillway Gates Up	Spillway Gates Down
Top of Dam	1232	—	—	—	—	—	—	—	—	—
Maximum Design Flood Pool	1229	162.7	27377	340	0	—	16000	28500	65000[5]	335000
Spillway Discharge @ 40,000 cfs Channel Capacity	1226.9	162±	27037	878	340	33500	16000	28400	40000	292000
Top of Raised Spillway Gates	1221.4	157.9	26159	282	1218	34000	16000	28100	0	184000
Minimum Required Flood Control Pool	1219.6	157±	25877	2169	1500	34100	16000	28300	—	154000
Permanent Spillway Crest	1205.4	148±	23708	1681	3669	35200	15900	27900	—	0
Maximum Required Flood Control Pool	1193.8	140±	22027	12003	5350	35700	15800	27500	—	—
Minimum Power Pool	1083	83±	10024	10024	17353	38000	14300	24500	—	—
Dead Storage	895	29±	2378	—	27377	—	0	0	—	—

Notes:
[1]Elevations refer to mean sea level datum.
[2]Exclusive of dead storage except as indicated.
[3]1980 configuration.
[4]With all turbines operating.
[5]Gates designed to release inflow to 400,000 cfs.

EXHIBIT B

DAVIS DAM AND LAKE MOHAVE
COLORADO RIVER, NEVADA-ARIZONA

PERTINENT DATA

Type of dam .... Zoned earthfill
Stream system .... lower Colorado River
Completion date .... January 1950

Reservoir .... Lake Mohave
Total capacity to elevation 647 feet (Ac-Ft) 1,818,000
Active capacity, elevation 533.39 feet (Ac-Ft) 1,810,000
Surface area (Acres) 28,200

Dimensions of Dam
Structural height (Feet) 200
Hydraulic height (Feet) 140
Top width (Feet) 50
Maximum base width (Feet) 1,400
Crest length (Feet) 1,600
Crest elevation (Feet) 655
Total volume of dam (Cu-Yd) 3,642,000

Spillway
Type: Concrete ogee weir, controlled by three 50- by 50-foot fixed wheel gates.
Elevation, top of gates (feet) 647
Crest elevation (feet) 597
Capacity at elevation 647 feet (CFS) 214,000

Outlet Works
Type: Two 22- by 19-foot tainter gates, one on each side of spillway section.
Capacity at elevation 610 feet (CFS) 43,400

PARKER DAM AND LAKE HAVASU
COLORADO RIVER, CALIFORNIA-ARIZONA

PERTINENT DATA

Type of dam .... Concrete arch
Stream system .... lower Colorado River
Completion date .... July 1938

Reservoir .... Lake Havasu
    Total capacity to elevation 450 feet (Ac-Ft) 648,000
    Available capacity, elevation 400-450 feet (Ac-Ft) 180,000
    Surface area (Acres) 20,400

Dimensions of Dam
    Structural height (Feet) 320
    Hydraulic height (Feet) 75
    Top width (Feet) 39
    Maximum base width (Feet) 100
    Crest length (Feet) 856
    Crest elevation (Feet) 455
    Total volume of dam (Cu-Yd) 380,000

Spillway
    Type: Overflow section at center of dam controlled by five 50- by 50-foot Stoney gates.
    Elevation, top of gates (feet) 450
    Crest elevation (feet) 400
    Capacity at elevation 455 feet (CFS) 400,000

Outlet Works
    Type: Four 22-foot-diameter steel penstocks through right abutment, each controlled by one 22- by 35-foot fixed wheel gate.
    Capacity at elevation 450 feet (CFS) 22,300

PAINTED ROCK DAM AND RESERVOIR
MARICOPA COUNTY, ARIZONA
PERTINENT DATA

Construction Completed		January 18, 1960
Stream System		Gila River
Drainage Area (Gila River Basin excluding Willcox and Animas closed drainages)	sq. mi.	50,800
Reservoir		
Elevation		
Streambed at Dam	ft., msl	524
Spillway Crest	ft., msl	661
Spillway Design Surcharge Level (Max. Water Surface)	ft., msl	696.3
Top of Dam	ft., msl	705
Area		
Spillway Crest	acres	51,400
Spillway Design Surcharge Level (Max. Water Surface)	acres	81,600
Top of Dam	acres	90,000
Capacity, gross		
Spillway Crest (Flood Control)	ac-ft	2,492,000
Spillway Design Surcharge Level (Max. Water Surface)	ac-ft	4,834,000
Top of Dam	ac-ft	5,575,000
Allowance for Silting (Sedimentation)	ac-ft	200,000
Dam (Rolled Earth-fill)		
Height Above Original Streambed	ft., msl	181
Crest Length	feet	4,450
Crest Width	feet	20
Design Freeboard	feet	8.7
Saddle Dike (Right)		
Crest Length	feet	200
Height	feet	12
Saddle Dike (Left)		
Crest Length	feet	500
Height	feet	50
Spillway (Detached, Broadcrest)		
Crest Length	feet	610
Design Surcharge on Spillway Crest	feet	35.3
Discharge at Spillway Design Surcharge	cfs	398,800
Master Plan	cfs	401,700
Outlet Works		
Controlled		
Length of Approach Channel (Trapezoidal, Unlined)	feet	150
Entrance Invert Elevation (Gate Sill Elevation)	ft., msl	53[illegible]
Number of Intake Gates (Tainter, Size-10' X 18')	each	[illegible]
Length of Transition Section (Gates to Outlet Conduit)	feet	123
Conduits (Circular)		
Number of Conduits	each	1
Size (Inside Diameter)	feet	25
Length	feet	925
Maximum Discharge at Spillway Crest	cfs	30,480
Regulated Discharge at Spillway Crest	cfs	22,500
Outlet Invert Elevation	ft., msl	519.8
Reservoir Design Flood		
Duration (Inflow)	days	18
Total Volume of Design Flood (Std. Proj. Flood)	ac-ft	2,800,000
Flood Volume over 22,500 cfs.	ac-ft	2,200,000
Inflow Peak	cfs	300,000
Controlled Outflow (Max. Avg. Outflow Capacity)	cfs	22,500
Reduction in Peak	cfs	227,500
Time to Drain Reservoir from Maximum WSE	days	70
Spillway Design Flood		
Length of Design Flood	days	18
Total Volume in 18 Days (Max. Probable Flood)	ac-ft	7,680,000
Inflow Peak	cfs	620,000
Outflow Peak	cfs	436,500
Reduction in Peak	cfs	183,500

EXHIBIT C.

RECORD OF DECISION

EXHIBIT C

RECORD OF DECISION
ALAMO LAKE
LA PAZ AND MOHAVE COUNTIES, ARIZONA

I have reviewed the Army Corps of Engineers Feasibility Report and Environmental Impact Statement (FR/EIS) for Alamo Lake, Arizona, dated April 1999 addressing the need for modification of the existing Alamo Lake project, Bill Williams River, La Paz and Mohave Counties, Arizona. Based on this review and the views of interested agencies and the concerned public, I find the modified operation plan recommended in the feasibility report to be technically sound, economically justified, in accordance with environmental statutes and in the public interest. Thus, I approve the recommended operation plan, known as the 1,125-foot plan, for implementation. The operation plan was authorized by Section 301(b) of the Water Resources Development Act of 1996. The purpose of the operation plan is to provide fish and wildlife benefits both upstream and downstream of Alamo Dam. This operation plan, which is also the national economic development plan, consists of the following:

- Managing Alamo Lake for a target surface elevation of 1,125 feet.
- Providing a base flow downstream of 25 cubic feet per second (cfs) from November to January and 40 – 50 cfs the remainder of the year.
- When lake levels exceed 1,125 feet, making releases that mimic pre-dam flood events with short duration high flows followed by long recessions.
- When lake levels are below 1,125 feet, making releases adequate to satisfy downstream water rights and support riparian habitat.
- Approximately every 5 years, drawing down the pool slowly, beginning in June, to 1,100 feet for inspection and maintenance of the outlet tunnel in October/November.

In addition to the no action alternative, thirteen operational scenarios were screened down to a final array of three alternatives. The final three alternatives focused on target lake water surface elevations of 1,125 feet, 1,100 feet (the existing operation and no action plan), and 1,070 feet. Each alternative was evaluated on its impact on the authorized flood control, recreation and water conservation project purposes and on fisheries and wildlife resources. These alternatives are fully discussed in the FR/EIS. Of the alternative plans considered, the 1,125-foot plan was selected because it provides the highest level of downstream riparian habitat restoration and the highest net economic development benefit while preserving the existing flood control storage, recreation resources, and wildlife habitat upstream from the dam.

The selected plan is the environmentally preferred alternative. All practicable means to avoid or minimize adverse environmental effects have been incorporated into the selected plan. There will be no significant adverse effects on environmental resources resulting from implementing the modified operating plan; consequently, no environmental mitigation is required.

The recommended operation plan is in compliance with applicable environmental requirements. Recommendations made by the U.S. Fish and Wildlife Service (USFWS) and the Arizona Game and Fish Department have been incorporated into the plan. Consultation under the Endangered Species Act for the bald eagle and the southwestern willow flycatcher has been completed. The USFWS has rendered a not likely to jeopardize opinion with incidental take statements, reasonable and prudent measures, and terms and conditions for both species. Water quality impacts have been evaluated in accordance with the Section 404(b)(1) guidelines and are not adverse. The Arizona Department of Water Quality has notified the Corps of Engineers that formal certification for the project is not required. Coordination with the Arizona State Historic Preservation Office pursuant to the National Historic Preservation Act of 1977, as amended has been accomplished. Based on this coordination and a survey performed by the Corps of Engineers, it has been determined that the Alamo Lake project will not have an effect on any properties that are eligible for, or are included in the National Register of Historic Places. The recommended plan is in compliance with the Clean Air Act because emissions of criteria pollutants attributable to the plan are anticipated to be minimal. Executive Order 12898, Environmental Justice, has been complied with since no minority or low-income communities are adversely affected by the recommended operation plan.

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resources Council's <u>Principles and Guidelines</u>. All applicable laws, regulations, Executive Orders, guidelines and local governmental plans were considered in evaluating the alternatives. Based on review of these evaluations, I find that the ecosystem restoration benefits gained by modifying the operation of Alamo Dam far outweigh any adverse effect. This Record of Decision completes the National Environmental Policy Act process.

Joseph W. Westphal
Assistant Secretary of the Army
(Civil Works)

12 MAY 2000
Date

EXHIBIT D.

BIOLOGICAL OPINION

On September 16, 1998, the Service responded to Corps by acknowledging receipt of their formal consultation request, acknowledging having sufficient information to begin, and beginning the formal consultation process.

On February 3, 1999, the Service transmitted a draft biological opinion to the Corps. The Corps responded with a March 9, 1999, letter, requesting some clarification and minor modifications of the draft biological opinion.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

Setting

Alamo Dam and Lake are located on the Bill Williams River, approximately 39 miles upstream from its confluence with the Colorado River in Lake Havasu, Arizona (Figure 1). The lake is on the border of La Paz and Mohave counties, Arizona. Paved access is from the town of Wenden on U.S. Highway 60.

Alamo Dam was constructed under authorization of the Flood Control Act of 22 December 1944 (Public Law 534, 78th Congress, 2nd Session). Construction of the dam and appurtenant works was started in March 1965 and completed in July 1968. The reservoir was filled to its original recreational pool elevation of 1,046 feet above mean sea level (msl) in March of 1970. Current Alamo Lake operations are directed according to a revised 1973 Reservoir Regulation (Water Control) Manual.

The Alamo Lake recreation area encompasses 22,856 acres of Corps withdrawn lands of which approximately 16,400 acres represent the lake area for a probable maximum flood event. Fish and wildlife management responsibilities for the entire area have been turned over to AGFD under a license agreement. Approximately 17,960 acres are specifically managed as the Alamo Wildlife Area by the AGFD and approximately 4,893 acres are managed for recreational purposes by ASP.

Alamo Lake is fed by two main tributaries, the Big Sandy and Santa Maria rivers. These rivers merge to form the Bill Williams River, approximately 8 miles upstream of Alamo Dam. The Bill Williams River continues downstream of the dam for approximately 39 miles until it flows into the Colorado River at Lake Havasu, immediately upstream of Parker Dam.

Most of the land along the Bill Williams River is federally owned. The City of Scottsdale owns the Planet Ranch located along the Bill Williams River, approximately 24 miles downstream of the dam. The Bill Williams River National Wildlife Refuge (BWRNWR) is located approximately 30 miles downstream of the dam to the confluence with the Colorado River.

The Alamo Lake Feasibility Study has been conducted under the authority of Section 216 of Public Law 91-611 (Flood Control Act of 1970). Section 216 authorizes the Corps to review the operation of completed projects....

> *"...when found advisable due to significantly changed physical or economic conditions, and then report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."*

Specific appropriations language authorizing the Reconnaissance Report dated July 1996 was included in the Energy and Water Development Appropriations Bill, 1995 Report [To accompany H.R. 4506], which stated:

> *"The Committee has provided $200,000 for the Corps of Engineers to initiate and complete a reconnaissance study to consider modifications of storage allocation and operation of the Alamo Dam, Bill Williams River in Arizona for fish and wildlife restoration and enhancement purposes. The Committee understands that further analysis is warranted because earlier studies have indicated that river flows can affect riparian habitat, including habitat at the Bill Williams National Wildlife Refuge."*

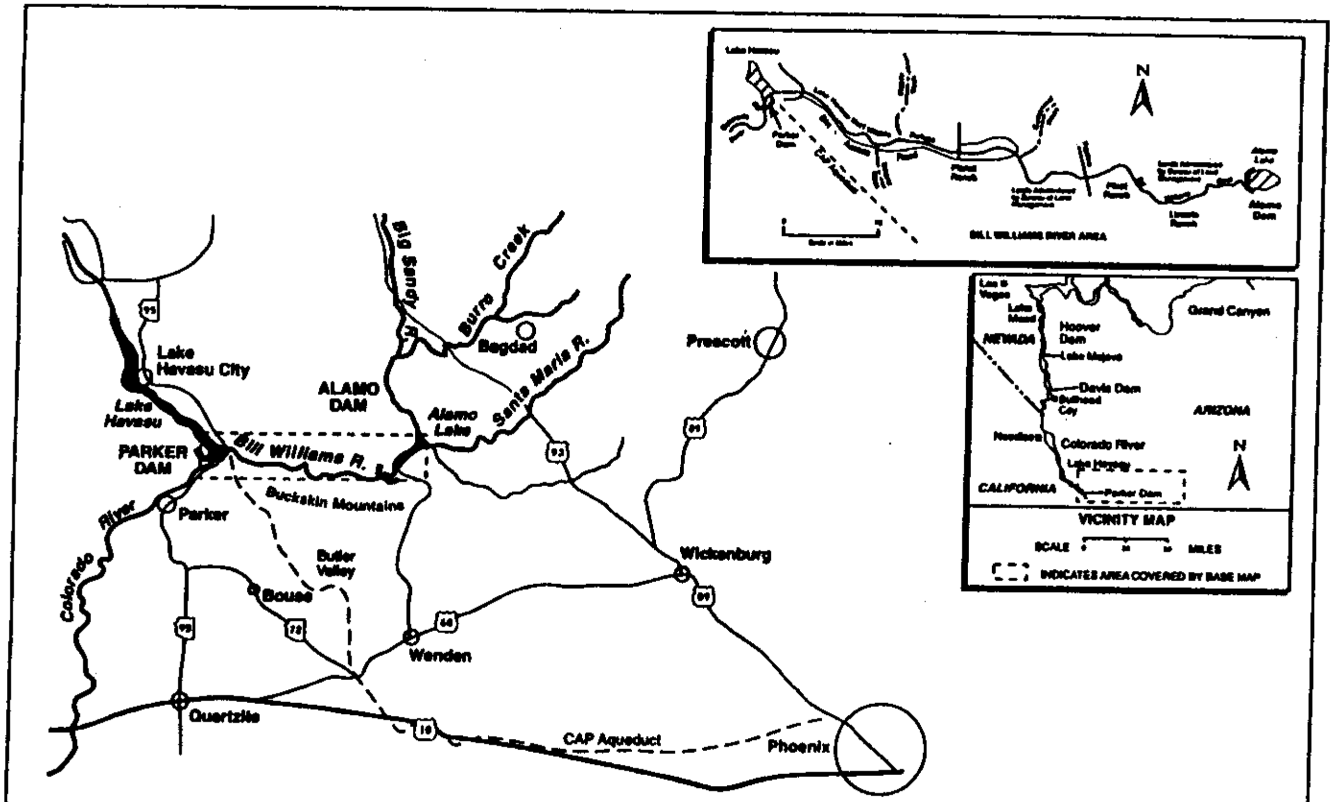
Section 301(b)(1) of the Water Resources Development Act of 1996 (WRDA 96) modified the project for flood control and other purposes—subject to completion of a feasibility report—to authorize the Secretary of the Army to:

> *"...operate the Alamo Dam to provide fish and wildlife benefits both upstream and downstream of the Dam. Such operation shall not reduce flood control and recreation benefits provided by the project."*

Objectives

The general planning objective guiding development was the balance between minimum flows needed to sustain and enhance riparian resources below the dam, and sustenance of suitable lake elevations with minimal fluctuations for reservoir resources and uses (including wildlife, fisheries and recreation).

Biological objectives affecting plan formulation include the establishment of native riparian habitat for fish and wildlife utilization through the manipulation of baseflows and flood flows in spring and fall; the maintenance of existing nesting and foraging habitat for wildlife species; and the preclusion of continued salt cedar establishment around the lake perimeter, the Bill Williams River tributaries, and downstream of the dam. Largemouth bass spawning success is dependent, in part, upon the net acreage of lake with water depths ranging from 0-20 feet. At Alamo Lake, suitable spawning habitat (depth) is optimized at lake elevations below 1,125 feet where submerged islands and ridges are within 6 m of the surface. As water surface elevations increase above 1,125 feet,



Source: Corps 1989

N

Not To Scale

Figure 1

Alamo Dam and Reservoir Study Area

the net acreage of suitable spawning habitat decreases until the water surface elevation reaches approximately 1,145 feet (BWRCTC 1994). Therefore, project alternatives above 1,125 feet were determined to have a declining effect upon existing fisheries resources as the net acreage of spawning habitat decreases.

Additionally, the probability of new inundation of existing cottonwood stands noticeably increases at or above 1,180 feet, resulting in expansion of salt cedar into higher elevations around the lake perimeter. Consequently, alternatives above 1,125 feet were unable to achieve all of the biological objectives as listed above, and were dropped from further analysis.

Proposed Action

The 1,125-foot target elevation water management alternative was selected by the Technical Committee as the plan which optimizes the resource objectives within operational constraints of Alamo Dam and provides for fish and wildlife benefits in perpetuity. Predicated on the analysis performed by the Technical Committee, the 1996 Reconnaissance Study (Corps 1996) and accompanying modified HEP analysis concluded the 1,125 foot plan would optimize the restoration of fish and wildlife values to the Bill Williams River and Alamo Lake ecosystem. The 1,125 foot plan would provide 80,000 acre-feet of lake storage above the 1,100-foot minimum lake level that represents current operations, for a total of 160,500 acre-feet of storage. The 1,125-foot Plan is considered the Proposed Action for the Alamo Lake Reoperation Project.

The Proposed Action would provide sufficient water storage for downstream flows, while keeping lake elevations greater than 1,100 feet for a majority of the time. When reservoir pool levels are below the target elevation, reduced reservoir releases would be made to maintain seasonal base flows ranging from 10-50 cfs throughout the Bill Williams River corridor. Operations would maintain relatively stable lake elevations.

The prescribed releases for the Proposed Action are presented in Table 1. Alamo Dam releases for riparian base flow requirements would range from 25 cfs between November and January and 40-50 cfs during the spring-fall period.

Above the 1,125-foot elevation, the release schedule attempts to mimic the pattern of pre-dam flood events. Pre-dam flood events typically had short duration high flows followed by long recession (tapering off).

Under the Proposed Action, Alamo Lake water levels would be decreased every five years for an inspection draw-down. Inspection of the outlet tunnel would occur in October/November, when reservoir inflows would be lowest (based on historic record) and downstream release requirements for riparian communities are low. The draw-down procedure for the inspection/maintenance would normally begin in June, permitting reservoir evacuation over a 6-month period without excessively high flows. In most cases, releases would be less than 1,000 cfs. An objective is to avoid root zone damage to the cottonwood trees caused by saturation from long-term inundation.

Table 1 Generalized Alamo Dam Release Schedule for the Proposed Action

If lake elevation is ≤1,125 feet (target elevation), then:

	Alamo Dam Releases			
Lake Elevation (ft, msl)	Oct	Nov-Jan	Feb-Apr	May-Sept
990-1070	10	10	10	10
1070-1100	15	10	25	25
1100 to Target Elevation	40	25	40	50

If the lake elevation exceeds the 1,125-foot target elevation at any time, then:

Lake Elevation (ft, msl)	Alamo Dam Releases (cfs)
1,125-1,126	Transition up to 1,000
1,126	1,000
1,127	2,000
1,128	3,000
1,129	4,000
1,130	5,000
1,131	6,000
1,132	6,621-7,000 (or outlet capacity)
1,148.4	7,000
Up to 1,235 feet (spillway crest)	7,000
From 1,235 - 1,265 feet (top of dam)	Over 7,000

If a monsoon event occurs during the draw-down period, outflows would mimic inflows as much as possible to provide the monsoon flow effect downstream. If, during a draw-down period, no monsoon event occurs and it is deemed that such an event would benefit the riparian zones, an artificial monsoon sequence of flows could be simulated. Normally, such a simulated monsoon event would be scheduled for early September, to mimic nature. It is expected that base-flow releases after the artificial monsoon release would be much less than the period prior to the monsoon release to ensure that the reservoir water surface elevation does not drop below elevation 1,100 feet.

Under the Proposed Action scenario, the larger spring and monsoon flushing releases would be coordinated with USBR operations on the Colorado River, similar to the present operating plan. If an excessive runoff condition occurred on the Colorado River, releases from Alamo Dam would be limited to the amount the USBR could incorporate into its river operation plan; however, base flows would be maintained. If the water elevation of Alamo Reservoir rises into the flood control pool, releases would be increased as necessary to be consistent with required flood control operation. In a flood control operation, outflow may be as high as 7,000 cfs, as shown in Table 1.

In a similar manner, base-flow releases would be coordinated with the resource agencies downstream, as appropriate. Hence, if a specified seasonal release below the target elevation was deemed unnecessary to sustain downstream riparian needs, releases would be adjusted accordingly.

Conservation Measures

Current management measures would continue as described in the Corps' Biological Assessment (Corps 1994) and the resultant Biological Opinion (Service 1996) for the operation of Alamo Dam, including control of public access to portions of the lake during the nesting season and continued monitoring of eagles in the area. Contingency measures for rescue of eggs or young birds in case of potential inundation of nests would also be maintained. Those measures are reiterated here noting modifications. Additions from the 1996 biological opinion are written in **bold,** deletions are written as ~~strike-out~~.

1.1 Corps personnel shall notify the Service and the AGFD whenever inundation of active bald eagle nests (nests containing eggs or nestlings) is possible. Notification shall be given at least 24 hours before possible inundation, **or as soon as the information becomes available**.

1.2 The Corps shall logistically assist any rescue operations arising out of the contingency described in 1.1 above. This shall include providing access to areas restricted from the public use, access for nestwatchers to telephones, and transportation in Corps boats to nest sites, if such boats are present at Alamo Lake.

1.3 The Corps shall logistically assist any foster operations arising out of the contingencies described in 1.1 and 1.2 above. If the Service and/or AGFD deem it appropriate to place eggs or young rescued under 1.2 into an Alamo Lake area eagle nest after interim care, the Corps shall provide access to areas restricted from public use, access for nestwatchers to telephones, and transportation in Corps' boats to nest sites, if such boats are present at Alamo Lake.

1.4 Help fund the Arizona Bald Eagle Nestwatch Program ~~through 1998~~ **as long as deemed necessary by the Arizona Bald Eagle Nestwatch Program** in order to provide early notification of impending nest inundation so that measures to rescue eggs or chicks from nests can be undertaken in a timely manner. Funding shall **begin this year and** be in the amount sufficient to staff three nestwatchers through the breeding season, or approximately $15,000 annually. In most years, the nest watchers would be stationed at Alamo Lake. However, they will be reassigned to other Breeding Areas (BAs) within Arizona when appropriate (i.e., following nest failure or confirmation of cliff-nesting) to further the recovery of the population which would further buffer any losses occurring at Alamo Lake. The Corps shall secure a written agreement with the AGFD as the AGFD coordinates the

Arizona Bald Eagle Nestwatch Program. ~~The AGFD has assured the Service that they have established procedures through which funding contributions are made.~~

2.1 ~~When bald eagles are nesting in snags on the lake, maintain the lake elevation no higher than 1120 feet from December 1 July 15 unless weather conditions and operating constraints of the dam render the 1120 foot elevation unattainable. This will help lengthen the integrity of the nest structure as well as allow additional response time for egg or nestling rescue during flood events. It should be noted that 2.1 would not be required when bald eagles are nesting at the cliff nest, provided that ongoing monitoring documents nesting at the cliff nest.~~

2.2 Use the Arizona Bald Eagle Nestwatch Program (1.4) to determine if bald eagles are nesting at the snag nest at any time during the breeding season. Information gained through monitoring will determine whether implementation of 2.1 is required.

2.3 ~~Develop a drawdown plan for releasing stored water following major floods in order to alleviate threats to snag nesting bald eagles. Development of the plan must consider removal of immediate and future flooding threats to the eagles as well as operational constraints of the dam, and will require that the Corps coordinate with appropriate personnel from the Service and the AGFD.~~

3.1 Notify the AGFD within 24 hours **(or as soon as information becomes available)** whenever buoys surrounding an occupied nest are displaced by flooding or other means and assist the AGFD in replacing the buoys. Corps assistance should include providing access to areas restricted from public use, access for nestwatchers to telephones, and transportation in Corps boats to nest sites, if such boats are present at Alamo Lake.

3.2 Use the Arizona Bald Eagle Nestwatch Program 1.4) to ensure that nestwatchers will be present at Alamo Lake to minimize harassment of the bald eagles by recreationists whenever lake levels permit access to snag nests.

STATUS OF THE SPECIES

Bald Eagle

The bald eagle south of the 40th parallel was listed as endangered under the Endangered Species Act of 1966 on March 11, 1967 (Service 1967). It was reclassified to threatened status on July 12, 1995 (Service 1995a). No critical habitat has been designated for this species. The bald eagle is a large hawk that historically ranged throughout North America except extreme northern Alaska and Canada and central and southern Mexico. Bald eagles nested on both coasts of the United States, from Florida to Baja California in the south and from Labrador, Newfoundland, to the Aleutian Islands, Alaska, in the north.

The bald eagle occurs in association with aquatic ecosystems, frequenting estuaries, large lakes, reservoirs, major rivers, and some seacoast habitats. Suitable habitat for bald eagles includes those areas with an adequate food base, perching areas, and nesting sites. In winter, bald eagles often congregate at specific wintering sites that are generally close to open water and that offer good perch trees and night roosts (Service 1995a).

There were an estimated one-quarter to one-half million bald eagles on the North American continent when Europeans first arrived. Initial population declines probably began in the late 1800s, and coincided with declines in the number of waterfowl, shorebirds, and other prey species. Direct killing of bald eagles was also prevalent. Additionally, there was a lost of nesting habitat. These factors reduced bald eagle numbers until the 1940s when protection for the bald eagle was provided through the Bald Eagle Protection Act (16 U.S.C. 668). The Act accomplished protection and a slower decline in bald eagle populations by prohibiting numerous activities adversely affecting bald eagles and increasing public awareness of bald eagles. The widespread use of dichloro-diphenyl-trichloroethane (DDT) and other organochlorine compounds in the 1940s for mosquito control and as a general insecticide caused additional declines in bald eagle populations. DDT accumulated in individual birds following ingestion of contaminated food. DDT breaks down into dichlorophenyl-dichloroethylene (DDE) and accumulates in the fatty tissues of adult females, leading to impaired calcium release necessary for egg shell formation. Thinner egg shells led to reproductive failure, and is considered a primary cause of declines in the bald eagle population. DDT was banned in the United States in 1972 (Service 1995a).

Since listing, bald eagles have increased in number and expanded in range due to the banning of DDT and other persistent organochlorine compounds, habitat protection, and recovery efforts. Surveys in 1963 indicated 417 active nests in the lower 48 states with an average of 0.59 young produced per nest. In 1994, 4,450 occupied breeding areas were reported with an estimated average of 1.17 young produced per occupied nest (Service 1995a).

Hunt *et al.* (1992) summarized the earliest records of bald eagles in the literature for Arizona. Coues noted bald eagles in the vicinity of Fort Whipple (now Prescott) in 1866, and Henshaw reported bald eagles south of Fort Apache in 1875. The first bald eagle breeding information was recorded in 1890 near Stoneman Lake by S.A. Mearns. Additionally, Bent reported breeding eagles at Fort Whipple in 1866 and on the Salt River Bird Reservation (since inundated by Roosevelt Lake) in 1911. Additionally, there are reports of bald eagles along rivers in the White Mountains from 1937, and reports of nesting bald eagles along the Salt and Verde Rivers as early as 1930.

From 1970 to 1990, 226 known eaglets fledged in Arizona, for an average of 10.8 young produced per year. Successful nests contained an average of 1.6 young per year (Hunt *et al.* 1992). In 1995, there were 36 known breeding areas, with 30 of those being occupied. Within those breeding areas, 22 nests were active, and six nests failed. Sixteen of the 22 nests were successful in producing young, and a total of 28 young hatched. Twenty-five of these young survived to fledge (Beatty *et al.* 1995). Results for the 1996 breeding season are not yet available.

In addition to breeding bald eagles, Arizona provides habitat for wintering bald eagles, which migrate through the state between October and April each year. For 1996, the standardized statewide Arizona winter count totaled 361 bald eagles, including 232 adults, 127 subadults, and two of unknown age. The most concentrated population of wintering bald eagles is found at Lake Mary and Mormon Lake, where 69 birds were located (Beatty and Driscoll 1996). Perch and roost trees that are sheltered from extreme weather and are close to abundant prey are especially important habitat features for wintering bald eagles (Grubb *et al.* 1989). Perch or roost sites at Navajo Lake, New Mexico included leafless mature cottonwoods, young saplings, live and dead ponderosa pine, douglas fir, pinyon pine, and juniper (Grubb 1984). Perches were typically in the upper half of trees. Wintering bald eagles also perched on rocks or outcrops, especially along ridgelines, and also perched on ice.

It is not known if the population of bald eagle in Arizona declined as a result of DDT contamination because records were not consistently kept during this time period. However, the possibility for contamination was present as DDT was used in Arizona and Mexico. Use of DDT in Mexico could potentially have contaminated waterfowl that then migrated through Arizona in addition to directly affecting juvenile and subadult eagles that traveled into Mexico. Many of the nest sites in Arizona are in rugged terrain not suitable for agricultural development, and may therefore have avoided the direct effects of DDT (Hunt *et al.* 1992).

Bald eagle breeding areas in Arizona are predominantly located in the upper and lower Sonoran life zones. The Luna Lake breeding area is unique in Arizona in that it is found in coniferous forests at Luna Lake, as opposed to occurring in Sonoran vegetation communities. All breed in close proximity to a variety of aquatic habitats including reservoirs, regulated river systems, and free-flowing rivers and creeks. The alteration of natural river systems has been both beneficial and detrimental to the bald eagle. While large portions of riparian forests were inundated or otherwise destroyed following construction of dams and other water developments, the reservoirs created by these structures enhance habitat for the waterfowl and fish species on which bald eagles prey.

Of 111 nests known in 1992, 46 were in trees, 36 on cliffs, 17 on pinnacles, 11 in snags, and one on an artificial platform. However, while there were more nests in trees, one study found that cliff nests were selected 73 percent of the time, while tree nests were selected 27 percent of the time. Arizona bald eagles are considered distinct behaviorally from bald eagles in the remaining lower 48 states in that they frequently construct nests on cliffs. Additionally, eagles nesting on cliffs were found to be marginally more successful at reproducing. Bald eagles in the southwest are additionally unique in that they lay eggs in January or February, which is early compared with bald eagles in other areas. It is believed that this is a behavioral adaptation to allow chicks to avoid the extreme desert heat of midsummer. Young eagles will remain in the vicinity of the nest until June (Hunt *et al.* 1992).

Bald eagles in Arizona consume a diversity of food items, including some invertebrates. However, their primary food is fish, which are generally consumed twice as often as birds, and four times as often as mammals. Bald eagles are known to catch live prey, steal prey from other predators (especially osprey), and use carrion. Carrion constitutes a higher proportion of the diet for juveniles and subadults than it does for adult eagles. Diet varies depending on what species are available locally. This can be affected by the type of water system on which the breeding area is based (Hunt *et al.* 1992).

A recovery plan was developed for bald eagles in the southwest recovery region in 1982. Goals of the recovery plan were to produce a reproductive output of 10 to 12 young per year and to determine occupancy of one or more pairs on a drainage other than the Salt or Verde Rivers. These goals have been met, and the bald eagle was reclassified nationwide to threatened status. While bald eagles in the southwest were initially considered a distinct population, the final rule notes that the Service has determined that bald eagles in the southwestern recovery region are part of the same bald eagle population found in the remaining lower 48 states.

While the bald eagle has been reclassified to threatened, and although the status of the birds in the southwest recovery region is on an upward trend, the population remains small and under threat from a variety of factors. Threats persist largely due to the proximity of bald eagle breeding areas to major human population centers. Additionally, because water is a scarce resource in the southwest recovery region, recreation is concentrated along available water courses. Some of the threats and disturbances to bald eagle include entanglement in monofilament (fishing line) and fishing hooks, overgrazing and related degradation of riparian vegetation, shooting, alteration of water systems for water distribution systems, maintenance of existing water development features such as dams or diversion structures, and disturbance from recreation. The use of breeding area closures and close monitoring through the Bald Eagle Nestwatch program have been and will continue to be essential to the recovery of this species.

Southwestern Willow Flycatcher

The southwestern willow flycatcher is a small grayish-green passerine bird (Order Passeriformes; Family Tyrannidae) measuring approximately 14.6 cm (5.75 inches) in length from the tip of the bill to the tip of the tail and weighing only 11 grams (0.4 ounces). It has a grayish-green back and wings, whitish throat, light gray-olive breast, and pale yellowish belly. Two white wingbars are visible (juveniles have buffy wingbars). The eye ring is faint to absent. The upper mandible is dark, the lower is light yellow grading to black at the tip. The song is a sneezy "fitz-bew" or a "fit-a-bew," the call is a repeated "whitt."

One of four currently-recognized willow flycatcher subspecies (Phillips 1948, Unitt 1987, Browning 1993), the southwestern willow flycatcher is a neotropical migrant that breeds in the southwestern U.S. and migrates to Mexico, Central America, and possibly northern South America during the non-breeding season (Phillips 1948, Stiles and Skutch 1989, Peterson 1990, Ridgely and Tudor 1994, Howell and Webb 1995). The historical range of the southwestern willow flycatcher included southern California, Arizona, New Mexico, western Texas, southwestern Colorado, southern Utah, extreme southern Nevada, and extreme northwestern Mexico (Sonora and Baja) (Unitt 1987).

The southwestern willow flycatcher is a riparian obligate, nesting along rivers, streams, and other wetlands where dense growths of willow (*Salix* sp.), *Baccharis*, buttonbush (*Cephalanthus* sp.), boxelder (*Acer negundo*), saltcedar (*Tamarix* sp.) or other plants are present, often with a scattered overstory of cottonwood (*Populus* sp.) and/or willow. These riparian communities provide nesting, foraging, and migratory habitat for the flycatcher.

This species is an insectivore, typically perching on a branch and making short direct flights, or sallying, to capture flying insects. Drost *et al.* (1998) found that the major prey items of the southwestern willow flycatcher, from 15 sites in Arizona and Colorado, consisted of true flies (Diptera); ants, bees, and wasps (Hymenoptera); and true bugs (Hemiptera). Other insect prey taxa included leafhoppers (Homoptera: Cicadellidae); dragonflies and damselflies (Odonata); and caterpillars (Lepidoptera larvae). Non-insect prey included spiders (Araneae), sowbugs (Isopoda), and fragments of plant material. Drost *et al.* noted significant differences in dietary items based on sites and habitats.

The southwestern willow flycatcher was listed as endangered, without critical habitat on February 27, 1995 (USFWS 1995b). Critical habitat was designated on July 22, 1997, and a correction notice was published in the Federal Register on August 20, 1997. Eighteen critical habitat units totaling 599 river miles in Arizona, California, and New Mexico were designated. In Arizona, critical habitat was designated along portions of the San Pedro River (100 miles), Verde River (90 miles) including Tavasci Marsh and Ister Flat, Wet Beaver Creek (20 miles), West Clear Creek (9 miles), Colorado River in the Grand Canyon (32 miles), and Little Colorado River and the West, East, and South Forks of the Little Colorado River (30 miles) (USFWS 1997a).

Habitat

The southwestern willow flycatcher breeds in dense riparian habitats from sea level in California to over 7000 feet in Arizona and southwestern Colorado. Throughout its wide geographic and elevational range, its riparian habitat can be broadly described based on plant species composition and habitat structure (Sogge *et al.* 1997). Two components that vary less across this subspecies' range are vegetation density and the presence of surface water. Based on the diversity of plant species composition and complexity of habitat structure, four basic habitat types can be described for the southwestern willow flycatcher. Those types are described below and should be referenced with photographs provided in Sogge *et al.* (1997).

Monotypic willow: Nearly monotypic, dense stands of willow (often *S. exigua* or *S. geyeriana*) 3 to 7 meters in height with no distinct overstory layer; usually very dense structure in at least lower 2 m; live foliage density is high from the ground to canopy.

Monotypic exotic: Nearly monotypic, dense stand of exotics such as saltcedar (*Tamarix* sp.) or Russian olive (*Elaeagnus angustifolia*) 4 to 10 meters (m) in height forming a nearly continuous, closed canopy (with no distinct canopy layer); lower 2 m may be very difficult to penetrate due to branch density; however live foliage volume may be relatively low from 1 to 2 m above ground; canopy density uniformly high.

Native broadleaf dominated: Comprised of dense stands of single species (often Goodding's or other willows) or mixtures of native broadleaf trees and shrubs including, but not limited to, cottonwood, willows, boxelder, ash, buttonbush, and stinging nettle from 4 to 15 m in height; characterized by trees of different size classes; may have distinct overstory of cottonwood, willow or other broadleaf species, with recognizable subcanopy layers and a dense understory of mixed species; exotic/introduced species may be a rare component, particularly in understory.

Mixed native/exotic: Dense mixtures of native broadleaf trees and shrubs (such as those listed above) mixed with exotic species such as tamarisk and Russian olive; exotics are often primarily in the understory, but may also be a component of overstory; the native and exotic components may be dispersed throughout the habitat or concentrated as a distinct patch within a larger matrix of habitat; overall, a particular site may be dominated primarily by natives, exotics, or be a more or less equal mixture.

Open water, cienegas, marshy seeps, or saturated soil are typically in the vicinity of flycatcher territories and nests; flycatchers sometimes nest in areas where nesting substrates were in standing water (Maynard 1995, Sferra *et al.* 1995, 1997). However, hydrological conditions at a particular site can vary remarkably in the arid Southwest within a season and between years. At some locations, particularly during drier years, water or saturated soil is only present early in the breeding season (i.e., May and part of June). However, the total absence of water or visibly saturated soil has been documented at several sites where the river channel has been modified (e.g., creation of pilot channels), where modification of subsurface flows has occurred (e.g., agricultural runoff), or as a result of changes in river channel configuration after flood events (Spencer *et al.* 1996).

Breeding Biology

The southwestern willow flycatcher begins arriving on breeding grounds in late April and May (Sogge and Tibbitts 1992, Sogge *et al.* 1993, Sogge and Tibbitts 1994, Muiznieks *et al.* 1994, Maynard 1995, Sferra *et al.* 1995, 1997). Nesting begins in late May and early June and young fledge from late June through mid-August (Willard 1912, Ligon 1961, Brown 1988a,b, Whitfield 1990, Sogge and Tibbitts 1992, Sogge *et al.* 1993, Muiznieks *et al.* 1994, Whitfield 1994, Maynard 1995). Southwestern willow flycatchers typically lay three to four eggs in a clutch (range = 2-5). The breeding cycle, from laying of the first egg to fledging, is approximately 28 days. Eggs are laid at one-day intervals (Bent 1963, Walkinshaw 1966, McCabe 1991); they are incubated by the female for approximately 12 days; and young fledge approximately 12 to 13 days after hatching (King 1955, Harrison 1979). Southwestern willow flycatchers typically raise one brood per year but have been documented raising two broods during one season (Whitfield 1990). They have also been documented renesting after nest failure (Whitfield 1990, Sogge and Tibbitts 1992, Sogge *et al.* 1993, Sogge and Tibbitts 1994, Muiznieks *et al.* 1994, Whitfield 1994, Whitfield and Strong 1995).

Southwestern willow flycatcher nests are open cup structures, approximately 8 centimeters (cm) high and 8 cm wide (outside dimensions), exclusive of any dangling material at the bottom. Nests are typically placed in the fork of a branch with the nest cup supported by several small-diameter vertical stems. The main branch from which the fork originates may be oriented vertically, horizontally, or at an angle, and stem diameter for the main supporting branch can be as small as three to four cm. Vertical stems supporting the nest cup are typically one to two cm in diameter. Occasionally, southwestern willow flycatchers place their nests at the juncture of stems from separate plants, sometimes different plant species. Those nests are also characterized by vertically-oriented stems supporting the nest cup. Spencer *et al.* (1996) measured the distance between flycatcher nests and shrub/tree center for 38 nests in monotypic saltcedar and mixed native broadleaf/saltcedar habitats. In monotypic saltcedar stands (n=31), nest placement varied from 0.0 m (center stem of shrub or tree) to 2.5 m. In the mixed riparian habitat (n=7), nest placement varied from 0.0 to 3.3 m.

Height of the nest varies across the southwestern willow flycatcher's range and may be correlated with the species and height of nest substrate, foliage densities, and/or overall canopy height. Southwestern willow flycatcher nests have been found as low as 0.6 m above the ground to 18 m above the ground. Flycatchers using predominantly native broadleaf riparian habitats nest relatively low to the ground (between 1.8 m and 2.1 m on average), whereas those using mixed native/exotic and monotypic exotic riparian habitats nest relatively high above the ground (between 4.3 m and 7.4 m on average).

Historic egg/nest collections and species' descriptions from throughout the southwestern willow flycatcher's range confirm the bird's widespread use of willow for nesting (Phillips 1948, Phillips *et al.* 1964, Hubbard 1987, Unitt 1987, T. Huels *in litt.* 1993, San Diego Natural History Museum 1995). Currently, southwestern willow flycatchers use a wide variety of plant species for nesting substrates primarily including Geyer willow, Goodding's willow, boxelder, saltcedar, Russian olive and live oak. Other plant species that southwestern willow flycatcher nests have been documented in include: buttonbush, black twinberry (*Lonicera involucrata*), Fremont cottonwood, white alder (*Alnus rhombifolia*), blackberry (*Rubus ursinus*), Russian olive, and *S. hindsiana*.

Brood parasitism of southwestern willow flycatcher nests by the brown-headed cowbird (*Molothrus ater*) has been documented throughout the flycatcher's range (Brown 1988a,b, Whitfield 1990, Muiznieks *et al.* 1994, Whitfield 1994, Hull and Parker 1995, Maynard 1995, Sferra *et al.* 1995, Sogge 1995b). Cowbirds lay their eggs in the nests of other species directly affecting their hosts by reducing nest success. Cowbird parasitism reduces host nest success in several ways. Cowbirds may remove some of the host's eggs, reducing overall fecundity. Hosts may abandon parasitized nests and attempt to renest, which can result in reduced clutch sizes, delayed fledging, and reduced overall nesting success and fledgling survivorship (Whitfield 1994, Whitfield and Strong 1995). Cowbird eggs, which require a shorter incubation period than those of many passerine hosts, hatch earlier giving cowbird nestlings a competitive advantage over the host's young for parental care (Bent 1963, McGeen 1972, Mayfield 1977a,b, Brittingham and Temple 1983). Where studied, high rates of cowbird parasitism have coincided with southwestern willow flycatcher population declines (Whitfield 1994, Sogge 1995a, Sogge 1995c, Whitfield and Strong 1995), or, at a minimum, resulted in reduced or complete elimination of nesting success (Muiznieks *et al.* 1994, Whitfield 1994, Maynard 1995, Sferra *et al.* 1995, Sogge 1995a, Sogge 1995c, Whitfield and Strong 1995). Whitfield and Strong (1995) found that flycatcher nestlings fledged after July 20th had a significantly lower return rate and that cowbird parasitism was often the cause of delayed fledging.

Territory size

Southwestern willow flycatcher territory size, as defined by song locations of territorial birds, probably changes with population density, habitat quality, and nesting stage. Estimated territory sizes are 0.24-1.3 ha for monogamous males and 1.1-2.3 ha for polygynous males at the Kern River (Whitfield and Enos 1996), 0.06-.2 ha for bird in a 0.6-0.9 ha patches on the Colorado River (Sogge 1995c) and 0.2-0.5 ha in a 1.5 ha patch on the Verde River (Sogge 1995a).

Rangewide Distribution and Abundance

Unitt (1987) documented the loss of more than 70 breeding locations rangewide, including locations along the periphery and within core drainages that form this subspecies range. Unitt estimated that the rangewide population probably was comprised of 500 to 1000 pairs. The current known population of southwestern willow flycatchers stands at approximately 587 territories (Table 2). Breeding occurs at approximately 75 sites (Sogge *et al.* 1997).

The data presented in Table 2 represents both a summary of current survey data as well as a composite of surveys conducted since 1992. Locations that had southwestern willow flycatchers for only one year were tabulated as if the location is still extant. Given that extirpation has been documented at several locations during the survey period, this method of analysis introduces a bias that may overestimate the number of breeding groups and overall population size. In addition, females have been documented singing. Because the established survey method relies on singing birds as the entity defining a territory (Tibbitts *et al.* 1994), double-counting may be another source of sampling error that biases population estimates upward. The figure of 587 southwestern willow flycatcher territories is a preliminary rangewide estimate for 1997 and is an approximation based on considerable survey effort, both extensive and intensive. Given sampling errors that may bias population estimates positively or negatively (e.g., incomplete survey effort, double-counting males/females, composite tabulation methodology), natural population fluctuation, and random events, it is likely that the total breeding population of southwestern willow flycatchers fluctuates between 350 and 550 pairs. A substantial proportion of individuals appear to remain unmated. At such low population levels, random demographic, environmental, and/or genetic events could

Table 2. Rangewide population status for the southwestern willow flycatcher based on 1996 survey data for New Mexico and California, and 1997 survey data for Arizona, Colorado, Nevada and Utah. Composite data indicated by () represents multi-year survey data for 1993-1996 for New Mexico and California and 1993-1997 for Arizona, Colorado, Nevada and Utah[1].

State	No. of Sites with Territories (Composite No. of Sites)	No of. Drainages with Territories (Composite No. of Drainages)	No. of Sites (Composite) with Territories			
			with ≤5	with 6-20	with >20	Total No. of Territories (Composite)
Arizona	41 (65)	12 (12)	33 (53)	8 (9)	1 (3)	190 (287)
California	11 (23)	8 (14)	7 (17)	2 (4)	2 (2)	91 (130)
Colorado	7 (15)	6 (11)	2 (10)	4 (4)	1 (1)	69 (92)
New Mexico	19 (30)	6 (8)	16 (26)	3 (3)	1 (1)	209 (232)
Nevada	5 (6)	3 (3)	4 (5)	1 (1)	0 (0)	20 (23)
Utah	5 (10)	4 (7)	5 (10)	0 (0)	0 (0)	8 (16)
Texas	?	?	?	?	?	?
Total	88 (149)	39 (55)	67 (121)	18 (21)	5 (7)	587 (780)

[1] Based on surveys conducted at >800 historic and new sites in AZ (Sogge and Tibbitts 1992, Sogge *et al.* 1993, Muiznieks *et al.* 1994, Sogge and Tibbitts 1994, Sferra *et al.* 1995, 1997, Sogge 1995a, Sogge *et al.* 1995, Spencer *et al.* 1996, McKernan 1997, McKernan and Braden 1998., McCarthey *et al.* 1998); CA (Camp Pendleton 1994, Whitfield 1994, Griffith and Griffith 1995, Holmgren and Collins 1995, Kus 1995, San Diego Natural History Museum 1995, Whitfield and Strong 1995, Griffith and Griffith 1996); CO (T. Ireland 1994 *in litt.*, Stransky 1995); NM (Maynard 1995, Cooper 1996, 1997, Parker 1997, Skaggs 1996, Williams 1995); NV (C. Tomlinson 1995 *in litt*, 1997); UT (McDonald *et al.* 1995, 1997, Sogge 1995b). Systematic surveys have not been conducted in Texas. For sites surveyed multiple years, highest single-year estimate of territories was used to tabulate status data. Tabulations do not include documented extirpations within survey period. Thus, individual state estimates and rangewide totals may be biased upward.

lead to loss of breeding groups and the continued decline of the species. The high proportion of unmated individuals documented during recent survey efforts suggests the southwestern willow flycatcher may already be subject to a combination of these factors (e.g., uneven sex ratios, low probability of finding mates in a highly fragmented landscape).

The results shown in Table 2 demonstrates the critical population status of the flycatcher. More than 75% of the locations where flycatchers have been found are comprised of 5 or fewer territorial birds. Approximately 20% of the locations are comprised of single, unmated individuals. The distribution of breeding groups is highly fragmented, with groups often separated by considerable distances (e.g., approximately 88 kilometer straight-line distance between breeding flycatchers at Roosevelt Lake, Gila County, Arizona, and the next closest breeding groups known on either the San Pedro River (Pinal County) or Verde River (Yavapai County). Continued survey efforts may discover additional small breeding groups. To date, survey results reveal a consistent pattern rangewide--the southwestern willow flycatcher population as a whole is comprised of extremely small, widely-separated breeding groups including unmated individuals.

Declining numbers have been attributed to loss, modification, and fragmentation of riparian breeding habitat, loss of wintering habitat, and brood parasitism by the brown-headed cowbird (*Molothrus ater*) (McCarthey *et al.* 1998, Sogge *et al.* 1997). Habitat loss and degradation is caused by a variety of factors, including urban, recreational, and agricultural development, water diversion and groundwater pumping, channelization, and livestock grazing. Fire is an increasing threat to willow flycatcher habitat (Paxton *et al.* 1996). Fire frequency in riparian vegetation increases with dominance by saltcedar (DeLoach 1991), and water diversions or groundwater pumping that results in dessication of riparian vegetation (Sogge *et al.* 1997). The presence of livestock and range improvements such as waters and corrals; agriculture; urban areas such as golf courses, bird feeders, and trash areas may provide feeding sites for cowbirds. These feeding areas coupled with habitat fragmentation, facilitate cowbird parasitism of flycatcher nests (Tibbitts *et al.* 1994, Hanna 1928, Mayfield 1977).

Arizona Distribution and Abundance

Unitt (1987) concluded that "Probably the steepest decline in the population level of *E.t. extimus* has occurred in Arizona..." Historic records for Arizona indicate the former range of the southwestern willow flycatcher included portions of all major river systems (Colorado, Salt, Verde, Gila, Santa Cruz, and San Pedro) and major tributaries, such as the Little Colorado River and headwaters, and White River.

As of 1997, 190 territories were known from 41 sites along 12 drainages statewide (Table 2). The majority of breeding groups in Arizona are extremely small; of the 41 sites where flycatchers have been documented, 80% (33) contain 5 or fewer territorial flycatchers. Moreover, 15% to 18% of all sites in Arizona are comprised of single, unmated territorial birds.

As reported by McCarthey *et al.* (1998), the greatest concentrations of willow flycatchers in Arizona in 1997 were near the confluence of the Gila and San Pedro Rivers (146 flycatchers, 76 territories); at the inflows of Roosevelt Lake (74 flycatchers, 39 territories); between Fort Thomas and Solomon on the middle Gila River (32 flycatchers, 18 territories); Topock Marsh on the Lower Colorado River (24 flycatchers, 12 territories); Verde River at Camp Verde (20 flycatchers, 10, territories); Alpine/Greer on the San Francisco River/Little Colorado River (16 flycatchers, 9 territories); and Alamo Lake on the Bill Williams River (includes Santa Maria and Big Sandy River sites) (16 flycatchers, 10 territories). The lowest elevation where territorial pairs were detected was 60 m at Adobe Lake on the Lower Colorado River. Nesting flycatchers were observed as low as 140 m at Topock Marsh and as high a 2530 m at the Greer town site.

In 1997, nest success or failure was documented at 131 of the 171 nesting attempts at 28 sites in Arizona. Of the 135 nests, an estimated 160 flycatchers fledged. The nest failure rate was 48%. Causes of nest failure included predation (29%), brood parasitism (8%), nest abandonment (7%), and unknown causes (3%) (McCarthey *et al.* 1998). Thirty-one percent of all parasitized nests were subsequently abandoned. One nest in Camp Verde, was parasitized, but successfully fledged at least one willow flycatcher. It is important to note that cowbird trapping programs occurred at seven of the monitored nest sites.

Table 3 lists all Federal agency actions that have undergone section 7 consultation and levels of incidental take permitted for the southwestern willow flycatcher rangewide since listing in 1995. As indicated in the table, many activities continue to adversely affect the distribution and extent of occupied and potential breeding habitat throughout Arizona. Stochastic events also continue to adversely affect the distribution and extent of occupied and potential breeding habitat. A catastrophic fire in June of 1996, destroyed approximately one km of occupied habitat on the San Pedro River in Pinal County. That fire resulted in the forced dispersal or loss of up to 8 pairs of flycatchers (Paxton *et al.* 1996).

<u>Reproductive Success</u>

Intensive nest monitoring efforts in California, Arizona, and New Mexico have revealed that: (1) sites with both relatively large and small numbers of pairs have experienced extremely high rates of brood parasitism; (2) high levels of cowbird parasitism in combination with nest loss due to predation have resulted in low reproductive success and, in some cases, population declines; (3) at some sites, the level of cowbird parasitism remains high across years, while at others parasitism varies temporally with cowbirds absent in some years; (4) the probability of a southwestern willow flycatcher successfully fledging its own young from a nest that has been parasitized by cowbirds is low (i.e., <5%); (5) cowbird parasitism and/or nest loss due to predation often result in reduced fecundity in subsequent nesting attempts, delayed fledging, and reduced survivorship of late-fledged young, and; (6) nest loss due to predation appears fairly consistent from year to year and across sites, generally in the range of 30 to 50%.

Table 3. Agency actions that have undergone section 7 consultation and levels of incidental take permitted for the southwestern willow flycatcher rangewide.

Action (County)	Year	Federal Agency	Incidental Take Anticipated
Arizona			
Cedar Bench Allotment (Yavapai)	1995	Tonto NF	Indeterminable
Tuzigoot Bridge (Yavapai)	1995*	NPS	None
Windmill Allotment (Yavapai)	1995	Coconino NF	Loss of 1 nest annually for 2 years
Solomon Bridge (Graham)	1995	FHWA	Loss of 2 territories
Tonto Creek Riparian Unit (Maricopa)	1995	Tonto NF	Indeterminable
Eastern Roosevelt Lake Watershed Allotment (Maricopa)	1995	Tonto NF	Indeterminable
Cienega Creek (Pima)	1996	BLM	1 nest annually by cowbird parasitism
Glen Canyon Spike Flow (Coconino)	1996	USBR	Indeterminable
Verde Valley Ranch (Yavapai)	1996*	Corps	Loss of 2 flycatcher territories
Modified Roosevelt Dam (Gila/Maricopa)	1996*	USBR	Loss of 45 territories; reduced productivity/ survivorship 90 birds
Lower Colorado River Operations (Mohave/Yuma)	1997*	USBR	Indeterminable
Blue River Road (Greenlee)	1997	A/S NF	Indeterminable
Skeleton Ridge (Yavapai)	1997	Tonto NF	Indeterminable
White Canyon Fire - Emergency Consultation (Pinal)	1997	Bureau	Harassment of 4 pairs
U.S. Hwy 93 Wickenburg (Mohave/Yavapai)	1997	FHWA	Harassment of 6 birds in 3 territories and 1 bird killed/decade

Table 3. Agency actions that have undergone section 7 consultation and levels of incidental take permitted for the southwestern willow flycatcher rangewide.

Action (County)	Year	Federal Agency[1]	Incidental Take Anticipated
Safford District Grazing Allotments (Greenlee, Graham, Pinal, Cochise & Pima)	1997	Bureau	Indeterminable
Lower Gila Resource Plan Amend. (Maricopa, Yavapai, Pima, Pinal, La Paz & Yuma)	1997	Bureau	Indeterminable
Storm Water Permit for Verde Valley Ranch (Yavapai)	1997	EPA	Indeterminable
Gila River Transmission Structures (Graham)	1997	AZ Electric Power Coop. Inc.	Indeterminable
Arizona Strip Resource Mgmt Plan Amendment (Mohave)	1998	Bureau	Harm of 1 nest every 3 years
CAP Water Transfer Cottonwood/Camp Verde (Yavapai/Maricopa)	1998	USBR	Indeterminable
Cienega Creek Stream Restoration Project (Pima)	1998	Bureau	Harassment of 1 bird
Kearny Wastewater Treatment (Pinal)	1998	FEMA	in consultation
Fort Huachuca Programatic (Cochise)	1998	US Army	in consultation
SR 260 Expansion (Yavapai)	1998	FHWA	in consultation
Wildlife Services (ADC) Nationwide consultation	1998	Wildlife Services	in consultation
California			
Prado Basin (Riverside/San Bernardino)	1994	Corps	None
Orange County Water District (Orange)	1995	Corps	None
Temescal Wash Bridge (Riverside)	1995	Corps	Harm to 2 flycatchers

Table 3. Agency actions that have undergone section 7 consultation and levels of incidental take permitted for the southwestern willow flycatcher rangewide.

Action (County)	Year	Federal Agency	Incidental Take Anticipated
Camp Pendleton (San Diego)	1995	DOD	Loss of 4 flycatcher territories
Lake Isabella Operations 1996 (Kern)	1996	Corps	Inundation 700 ac critical habitat, reduced productivity 14 pairs
Lake Isabella Long-Term Operations (Kern)	1997	Corps	Indeterminable
Nevada			
Gold Properties Resort (Clark)	1995	BIA	Harm to 1 flycatcher from habitat loss
Las Vegas Wash, Pabco Road Erosion Control Structure	1998	Corps	Harm to 2-3 pairs of flycatchers
New Mexico			
Corrales Unit, Rio Grande (Bernalillo)	1995	Corps	None
Rio Puerco Resource Area	1997	Bureau	None
Farmington District Resource Management Plan	1997*	Bureau	None
Mimbres Resource Area Management Plan	1997*	Bureau	1 pair of flycatchers
Belen Unit, Rio Grande (Valencia)	1998	Corps	Consultation in progress

BIA = Bureau of Indian Affairs; Bureau = Bureau of Land Management; Corps = Army Corps of Engineers; DOD = Dept. of Defense; EPA = Environmental Protection Agency; FEMA = Federal Emergency Management Agency; FHWA = Federal Highway Administration; NF = National Forest;
NPS = National Park Service; USBR = U.S. Bureau of Reclamation; USFS = U.S. Forest Service.

* Jeopardy opinions.

Table 4. Nest predation and brood parasitism rates documented for the southwestern willow flycatcher across its range[1].

Location	Pre-1993	1993	1994	1995	1996
S. Fork Kern River (Kern Co., CA)					
% nests parasitized[2]	50 - 80	38*	16*	19*	11*
% nests depredated	33 - 42	37	47	34	28
San Luis Rey River (San Diego Co. CA)					
% nests parasitized	-	-*	0*	0*	?
% nests depredated	-	-	28	5	?
Colorado River (Coconino Co., AZ)					
% nests parasitized	≥50	100	44	100	0
% nests depredated	-	30	78	0	0
Verde River (Yavapai Co., AZ)					
% nests parasitized	-	100	50	extirpated	extirpated
% nests depredated	-	100	50		
Little Colorado River (Apache Co., AZ)					
% nests parasitized	-	-	22	0	57
% nests depredated	-	-	33	28	14
Rio Grande (Socorro Co., NM)					
% nests parasitized	-	-	20	66	?
% nests depredated	-	-	40	60	?
Gila River (Grant Co., NM)					
% nests parasitized	-	-	-	16-27	?
% nests depredated	-	-	-	45	?

[1] Sources: Sogge and Tibbitts (1992), Sogge *et al.* (1993), Brown (1994), Maynard 1994, Muiznieks *et al.*(1994), Sogge and Tibbitts (1994), Cooper (1996, 1997), Sferra *et al.* (1997), Skaggs (1995), Sogge (1995a), Sogge *et al.* (1995), Parker (1997), Petterson and Sogge (1996), Spencer *et al.* (1996), Whitfield and Strong (1995), Whitfield and Enos (1996).

[2] Proportion of nests containing at least one brown-headed cowbird egg.

* Brown-headed cowbird control program implemented.

Nest loss due to predation is common among small Passerines. The rates documented for southwestern willow flycatchers are also typical for small Passerines (i.e., rates < 50%). However, even at these "typical" levels, nest loss due to predation is a significant factor contributing to low reproductive success. Especially in a depressed population, nest predation presents a difficult management challenge because of the variety of predators. Documented predators of southwestern willow flycatcher nests identified to date include common king snake (*Lampropeltis getulus*) and Coopers hawk (*Accipiter cooperii*) (McCarthey *et al.* 1998, Paxton *et al.* 1997). Efforts to reduce predation may include restricting activities in flycatcher habitat that attract predators, such as camping, picnicking, etc. where pets are loose and refuse is concentrated.

The data presented above and in Table 4 demonstrate that cowbird parasitism and nest depredation are affecting southwestern willow flycatchers throughout their range. Cowbirds have been documented at more than 90% of sites surveyed (Sogge and Tibbitts 1992, Sogge *et al.* 1993, Camp Pendleton 1994, Muiznieks *et al.* 1994, Sogge and Tibbitts 1994, T. Ireland 1994 *in litt.*, Whitfield 1994, C. Tomlinson 1995 *in litt.*, Griffith and Griffith 1995, Holmgren and Collins 1995, Kus 1995, Maynard 1995, McDonald *et al.* 1995, Sferra *et al.* 1995, Sogge 1995, 1996, San Diego Natural History Museum 1995, Stransky 1995, Whitfield and Strong 1995, Griffith and Griffith 1996, Skaggs 1995, Spencer *et al.* 1996, Whitfield and Enos 1996, Sferra *et al.* 1997, McCarthey *et al.* 1998). Thus, the potential for cowbirds to be a persistent and widespread threat remains high. Cowbird trapping has been demonstrated to be an effective management strategy for increasing reproductive success for the southwestern willow flycatcher as well as for other endangered Passerines (e.g., least Bell's vireo [*Vireo bellii pusillus*], black-capped vireo [*V. atricapillus*], golden-cheeked warbler [*Dendroica chrysoparia*]). It may also benefit juvenile survivorship by increasing the probability that parents fledge birds early in the season. Expansion of cowbird management programs has the potential to not only increase reproductive output and juvenile survivorship at source populations, but also to potentially convert small, sink populations into breeding groups that contribute to population growth and expansion.

ENVIRONMENTAL BASELINE

The environmental baseline includes past and present impacts of all Federal, State, or private actions in the action area, the anticipated impacts of all proposed Federal actions in the action area that have undergone formal or early section 7 consultation, and the impact of State and private actions which are contemporaneous with the consultation process. The environmental baseline defines the current status of the species and its habitat in the action area to provide a platform to assess the effects of the action now under consultation.

The Bill Williams River contains the last extensive native riparian woodland habitat in the lower Colorado River area. Much of the native riparian community, however, has been lost or severely degraded since construction of Alamo Dam. Dam operations have restricted flows of 10 cfs of sediment-poor water during much of the year. Additionally, long-duration water conservation releases (for periods greater than 60 days) sometimes inundate the vegetation. This altered water regime has severely stressed existing native vegetation, prevented natural recruitment of cottonwoods, and allowed native vegetation to be extensively replaced by nonnative salt cedar, which has much less habitat value. A properly functioning riparian ecosystem could be restored by implementing a flow regime that mimics the pattern of historic pre-dam flows.

There are both new and long-term ongoing actions in the project area. Effects of these activities on Alamo Lake and on the Bill Williams River watershed have had profound effects on the river and associated riparian areas. Water diversions and return flows, flood control projects, livestock grazing, feral burro grazing, recreational activities, and changes in annual flows due to off-stream uses of water have affected the distribution, stability, and regeneration of native riparian vegetation. Cottonwood-willow/saltcedar habitat has experienced a lack of recruitment of the cottonwood-willow component, except for a few sporadic events. Overuse of the riparian areas by livestock has hindered or eliminated most regeneration of cottonwoods, sycamores, and willows which could be used as perching or nesting substrate, until recently. A biological opinion with BLM on the Lower Gila Resource Area Plan Amendment (Service 1997b) provided for managing the burro herd to promote riparian regeneration and woody species recruitment, primarily in the lower Big Sandy and Santa Maria River areas.

Bald Eagle

Degradation of the riparian habitat within the Bill Williams River corridor has affected pairs of nesting bald eagles. The loss of riparian vegetation due to activities described above has affected the habitat of the bald eagle. Nests in the Alamo breeding area were usually placed in trees, primarily cottonwood snags killed by inundation at the upper lake inflow. Lack of cottonwood recruitment has left few or no suitable snags remaining. In the early 1980s, a pair of bald eagles, then a Federally listed endangered species, was discovered nesting in a partially inundated cottonwood tree within the upper reaches of Alamo Lake. Subsequently, another pair was discovered nesting on a bluff in the canyon wall downstream of the dam. The use of the lake by the eagles for foraging prompted the Service to request that the lake elevation remain within the range of 1,100-1,135 feet for the conservation of the eagles. The request was then made to ensure sufficient lake surface foraging area for the eagles living in the two nests. The 1,135 maximum lake elevation was requested to prevent inundation of the reservoir nest.

Bald eagles both winter and nest in the project area; thus, bald eagles may be found there any time of year and use the Big Sandy, Santa Maria, and Bill Williams Rivers, and Alamo Lake for foraging. In the latest published Arizona bald eagle winter count report (Beatty and Driscoll 1996), three adults and one subadult were found in the Alamo Lake area. Largemouth bass are an important prey item for bald eagles in the project area (Werner pers comm).

Three breeding areas are known from the project area: Chino, Alamo, and Ives Wash (Corps 1998). The Ives Wash breeding area is immediately downstream from Alamo Dam, Alamo is at the upper end of the lake, and Chino is on the lower Big Sandy River. The Chino site has been unoccupied for the last 10 years and is considered an historic breeding area in 1998 (Driscoll *et al.* 1998). Most breeding areas have several nests which are thought to provide several benefits, including avoiding infestations of nest parasites. These provide an alternative nest if the original nest becomes unusable, and advertise to other eagles that the territory is occupied. The Alamo and Ives Wash sites are of most concern in the project area, as the Chino area is upstream of lake influence (Corps 1994).

At 1,120 feet msl, the Alamo site is the lowest elevation breeding area in Arizona within the Lower Sonoran Life Zone. This breeding pair was established in 1986 when the radio tagged female from the Chino breeding area constructed a nest with a mate at the northern end of Alamo Lake. Two subsequent nests were also constructed in cottonwood snags in the northern end of the lake by 1990. The Alamo pair tended to nest early, laying eggs in early January. Young hatched approximately five weeks later. Two additional nests were constructed in cottonwood snags in the early 1990's. Record rainfall in 1993 resulted in unusually high water at the lake. Water levels quickly reached 1,130 feet in elevation resulting in the inundation of four nests. A clutch of two eggs were rescued and one egg was subsequently hatched at the Phoenix Zoo. The requirement to restrict the lake elevation to 1,120 feet from December 1 through July 15, was designed to protect a nest in a snag which no longer exists.

A new nest was established by the Alamo pair on the cliffs above Alamo Dam. Another clutch of eggs was subsequently fledged in 1993. Since none of the four inundated nests survived the flood and one entire cottonwood snag disappeared, nesting has usually continued in the cliffs. In 1996, the main supporting branch in what may be the last best cottonwood snag broke, sending the nest to the ground. The Alamo nest failed in 1997 (Beatty et al 1998).

The Ives Wash breeding area is located on the Bill Williams River approximately one mile downstream from Alamo Dam and on the upper reaches of Alamo Lake in Woody's cove. A pair has been observed nesting in Ives Wash since 1987 although adults are occasionally replaced. Although a cottonwood snag was used for nesting during one year prior to the 1993 flood, the nest within the cliffs above the Bill Williams River has been used consistently before and after the flood. The pair has been observed foraging both within the lake and along the Bill Williams River. Most foraging along the Bill Williams River was observed during the lower flow periods, when prey was more easily seen and caught (Corps 1994). The Ives Wash nest failed in 1997 (Beatty *et al.* 1998).

Despite recent setbacks (both nest failures in 1997), combined occupancy, success, and total productivity levels at the Alamo and Ives breeding areas are above the Arizona average. From 1987 to 1994, Alamo and Ives maintained an occupancy rate of 100 percent, a success rate of 87.5 percent, and an average productivity of 1.21 young fledged per breeding area per year. The overall Arizona population averaging a nesting success rate of 47.3 percent, and a productivity of 0.71 young fledged per BA per year (Service 1996).

In its Biological Opinion for the Operations of the Alamo Dam and Alamo Lake (Service 1996), the Service placed terms and conditions in its incidental take statement that the reservoir be maintained at a level of approximately 1,120 feet from December 1 through July 15 when bald eagles are nesting in snags. In its incidental take statement, the Service identified the likelihood of two nests being destroyed, take of four eggs or nestlings through harassment during rescue operations to avoid take by death, after opinion issuance in 1996 and through 1998. Reasonable and prudent measures were provided to minimize incidental take as follows: 1)reduction of the likelihood of drowning nestlings and/or eggs; 2) reduction of the likelihood of occupied bald eagle nest inundation, and; 3) reduction of the possibility of harassment of nesting bald eagles by the public.

Southwestern Willow Flycatcher

The altered flow regime of the Bill Williams River downstream of the Alamo Dam has resulted in the degradation of the riparian habitat (Bill Williams River Corridor Technical Committee, 1994). The major cause of the degradation has been attributed to the relative absence of maximum discharges which tended to result in reduced recruitment of cottonwoods (Shafroth, *et al.* 1998). Between 1,100 feet and 1,140 feet lies a delta dominated by younger cottonwood and willow trees (Corps 1996). Between 1,140 and 1,208 is a band of saltcedar. At the active channel, there is a mix of both cottonwood-willow and saltcedar dominated vegetation. Depending on lake level at the arrival of southwestern willow flycatchers, these habitats are available for breeding activities. Elevations of occupied territories in the confluence area are approximately 1,150; 1,160; 1,190; 1,200 feet msl, all above the 1,125 target elevation.

In 1995, six flycatcher territories were located along the Big Sandy River and nesting was confirmed for two of these territories (Arizona Game and Fish Department /Arizona State Parks 1997). Six breeding territories and two breeding pairs were also identified in the Bill Williams River National Wildlife Refuge (McKernan 1997). Surveys in 1996 and 1997 have confirmed the presence of breeding pairs immediately upstream of Alamo Lake near the confluence of Santa Maria and Big Sandy Rivers (McCarthey personal communication). Heavy rains and runoff from the 1997-1998 *El Niño* rainy season resulted in the inundation of a substantial portion of the willow habitat on the upper end of Alamo Lake (McCarthey personal communication). However, as of July, 1998, AGFD had reported 2 nesting pairs at the Bill Williams River National Wildlife Refuge, 5 territories with 2 pairs at Brown's Crossing, 6 territories with 3 active nests at the confluence of the Big Sandy River with Alamo Lake, and 2 territories with 1 pair at the Santa Maria confluence with Alamo Lake (Figure 2). Extended inundation may result in loss of willow habitat for the species. There is, however, potential for additional habitat for the southwestern willow flycatcher both at the upper end of Alamo Lake and the tributaries to the lake, as well as downstream of the Dam along the Bill Williams River.

As legitimate cattle grazing in the riparian sections of the action area is rarely authorized, effects of cattle grazing generally result from strays from adjacent areas. In the Bill Williams River, BLM has a standing trespass order for those public lands whereby any cattle found there are held to be in trespass and removed.

Two biological opinions have been issued within the action area concerning project effects to the southwestern willow flycatcher. A biological opinion dated August 27, 1997, considered effects of improving Highway 93 at the river crossings of the Big Sandy and Santa Maria Rivers. In this non-jeopardy opinion, short-term reduced productivity of two nests at the Big Sandy River and disruption of attempted nesting at the Santa Maria River was predicted. Cowbird trapping and habitat compensation are being implemented to offset the effects.

A biological opinion dated October 2, 1997, considered the effects of wild burro use in the lower Big Sandy and Santa Maria River areas. This non-jeopardy opinion considered incidental take to be habitat-related or from direct nest disturbance. To offset these effects, BLM will remove burros in the Alamo Herd Management Area in response to effects of burros on vegetation above a certain reference level.

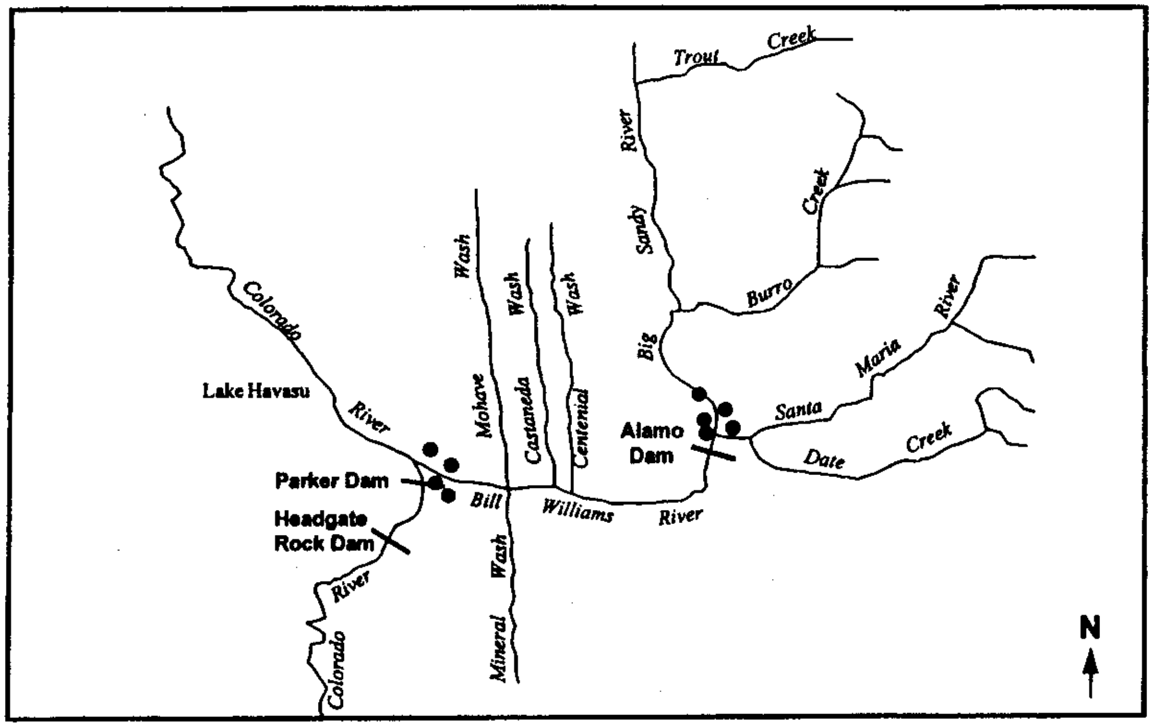
EFFECTS OF THE ACTION

Bald Eagle

Implementation of the Proposed Action would result in the management of the reservoir and downstream areas of the Bill Williams River to a level that more closely approximates natural river flows. Additionally, the Proposed Action would be consistent with the USFWS' recommendation that the reservoir level be maintained at a minimum level of 1,100 feet (BWRCTC 1994). The Proposed Action would make it easier to operate the dam during almost all but dam inspection periods and extreme drought conditions above this level.

If nesting again occurs in the cottonwood snags, the nests could still be prone to inundation during extremely heavy periods of rain, and therefore, would likely be adversely affected. Modeling for the period of record between 1928 and 1993 shows that reservoir peaks above 1,135 would have occurred seven times, or 11 percent of the period (Corps 1996). When inflows are high, releases with higher peaks than the past should reduce the elapsed time when the reservoir water surface elevation exceeds 1,135 feet. This would reduce the chance of take of bald eagles in cottonwood snags over some other alternatives considered. An often-used nest tree was situated at 1,138 feet in recent years. Maintenance at the 1,125 foot level would increase the aquatic resources within the lake. In turn, this is expected to increase the available food sources for the eagles in the area (BWRCTC 1994).

The riparian areas of the Bill Williams River would be subjected to a more natural water flow including periods of relatively high water flows. This is anticipated to result in a substantial enhancement and expansion of the riparian resources (Corps 1996). In the long term, this area is expected to become a more natural foraging area for bald eagles. It is also likely that additional recruitment of cottonwoods could occur within the Bill Williams River, increasing potential nesting sites.



● - Presumed Nesting Pairs

Not to Scale

Source: State of Arizona Heritage Program Data Base

Figure 2.
Distribution of Nesting Southern Willow Flycatcher in the Bill Williams River Watershed 1994-1996

Southwestern Willow Flycatcher

Implementation of the Proposed Action would likely increase riparian habitat downstream of the dam through the establishment of a more natural flow regime. Therefore, implementation of the Proposed Action would be expected to increase the habitat for the southwestern willow flycatcher in the Bill Williams River. The expected increase of likely suitable (saltcedar or cottonwood-willow) habitat with the proposed action is approximately 67 acres, a 6 percent increase over the future without the project. Most, but not all of this increase, is expected in the Bill Williams River.

The nature of impacts to habitat for southwestern willow flycatchers in the vicinity of Alamo Lake depend largely on where it is found. Dense stands of riparian vegetation, including Goodding willow (*Salix gooddingi*), become established episodically along the Santa Maria and Big Sandy River following spring floodflows. As spring flows recede many seedlings perish from lack of adequate soil moisture. Others which germinated in sites supported by baseflow of springs along the sides of the rivers may become established. In addition, seedlings located in the Bill Williams floodplain near the upper end of Alamo Lake may be supported for some time by high groundwater at the elevation of the lake, which is not a reliable source since the lake will recede due to evaporation at a rate of at least 6 vertical feet per year (pan evaporation in Phoenix) even without deliberate releases from the dam.

Willows and other riparian vegetation in the area depend to a large degree on baseflow of the Big Sandy and Santa Maria Rivers, resulting in the established vegetation occurring in or near the active channels of those rivers. Neither the Big Sandy or Santa Maria are regulated above Alamo Dam and both experience large increases in flow during flood periods. In February of 1993 the flow on the Big Sandy, at the gage in Wickiup upstream of the lake, ranged from 137 cfs to 68,700 cfs (USGS 1994). During the same month flows on the Santa Maria, at the gage near US 93, ranged from 133 cfs to 15,700 cfs (USGS 1994). The combined flows were on the order of 84,000 cfs below the confluence as the water entered Alamo Lake. Vegetation depending on base flow along the Big Sandy and Santa Maria Rivers was subject to intense scour and succession was set back to bare ground in much of the area. The riparian habitat at the upper end of Alamo Lake and along the Big Sandy and Santa Maria Rivers is consequently ephemeral and dynamic in nature.

In analyzing potential impacts of the proposed re-operation to nest sites from inundation by the lake, elevations of these sites were considered. Ground elevations at nest sites documented on the Big Sandy are approximately 1150 and 1200 feet msl. Ground elevations at nest sites documented on the Santa Maria are approximately 1160 and 1190 feet msl. Comparing inundation by the lake itself, as contrasted with inundation by floodflows which is part of the without project condition, the proposed re-operation includes maximal releases at a much lower elevation of the lake, generally reducing the likelihood of inundation of nests along the Big Sandy and Santa Maria Rivers. The HEC-5 analysis performed by the Corps concluded that the percent of time that the water surface of Alamo Lake would be between 1144 and 1154 feet msl would remain the same at 0.2% between the with and without project conditions and that the number of days the water surface would be above 1171.3 would drop from 27 to 0 based on the period of record (BWRCTC 1994).

In addition to considering probability of inundation by the lake, timing of inundation must be considered as well. High inflows into Alamo Lake typically occur early in the year. Since the proposed re-operation includes high releases at a much lower lake elevations, generally during or immediately following the inflow period, the probability that nest sites inundated early in the spring would no longer be inundated by late May, and therefore usable that year, would be higher with the proposed re-operation. This was the case in the high inflow year of 1998. Flycatchers had trees in which to build nests over water that had receded since the late winter-early spring period. Additionally, unless willows are completely submerged, the short period of inundation is unlikely to cause mortality of the trees.

There may be a slightly increased potential for inundation of some nesting sites near the lake itself during high inflow years with the proposed action, but reduced potential for inundation of nesting sites nearer the top of the water conservation pool. With all known nest sites occurring at or above 1,150, the frequency of reaching this elevation is expected to occur during the month of May only 1 in 500 years, and is even less frequent from June through August. The lake should reach its highest elevation in May. Direct take of birds at actual known nest sites is unlikely because the frequency of lake elevation rising markedly during the June-August nesting period is extremely low. Flows will exist above the target elevation of 1,125 feet about 1 in 7 years during the month of May forbidding the availability of this area for nesting. It is not clear how this will affect newly established sites for southwestern willow flycatcher. Flycatchers may establish at or near the 1,125 even though nesting is available at nearby higher elevation where known nests occur. Birds successfully establishing at or near the 1,125 level are not likely to be flooded later in the year. The establishment of 67 acres of new saltcedar or cottonwood-willow, may include some additional suitable willow flycatcher habitat. The net long-term effect should be an increase and enhancement of southwestern willow flycatcher habitat throughout the Bill Williams River system, primarily downstream of Alamo Dam.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act. The lands withing the action area are overwhelmingly Federally managed. Most actions are likely to have a Federal nexus. Therefore, few cumulative effects are expected. Recreation use, however, is likely to grow at a rate of 1.7 percent per year at which carrying capacity would be reached at 2030.

Bald Eagle

It is likely that the recreational use of Alamo Lake and potentially the Bill Williams River would increase in the future, due primarily to the increase in population and recreational demand as well as somewhat enhanced fisheries and recreational opportunities. This increased human presence in the area would increase the potential for human disturbance to nesting or foraging eagles. The Corps' ongoing conservation measures, however, would continue to reduce that effect.

Southwestern Willow Flycatcher

The AGFD is actively addressing effects of recreation, cattle and feral burros in the Alamo Lake area under its license agreement to manage the area for fish and wildlife purposes. To this end, investigations on impacts of burros to riparian habitat within the area have been completed. These effects are being addressed through ongoing land management planning which complements dam operation and water management planning outlined by the BWRCTC. Maintenance of fences is currently being considered as an additional management measure to help reduce impacts to riparian habitat. Coordination between AGFD and BLM is continuing to establish appropriate numbers and locations of burros for effective management and habitat.

CONCLUSION

After reviewing the current status of the southwestern willow flycatcher and the bald eagle, the environmental baseline for the action area, the effects of the proposed Alamo Lake Re-operation and Ecosystem Restoration and the cumulative effects, it is the Service's biological opinion that the action, as proposed, is not likely to jeopardize the continued existence of the southwestern willow flycatcher or the bald eagle. No critical habitat has been designated for the bald eagle, therefore, none will be affected. In Arizona, critical habitat for the southwestern willow flycatcher was designated along portions of the San Pedro River, Verde River, Wet Beaver Creek, West Clear Creek, Colorado River in the Grand Canyon, and the Little Colorado River and the West, East, and South Forks of the Little Colorado River. This project, however, does not affect those areas and no destruction or adverse modification of that critical habitat is anticipated.

This proposed action was deemed, by an interagency interdisciplinary group, to optimize benefits to bald eagles, southwestern willow flycatcher habitat, and other resources, among a host of alternatives, while still operating the plan to meet the project needs. Although there is a chance for incidental take of southwestern flycatchers due to rare inundation of nests from reservoir elevations over 1,150 feet in May and June, the most likely adverse effect will likely be infrequent inundation of habitat between the 1,125 and 1,140 foot elevations, not resulting in take of the known nest sites. Such inundation is expected to constitute a short-term setback in habitat availability and is more than balanced by the creation of new habitat. Bald eagles will have additional riparian habitat to use and a larger potential food supply in the reservoir. Since the breeding area most at risk now includes at least one cliff nesting site, and remaining large cottonwoods are further upstream, the chance for incidental take is diminished.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the Corps so that they become binding conditions of any grant or permit issued an applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require an applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(i)(3)]

AMOUNT OR EXTENT OF TAKE

Bald Eagle

The Service anticipates four bald eagle eggs or fledglings every ten years could be taken as a result of this proposed action. The incidental take is expected to be in the form of harm or harassment due to removal from nests to avoid inundation by rising lake levels, per the Corps' project description. Such inundation could occur in 11% of simulated years, as predicted in the HEC-5 analyses.

Southwestern Willow Flycatcher

The Service anticipates one nest with two eggs or fledglings every twenty years could be taken as a result of this proposed action. The incidental take is expected to be in the form of kill due to inundation. Inundation during the summer season is extremely unlikely and much less than the 11% of years predicted in the HEC-5 analyses.

The Fish and Wildlife Service will not refer the incidental take of any migratory bird or bald eagle for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 703-712), or the Bald and Golden Eagle Protection Act of 1940, as amended (16 U.S.C. §§ 668-668d), if such take is in compliance with the terms and conditions (including amount and/or number) specified herein.

EFFECT OF THE TAKE

Bald Eagle

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

Southwestern Willow Flycatcher

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

Bald Eagle

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of the bald eagle:

1. Reduce likelihood of drowning of nestlings and/or eggs.
2. Reduce the likelihood of loss of occupied bald eagle nests and snags
3. Reduce the likelihood of harassment of nesting bald eagles by the public

Southwestern Willow Flycatcher

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of the southwestern willow flycatcher:

1. Reduce the likelihood that sufficient habitat quantity and quality is compromised in the Big Sandy-Santa Maria confluence with Alamo Lake such that it supports less than the current population of flycatchers.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

Bald Eagle

To implement the reasonable and prudent measures the Corps shall complete the previously agreed upon Conservation Measures described in the Proposed Action of this document as modified from the 1996 Biological Opinion issued to the Corps. In addition, we add one term and condition (labeled 2.4) to replace the deletion of 2.1 and 2.3 from the 1996 biological opinion.

2.4 When bald eagles are nesting in snags on the lake, maintain the lake levels to ensure the protection and integrity of the nest structure and to allow response time for egg or nestling rescue during flood events. Operations shall be modified between December 1 and July 15, and be coordinated with personnel from the Service and AGFD. This requirement is not in force when bald eagles are nesting at the cliff sites.

Southwestern Willow Flycatcher

1.1 Habitat monitoring of the Big Sandy-Santa Maria confluence area, including areas occupied by southwestern willow flycatchers in 1998, shall be implemented on a yearly basis. Aerial extent and structure of riparian vegetation supporting flycatchers shall be quantified for trends over time and compared with inflows and lake levels. Lake elevations, and timing, during the reporting period will be compared with elevations of known southwestern willow flycatcher nest sites and timing of occupation, which, when used with other pertinent information, will be used as an assessment associated with dam operations.

1.2 Monitoring of southwestern willow flycatcher use of the confluence area, including areas occupied in 1998, shall be implemented on a yearly basis to ascertain take of individuals of the species that causes kill, harm or harassment to the species. This monitoring shall be accomplished using trained and permitted flycatcher biologists. AGFD has an ongoing program that could fulfill 1.2. The collection of presence/absence data will assist in documenting and monitoring territory establishment and breeding locations.

1.3 Make the monitoring data available to the expanding range-wide southwestern willow flycatcher Information Management System and Geographic Information System begun by U.S. Geological Survey-Biological Resources Division in Flagstaff, Arizona, and the Bureau of Reclamation in Phoenix. Having the Big Sandy-Santa Maria-Bill Williams birds on this system will ensure that monitoring data are shared and analyzed together with birds in the remainder of the species' range.

1.4 A report of the results of the monitoring, including complete and accurate records of all incidental take that occurred during the course of the project, shall be submitted to the Service yearly, on the anniversary date of the biological opinion accompanying this incidental take statement. This report will also describe how the terms and conditions of all reasonable and prudent measures in this incidental take statement were implemented.

1.5 At five year intervals, determine, in cooperation with AGFD and the Service, whether operations are allowing sustained habitat and productivity of flycatchers in the Big Sandy-Santa Maria inflow area. If, at any review period, it appears lake/dam operations are having a different effect than anticipated, prepare a strategy that conserves the flycatcher and its habitat at the confluence/inflow area.

Upon locating a dead, injured, or sick individual of an endangered or threatened species, initial notification must be made to the nearest Service Law Enforcement Office at Federal Building, Room 105, 26 North McDonald, Mesa Arizona, 85201 (telephone: 602/379-6443) or the Arizona Ecological Services Field Office at 602/640-2720, within three days of its finding. Written notification must be made within five calendar days and include the date, time, and location of the finding, a photograph of the animal, and any other pertinent information. The notification shall be sent to Law Enforcement with a copy to the Arizona Ecological Services Field Office. Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible state for later analysis of cause of death. In conjunction with the care of sick or injured endangered species or preservation of biological materials from a dead animal; the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed.

The Service believes that no more than four bald eagle eggs or fledglings every ten years and two southwestern willow flycatcher eggs or fledglings every twenty years will be incidentally taken as a result of the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The Federal agency must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1. Produce a pamphlet for distribution to the interested public on the values of riparian habitat, bald eagles, and southwestern willow flycatchers, and management efforts at Alamo Dam.

2. Continued shared funding of the Arizona Bald Eagle Nestwatch Program, coordinated by the Arizona Game and Fish Department after eventual delisting, would continue conservation efforts and help ensure adequate monitoring after recovery.

3. Contribute funding for wintering grounds surveys for the southwestern willow flycatcher

4. Contribute funding for a study to investigate the physiological condition/health of southwestern willow flycatchers breeding in native versus non-native habitats. This project has the potential of shedding light on whether non-native saltcedar is less productive nesting habitat for flycatchers compared to native tree habitat.

5. Contribute funding for the range-wide southwestern willow flycatcher Information Management System and Geographic Information System. Funding should be sufficient to cover the project area.

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

REINITIATION NOTICE

This concludes formal consultation on the actions outlined in your request. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

The Service appreciates the Corps' efforts on this project. It will have great long-term benefits to the riparian and aquatic resources in western Arizona and to endangered species conservation. We trust you will inform the other members of the Bill Williams River Corridor Steering and Technical Committees of our thanks. For further information please contact Debra Bills or Tom

Gatz. Please refer to the consultation number, 2-21-98-F-329, in future correspondence concerning this project.

Sincerely,

David L. Harlow
Field Supervisor

cc: Regional Director, Fish and Wildlife Service, Albuquerque, NM (GM:AZ/NM)
Complex Manager, Colorado River Refuges Complex, Yuma, AZ

Refuge Manager, Bill Williams National Wildlife Refuge, Parker, AZ
State Director, Bureau of Land Management, Phoenix, AZ
Director, Arizona Game and Fish Department, Phoenix, AZ
Director, Arizona State Parks, Phoenix, AZ

98-329.wp:DTB:jh

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EXHIBIT E.

GUIDANCE ON PREPARATION OF DEVIATIONS FROM APPROVED WATER CONTROL PLANS (CESPD R 1110-2-8)

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION CORPS OF ENGINEERS
333 Market Street
San Francisco, California 94105-2195

CESPD-MT-E

REGULATION
No. 1110-2-8

12 September 2002

Engineering and Design
GUIDANCE ON THE PREPARATION OF DEVIATIONS FROM APPROVED WATER CONTROL PLANS

1. PURPOSE. This document establishes the protocol for reporting deviations from approved Water Control Plans for water control projects within the South Pacific Division. It defines coordination, review, and approval procedures between the Division and District offices. Approval from Division must be obtained from all deviations (reference e., paragraph 6.b.) [1]

2. APPLICABILITY. The following is applicable to all South Pacific Division Districts and field-operating activities having civil works responsibilities.

3. REFERENCES. Authority and guidance can be found in:

a. ER 200-2-2 (33 CFR 230), 4 March 1988, subject: Procedures for Implementing NEPA.

b. ER 1105-2-100, 22 April 2000, subject: Guidance for Conducting Civil Works Planning Studies.

c. ER 1110-2-240 (33 CFR 222.5), 8 October 1982, subject: Water Control Management.

d. ER 1110-2-241 (33 CFR 208.1), 24 May 1990, subject: Use of Storage Allocated for Flood Control and Navigation at Non-Corps Projects.

e. ER 1110-2-1400, 30 September 1993, subject: Reservoir Water Control Centers.

f. ER 1110-2-8156, 31 August 1995, subject: Preparation of Water Control Manuals.

g. ER 1165-2-501, 30 September 1999, subject: Civil Works Ecosystem Restoration Policy.

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[1] This regulation supercedes CESPD-ET-EW Regulation, Subject: Guidance On The Preparation Of Deviations From Approved Water Control Plans dated 1 August 1999.

h. EP 1165-2-502, 30 September 1999, subject: Ecosystem Restoration – Supporting Policy Information.

i. EM 1110-2-3600, 30 November 1987, subject: Management of Water Control Systems.

j. CESPD R 1110-2-8, August 1999, subject: Guidance on the Preparation of Deviations From Approved Water Control Plans.

4. OVERVIEW.

a. Water Control Plans are prepared for all Corps projects and non-Corps projects within Federal flood control space. For Corps projects, the Water Control Plan is all encompassing in that it covers regulation of the project over the entire regime of pool elevations and conditions. The Corps' responsibility regarding non-Corps reservoirs is defined by Section 7 of the Flood Control Act of 1944 (58 Stat 890), which directs the Secretary of the Army to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds.

b. Water Control Plans define the regulation criteria and guidelines that govern how and when water will be stored and released from a project. The process of formulation and eventual approval of the Water Control Plan is a complex and time-consuming process because the plan must account for diverse goals (flood control, the environment, water quality, recreation, water supply, hydropower, etc.) and situations (e.g. normal, flood, drought, and emergency operations). Formulation of these plans requires a comprehensive knowledge of such diverse items as: project goals, project history, authorizing legislation, Corps policies and regulations, how a project interacts with other reservoirs within a basin, the role of other water interests/agencies, the effects to the general public in relation to environmental and aesthetic considerations, basin meteorology and hydrology, changing conditions (e.g. sedimentation, channel capacity, scour, etc.), and the physical capabilities of project features, such as outlet works, spillways, flood routing characteristics, etc.). Prior to approval and implementation, the proposed Water Control Plan is released for public review and comment. The public review process normally occurs concurrently with the NEPA public review process.

c. Deviations from approved Water Control Plans occur because every possible circumstance cannot be accounted for in a Water Control Plan. The competing goals and complex interactions of interested groups/agencies can cause even seemingly inconsequential deviations from an approved plan to lead to unforeseen environmental and legal complications. This regulation serves to assist a District in preparing their deviation requests. It outlines a minimum set of considerations that need to be addressed when making a recommendation to deviate from an approved Water Control Plan.

d. Deviations from approved Water Control Plans are intended, therefore, to address unforeseen and unique circumstances. They are not intended as a means for identifying or initiating new opportunities to re-operate or reallocate storage in response to new and changing public needs.

5. DEFINITIONS.

a. Emergency Deviations. An emergency deviation from an approved Water Control Plan is one that is required due to an emergency situation. An emergency situation is defined herein as a situation in which there is a potential for injury, loss of life, threat to the project, or other serious hazards; but furthermore, also demanding immediate action, such that time constraints render impractical notification to the division. Depending upon the need for immediate action, an emergency situation could include: drowning and other accidents, assistance to local authorities responding to an emergency (e.g. police and fire departments), failure of operations facilities, chemical spills, treatment plant failures, and other temporary pollution or water quality problems. Water control actions necessary to abate the problem are taken immediately unless such action would create equal or worse conditions.

b. Planned Deviations. Planned deviations cover all other deviations not addresses by an emergency deviation.

6. OFFICE OF RECORD. The originating District's water control management office will be responsible for maintaining all relevant records documenting the deviation.

7. GENERAL INFORMATION FOR PREPARING ALL DEVIATIONS.

a. Approval of Deviations. Approval for all deviations must be obtained from the Division Commander or delegated representative prior to their implementation. As noted in paragraph 5.a, an emergency deviation situation may warrant an immediate action, delegated to the Leader, Water Management Team or his designated representative. The Leader of the Water Management Team shall consult with the Chief of Engineering and Construction and appropriate SPD staff and subsequently advise the Director, Military and Technical Services Directorate of the temporary change. Approval may be made by telephone, E-mail, or FAX.

b. Preparation of Deviations. Processing of a deviation request originates at the District water control management office. The District Commander may delegate signature authority for requesting deviations from approved water control plans to the appropriate functional division head or designated representative. Consultation with the District staffs, including engineering, planning, environmental, economics, operations, construction and legal must take place.

c. Costs and Charges for Preparing Deviations. Deviations from approved Water Control Plans require a similar level of scrutiny as applied to permanent changes to a water control plan. Any District charges incurred for processing a deviation are to be assessed and collected from the agency/entity requesting the deviation. The District should estimate the cost to process the deviation and provide that estimate to the requesting agency/entity. The District must collect the funds (in a revolving fund advance account under Support for Others) prior to processing the deviation request. Examples of costs for which the requesting entity would be responsible include costs for any required reviews or studies concerning associated hydrologic, water control, legal, real estate, and environmental maters. After the deviation work is completed, any amount of funds left over in the account would be paid back to the requesting entity.

d. Fees for Water Supply Deviations. Deviations that result in Corps project flood control space being used for water supply purposes must address reimbursement by the sponsor to the Federal government for use of the flood control space. The district's deviation request package must include an economic analysis that determines a value for the reallocated flood control space. Section 7 projects will not require the economic analysis, as water supply charges are under the authority of the project owner.

e. Time to Prepare Deviations. District offices should also inform potential agencies/entities that the lead time required to assemble the necessary information required to evaluate a deviation request may be on the order of months (normally due to the required environmental analysis and the public review process). Thus, the request to the District should be made well in advance of the proposed initiation date fro the deviation. The requesting agency/entity should also be made aware that approval of the deviation request would depend upon such things as a review of the impacts (e.g., environmental, hydrologic, legal, etc.).

f. Coordinating with Division Staff. Preparation of a deviation package is a time consuming and costly undertaking, and incomplete or inadequate package can delay approval, District personnel are encouraged to coordinate any questions or concerns about potential deviations and to discuss any atypical situations with their Division counterparts early in the process and before the package submittal. All technical review will be conducted at the District level and will provide a review certification. In an emergency situation, a formal quality certification will most likely not be required. Appendix D lists the Division staff with which deviation-related issues are to be coordinated Division will provide updates to Appendix A as needed.

g. Non-Corps Projects. Deviation requests fro non-Corps (Section 7) projects must be prepared with the approval of the project owner. This is required because project owners are responsible for assuring that the project is operated as prescribed in the Water Control Plan developed in concert with the Corps' flood control interest. The owner is also ultimately responsible for dam safety at the project and for funding the project.

h. Environmental Requirements. Each deviation request shall include a summary of the environmental effects of the proposed deviation and a statement of how the proposal is in compliance with pertinent environmental requirements, including but not limited to the National Environmental Policy Act (NEPA), Endangered Species Act, the Clean Water Act, and the Clean Air Act and Section 176 Conformity Determination. NEPA documentation requirements ordinarily are met by an Environmental Assessment (EA) of the proposed action with a Finding of No Significant Impact (FONSI) signed by the District Commander. If an existing Environmental Impact Statement/Record of Decision or EA/FONSI accurately covers the action, and if there have been no environmental changes since that documentation, this can be cited. Supporting environmental documents shall be included in the deviation request package when it is submitted. Typically these will include an EA, a signed FONSI, a Biological Assessment, and a final Biological Opinion or a letter from Fish & Wildlife or National Marine and Fishery

Service concurring that there is not likely to be adverse effect on listed species. Sometimes other documents, such as 404(b)(1) evaluation are required. In the case of emergency deviation, the emergency provisions and requirements of he various environmental laws should be followed.

i. Required Information/Analysis. Table 1 outlines the information and analysis that are required in a deviation request package that is submitted to Division.

TABLE 1
Information and Analysis Required in a Deviation Request Package

a. Copy of sponsor's/project owner's letter requesting a deviation.
b. A description of the deviation.
c. Its effects on the operational objectives or project purposes.
d. A description of the potential flood threat over the period of the deviation.
e. The current and predicted maximum reservoir storage and elevation.
f. Documentation that the proposed deviation is in compliance with all pertinent environmental laws.
g. The effect on other agencies and individual interest.
h. The coordination that has taken place with other agencies.
i. Alternative measures that could be taken.
j. Recommendation/rationale on whether a permanent change to the Water Control Plan for this situation is warranted.
k. A District legal opinion.
l. Any recommended fees or reimbursements to the Federal Government.
m. Any other information that may be pertinent to the deviation request.
n. The District Commander's recommendation.
o. Quality Control Certification

8. PREPARING EMERGENCY DEVIATIONS

a. Emergency deviations are the only type of deviation that do not require prior approval from Division, and must only be used if events warrant an immediate emergency action, such that time constraints render impractical notification to the Division. However, even in an emergency situation, the District shall notify the Division of the action as soon as possible, and shall comply with all applicable requirements.

b. A record of the emergency deviation shall be developed at the district office and transmitted to the Division office within a day of the action taken.

c. Procedures for emergency deviations:

(1) Take the necessary action.

(2) Contact Division as soon as possible (See Appendix A for telephone numbers) to describe the action taken and the cause (NOTE: The order of (1) and (2) may be reversed depending on the nature of the emergency). Continuation of the deviation will require Division approval.

(3) The District shall provide written conformation to the Division office within 7 days of the deviation. The correspondence shall include the items outlined in Table 1 (as applicable).

(4) The Division shall respond within 3 days of the district's notification of the emergency deviation.

9. PREPARING PLANNED DEVIATIONS.

a. The District shall inform Division within 2 days of receiving a request for a proposed deviation.

b. At least 7 days prior to the proposed action, the District shall transmit a deviation request package to the Division office. The deviation request package shall include the items in Table 1. This package may be initially transmitted electronically.

c. The Division shall review the proposal and approve or disapprove the District's deviation request within 5 days, assuming a complete package with all required documentation has been received. Early, detailed, coordination and transmittal of documents to Division may reduce the processing time.

d. The District and Division shall follow-up with formal correspondence within 3 days of their electronically transmitted request (District) and approval/disapproval (Division).

10. SPECIAL CIRCUMSTANCES.

Per reference 3.c, Water Control Plans are subject to continuing and progressive study in order to keep them current. Should a new re-operation or reallocation opportunity be identified for a Corps project, then it should be addressed under authority of Section 216 of Public Law 911-611, an Initial Appraisal Report can be conducted with O&M funding to determine whether or not a study, if deemed appropriate, among other things, could initiate the process to incorporate the new opportunity in the project's Water Control Plan. Re-operation or reallocation studies for non-Corps projects would need to be initiated by the project owner.

FOR ROBERT L. DAVIS COL, EN
BG, USA DEPCDR
Commanding

1 Appendix
APP A – CESPD Phone list for Coordination of Water Control Plan Deviations
APP B - Quality Control Certification

DISTRIBUTION:
Electronic Copy Available

APPENDIX A

CESPD Phone List for Coordination of Water Control Plan Deviations

Note: Initial District notification to the Division shall be made to Water Management.

Water Management	Office
Donald Bergner	(415) 977-8101
Boni Bigornia	(415) 977-8102
Terry Mendoza	(415) 977-8106
Tom Wang	(415) 977-8120
Frank Khroun	(415) 977-8111
Ed Sing	(415) 977-8117

Internal SPD Coordination with Respective District Support Team Members

Legal

(SPN/SPA)	Mary Gillespie	(415) 977-8214
(SPL/SPK)	Dan Dykstra	(415) 977-8211

Planning & Environmental

(SPL/SPN)	Les Tong	(415) 977-8170
(SPA)	Jim Conley	(415) 977-8108
(SPK)	Clark Frentzen	(415) 977-8164

Real Estate

(SPL/SPN)	Marilyn Rodriguez	(415) 977-8188
(SPK/SPN)	Richard Guthrie	(415) 977-8186

Operations

(SPL/SPN)	George Domurat	(415) 977-8050
(SPK)	Phil Turner	(415) 977-8058
(SPA)	Jonathan Yip	(415) 977-8057

Program Management

(SPN)	Jeannie Hritz	(415) 977-8228
(SPK)	Marcelo Pascua	(415) 977-8232
(SPA)	Hoa Ly	(415) 977-8229

APPENDIX B

DISTRICT ENGINEER'S QUALITY CERTIFICATION

COMPLETION OF QUALITY CONTROL ACTIVITIES

The District has completed the review/analysis of the water control deviation from the Approved Water Control Plan for *(Project Name and Location).* Certification is hereby given that all quality control activities appropriate to the level of risk and complexity inherent in this analysis have been completed.

GENERAL FINDINGS

Compliance with clearly established policy principles and procedures, utilizing clearly justified and valid assumptions, data and the reasonableness of the results. The undersigned recommends certification of the quality control certification for this deviation request.

_____________*(Signature)*_____________ ____*(Date)*
Chief, Responsible Functional Element

CERTIFICATION OF LEGAL REVIEW*

The request f or a water control deviation from the approved Water Control Plan report for *indicate name of project*, has been fully reviewed by the Office of Counsel, and is approved as legally sufficient.

_____________*(Signature)*_____________ ____*(Date)*
District Counsel

QUALITY CERTIFICATION

All issues and concerns resulting from technical review of the water control deviation have been resolved. This deviation is recommended for approval.

_____________*(Signature)*_____________ ____*(Date)*
District Commander

EXHIBIT F.

DISTRICT CERTIFICATION
FOR APPROVAL OF
THE WATER CONTROL MANUAL

US ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT
DISTRICT ENGINEER'S QUALITY CONTROL CERTIFICATION

Alamo Dam and Lake Water Control Manual

COMPLETION OF QUALITY CONTROL ACTIVITIES

Los Angeles District, Engineering Division has completed the Alamo Dam and Lake Water Control Manual, Bill Williams River, Arizona. Certification is hereby given that all quality control activities defined in the Water Control Manual appropriate to the level of risk and complexity inherent in the project have been completed. An independent review of the Water Control Manual has been completed and the documentation of the quality control process is enclosed. The manual has been reviewed for technical and functional adequacy and has been revised in response to the local interest groups and the District Independent Technical Review Team. The updated final document is available at the following web site:
http://www.spl.usace.army.mil/resreg/htdocs/ITRT_Review_Documents.htm.

Brian Tracy 11/6/03
Brian Tracy *-Date-*
Independent Technical Review Manager

Joseph B. Evelyn 11-6-03
Joseph Evelyn, P.E. *-Date-*
Chief, H & H Branch

QUALITY CONTROL CERTIFICATION

As noted above, all issues and concerns resulting from technical review of the product have been resolved.

Terri Kaplan Chief, Real Estate Division	11/10/03 Date
For Ruth Villalobos Chief, Planning Division	11/10/03 Date
For Larry Minch Chief, Office of Counsel	11/13/03 Date
George L. Beams, P.E. Chief, Construction-Operation Division	11/13/03 Date
Robert E. Koplin, P.E. Chief, Engineering Division	11/13/03 Date
Brian Moore Chief, Programs & Project Management Division	11/13/03 Date
Richard G. Thompson Colonel, U.S. Army District Engineer	11/14/03 Date