US Army Corps of Engineers®

# Water Control Manual

DRAFT

## Chariton River Basin
## Rathbun Dam and Reservoir
## Iowa

## Kansas City District

**Revised**

**_____ 2015**

# WATER CONTROL MANUAL

# RATHBUN DAM AND RESERVOIR

Chariton River Basin
Iowa

DRAFT

U.S. ARMY CORPS OF ENGINEERS

NORTHWESTERN DIVISION, OMAHA, NEBRASKA

KANSAS CITY DISTRICT, KANSAS CITY, MISSOURI

JULY 2015

# Rathbun Dam

Intake Tower

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3,000 cfs Outlet Release on July 26, 2010

## NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual (WCM) be used in loose-leaf form, 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 WCM current. Changes to individual pages must carry the date of revision, which is the Division's approval date.

## REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during duty hours, please contact the Water Management Section, Hydrologic Engineering Branch, Kansas City District Office at (816) 389-3545. If this office cannot be contacted, assistance can be obtained by contacting one of the numbers listed below. In emergencies during non-duty hours call the District's 24-hour Emergency Management Line at (816) 426-6320. Section VII of this WCM contains detailed instructions for emergency regulation.

### DAYTIME CONTACT NUMBERS

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| OFFICE | TELEPHONE |
|---|---|
| Emergency Management Branch | (816) 389-3282 |
| Hydrologic Engineering Branch | (816) 389-3159 |
| Water Management Section | (816) 389-3545 |
| Rathbun Project Office | (641) 647-2464 |

WATER CONTROL MANUAL

Rathbun Reservoir and Dam

U.S. Army Corps of Engineers
Kansas City District/Northwestern Division
April 2015

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## PERTINENT DATA

a. Location: Rathbun Dam is located at mile 142.3 on the Chariton River in Appanoose County, Iowa. The dam is 5 miles north of Centerville, 1.8 miles north of Rathbun, 3.9 miles upstream from Walnut Creek, and 30.1 miles upstream from the Iowa-Missouri state line.

b. Drainage Area: The contributing drainage area above Rathbun Dam is 549 square miles. One inch of uniform runoff over this area would result in 29,280 acre feet of runoff into Rathbun Reservoir.

c. Dam, Outlet and Spillway Data: The dam is an earth fill structure with a length of 10,600 feet, and maximum height of 101 feet above the streambed. The dam has a crest elevation of 946 feet, and a top width of 30 feet. A gated outlet conduit is located in the right abutment of the dam. The intake invert elevation is 855.0 feet and the outlet invert is at 852.0 feet. The single conduit has an 11 feet horseshoe shape and is 539 feet long. Two 2.0 feet x 2.0 feet hydraulic slide auxiliary gates are located in the main gate for low flow releases. An uncontrolled spillway is located near the right abutment with a crest elevation at 926 feet and a crest width of 500 feet.

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d. Real Estate Procurement:

Fee Taking Line: Elevation 931.0 feet, (NGVD 29)

Flowage Easements: Acquired in remote areas of the lake where it was a financial advantage to the Government to acquire easements

e. Storage & Discharge:

| | Elevation (ft NGVD 29) | Surface Area (Acres) | Total Storage (AF) | Increment Storage (AF) | Spillway Capacity (cfs) | Outlet Capacity (cfs) |
|---|---|---|---|---|---|---|
| Surcharge | 940.0 | 31,135 | 939,392 | 368,859 | 45,600 | 5,680 |
| Flood Pool | 926.0 | 22,452 | 570,533 | 349,173 | 0 | 5,160 |
| Multipurpose | 904.0 | 10,329 | 221,360 | 221,360 | 0 | 4,200 |
| Streambed | 845.0 | 0 | 0 | 0 | 0 | 0 |

Area-Capacity-Elevation Data Revised January 2000
Original Sediment Reserve 24,000 acre feet

**ABBREVIATIONS**

| | |
|---|---|
| WCM | Water Control Manual |
| USACE | U.S. Army Corps of Engineers |
| WCP | Water control plan |
| NWK | Kansas City District of the U.S. Army Corps of Engineers |
| NGVD29 | Sea Level Datum of 1929 or National Geodetic Vertical Datum of 1929 |
| NAVD88 | North American Vertical Datum of 1988 |
| NOAA | National Oceanic and Atmospheric Administration |
| AF | Acre-feet |
| DM | Design Memorandum |
| cfs | Cubic feet per second |
| ER | Engineering Regulation |
| MPP | Multipurpose pool |
| NWD | Northwestern Division |
| MRBWM | Missouri River Basin Water Management |
| WLMP | Water Level Management Plans |
| NRCS | Natural Resources Conservation Services |
| IDNR | Iowa Department of Natural Resources |
| USGS | U.S. Geological Survey |
| USPHS | U.S. Public Health Service |
| ppm | Parts per million |
| NWS | National Weather Service |
| DCPs | Data Collection Platforms |
| GOES | Geostationary Orbiting Environmental Satellite |
| CWMS | Corps Water Management System |
| Iowa DOT | Iowa Department of Transportation |
| FTP | File Transfer Protocol |
| RFC | NWS River Forecast Center |
| LAN | Local Area Network |
| NWSRFS | National Weather Service River Forecast System |
| API | Antecedent Precipitation Index |
| SAC-SMA | Sacramento Soil Moisture Accounting |
| HEC-HMS | Hydrologic Engineering Center Hydrologic Modeling System |
| RRWA | Rathbun Regional Water Association |
| WRP | Wetland Reserves Program |
| EWRP | Emergency Wetlands Reserve Program |
| EA | Environmental Assessment |
| MDC | Missouri Department of Conservation |
| USFWS | U.S. Fish and Wildlife Service |
| MDNR | Missouri Department of Natural Resources |
| MGD | Millions of Gallons per Day |
| POR | Period of record |

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# 1 - INTRODUCTION

## 1-01. Authorization.

This WCM has been prepared as directed in ER 1110-2-240, Water Control Management, and is in compliance with instructions contained in ER 1110-2-8156, Preparation of Water Control Manuals. Construction of Rathbun Dam was authorized by the Flood Control Act of 1954 (Public Law 83-780).

## 1-02. Purpose and Scope.

Rathbun Dam was constructed by the U.S. Army Corps of Engineers (USACE) on the Chariton River, near Rathbun, Iowa, as part of a comprehensive plan for flood control and water resource development in the Missouri River basin. This WCM includes descriptions of the project authorized purposes, project features, project history, watershed characteristics, data collection and communication networks, forecast methodology, water control plan (WCP), effect of the WCP, and water control management.

## 1-03. Datum.

In the original design and construction of Rathbun Dam, elevations on design drawings and reservoir levels were referenced to the Sea Level Datum of 1929, which was based upon measured water levels at 26 tide stations in the United States and Canada, and commonly referred to as "feet above mean sea level". In 1973 the Sea Level Datum of 1929 was renamed the National Geodetic Vertical Datum of 1929 (NGVD29). The NGVD29 datum was subsequently replaced by the North American Vertical Datum of 1988 (NAVD88) as the current vertical reference datum used by the National Oceanic and Atmospheric Administration (NOAA). NAVD88 is based upon a single point as the reference point from which all other elevations are measured. The NAVD88 datum is more accurate than the NGVD29 datum, and takes into account variations in earth surface due to subsidence and rebounding, and distortions caused by gravity. Corps policy specifies that all projects be referenced to the current NOAA vertical reference datum (NAVD88) in ER 1110-2-8160.

In this WCM, reservoir and river levels use the NGVD29 datum and have not been converted to the NAVD88 datum because of the desire to provide reservoir and river levels that are consistent with historical events and the original design drawings for the project. The conversion from NGVD29 datum to NAVD88 datum varies depending upon location. At Rathbun Dam, to convert from NGVD29 to NAVD88 datum, add 0.04 feet. Within this WCM, elevations will be with regards to NGVD29 unless otherwise stated. The following table provides conversion for bench marks in the Rathbun Reservoir area.

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**Table 1-1: Conversion from NGVD29 to NAVD88 Elevation**

| Point Name | Elevation in feet (NAVD88) | Elevation in feet (NGVD29) | Delta Elevation in feet | Latitude | Longitude |
|---|---|---|---|---|---|
| Tower LT | 953.16 | 953.12 | 0.04 | 40 50 02.48046 N | 92 52 30.12675 W |
| BM TSD | 944.95 | 945.02 | 0.07 | 40 49 24.62706 N | 92 53 39.91667 W |
| BM RT-A | 925.72 | 925.76 | 0.04 | 40 49 17.15426 N | 92 53 48.32405 W |
| BM C-LT | 944.02 | 944.04 | 0.02 | 40 50 12.95649 N | 92 52 09.57121 W |
| BM Office | 965.70 | 965.70 | 0.00 | 40 49 08.20548 N | 92 54 08.62324 W |

**1-04. Related Manuals and Reports.**
Rathbun Reservoir is the only flood control reservoir constructed by USACE in the Chariton Basin. This WCM supersedes the Chariton River Basin Lake Regulation Manual, Rathbun Lake, Iowa, dated May 1974, as revised September 1980. Other prior reports pertinent to the project include:

**Design Memorandum No. 2, Hydrology.**
This memorandum, dated February 1957 and revised December 1961, recommended 132,000 AF of storage for conservation and 24,000 AF for sediment reserve. This represents no change in total project storage, but does include a reallocation of 2,000 AF of storage from conservation to sediment reserve to provide for 100-year project life. No operating plan for use of the storage was provided.

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**Design Memorandum No.3, General.**
This memorandum, dated March 1963 and revised March 1964, included a recommendation for raising the full pool elevation by 2.7 feet to provide an additional storage of 50,000 AF in the conservation pool for water quality control purposes. Addition of this storage would place the elevation of the top of conservation pool at 903.7 ft, as opposed to an elevation of 898.6 ft for the 132,000 AF of storage proposed by DM No. 2. Investigations into the recreation potential, the desirability of water quality control storage, the water supply potential, the needs for navigation supplementation, and fish and wildlife storage requirements led to the initial storage allocations. The storage was reallocated in 1985 and the current storage allocations are provided on Plate 1-1. Minimum flow requirements for water quality control were established at 11 cfs, to be increased by the year 2060, as required, to 33 cfs. Storage assigned to navigation supplementation would be released for that purpose, as originally authorized. No additional regulation criteria were presented.

Related manuals are provided in Table 1-2.

**Table 1-2: Related Manuals – Rathbun Project**

| TITLE | APPROVAL DATE |
|---|---|
| Rathbun Dam & Reservoir, General Design Memorandum No. 2, Hydrology | February 1957 |
| Rathbun Dam & Reservoir, General Design Memorandum No. 3, General and Appendices | March 1963 |
| Rathbun Dam & Reservoir, General Design Memorandum No. 8, Outlet Works | July 1964 |
| Rathbun Dam & Reservoir, General Design Memorandum No. 7, Soil Data, Embankment Design and Spillway | December 1964 |
| Rathbun Dam Master Plan, Design Memorandum No. 5C | March 1970 |
| Rathbun Dam & Reservoir, General Design Memorandum No. 8, Stilling Basin Repair | December 1978 |
| Rathbun Dam & Reservoir, General Design Memorandum No. 5C, Appendix F, Lakeshore Management Plan | February 1980 |
| Rathbun Dam & Reservoir, General Design Memorandum No. 17, Seepage Collector System | November 1987 |
| Rathbun Dam & Reservoir, General Design Memorandum No. 16, Fish Hatchery Intake | January 1990 |
| Rathbun Dam & Reseroir, O&M Manual Volume III, Dam Surveillance Plan | 2002 |
| Rathbun Dam & Reseroir, O&M Manual Volume II, Emergency Action Plan | 2011 |

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**1-05. Project Owner.**
Rathbun Reservoir is owned by USACE.

**1-06. Operating Agency.**
The Kansas City District of the U.S. Army Corps of Engineers (NWK) is the operating agency for Rathbun Reservoir. The project office is manned during normal business hours five days a week during the winter and seven days a week during other times of the year. The project office contact information is:

Rathbun Project Office
20112 Hwy J5T
Centerville, Iowa 52544
Office Telephone 641-647-2464

**1-07. Regulating Agencies.**

Engineering Regulation (ER) 1110-2-240, dated August 1995, stipulates that District Commanders are primarily responsible for background studies and for developing plans and manuals required for reservoirs, locks and dams, major control structures, and interrelated systems in their respective areas. Policies and general guidelines are prescribed by ERs, while specific requirements to implement these guidelines are established by the Division Commander. Division Commanders are delegated the primary responsibility for water control management within their respective areas and for evaluations and performance of activities associated therewith. Division Commanders are delegated the authority for review and approval of the WCP, WCM and associated activities. Division Commanders are responsible for providing management and technical assistance required to assure that plans and manuals are prepared on a timely and adequate basis, and for pertinent coordination among districts, divisions, and appropriate entities. It is the role of the District Water Management Section to make hydrologic forecasts for use in the regulation of the reservoirs for flood control and other authorized purposes, and for the benefit of USACE constructed projects and flood-mitigating activities. The District Water Management Section staff also provide release change orders for day-to-day lake regulation consistent with hydrologic forecasts and water control plan criteria. The day-to-day coordination with stakeholders and other responsible Federal, State, and local agencies is the responsibility of the Water Management Section staff and the Rathbun Project Office staff.

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# 2 - DESCRIPTION OF PROJECT

## 2-01. Location.

Rathbun Dam is located at mile 142.3 on the Chariton River, a left bank tributary of the Missouri River. The Dam is in Sections 25, 35, and 36, Township 70N, Range 18W, in Appanoose County, Iowa, about 5 miles north of Centerville, and 16 miles north of the Missouri-Iowa State line. A location map of the Chariton River basin is provided as Plate 2-1. The Rathbun Dam components and immediate downstream area are illustrated in Figure 2-1.

## 2-02. Purpose.

Rathbun Reservoir is a multipurpose project for flood control, water supply, water quality, navigation, recreation, and fish and wildlife. The authorizing documents for these purposes are:

a. PL 83-780 Flood Control Act of 1954 (flood control, navigation, water quality).

b. PL 78-534 Flood Control Act of 1944 (recreation).

c. PL 85-624 Fish and Wildlife Coordination Act (fish/wildlife)

d. PL 85-500 Water Supply Act of 1958 (water supply)

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## 2-03. Physical Components.

The relative locations of the physical components are provided in Figure 2-1.

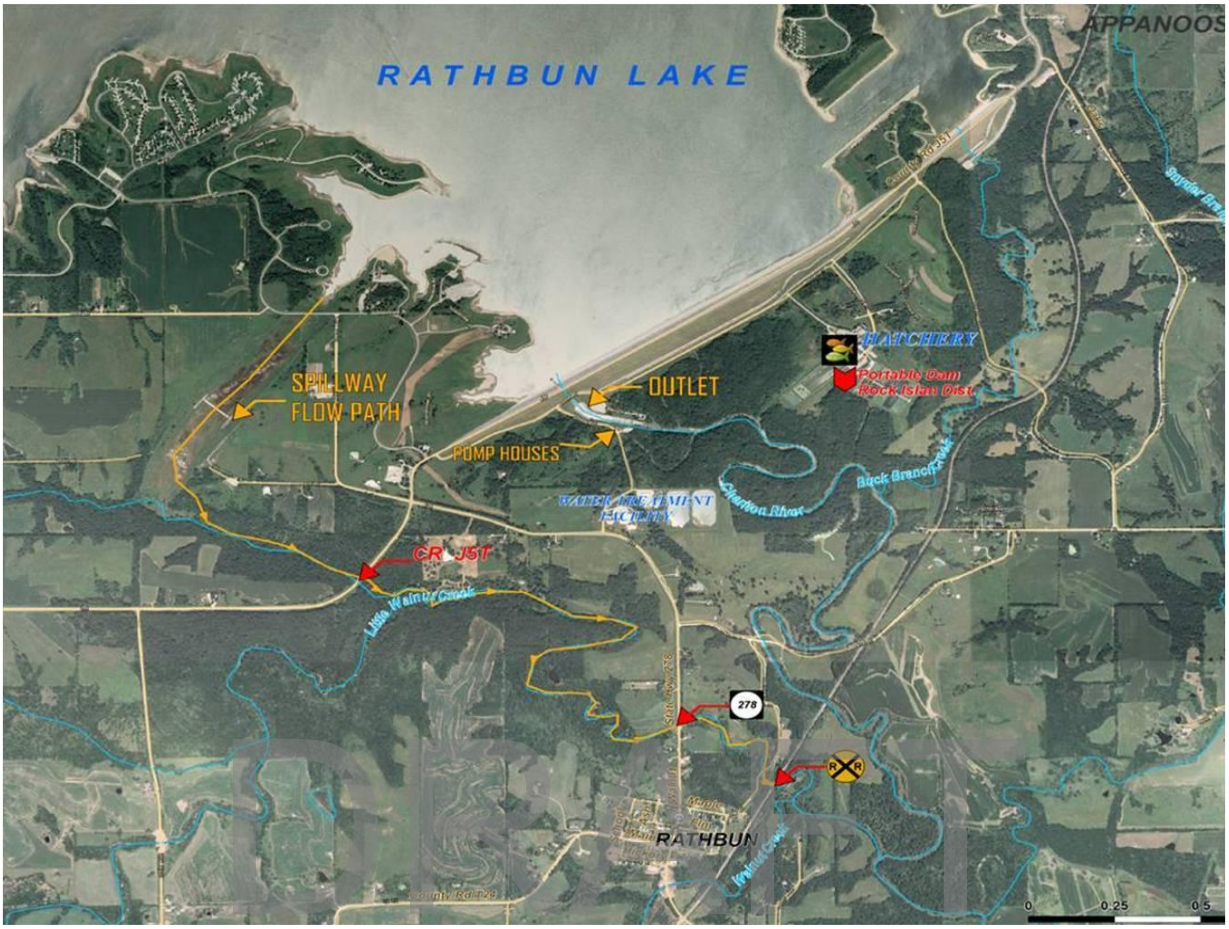


**Figure 2-1: Rathbun Dam**

**Embankment.**

The Dam consists of two zoned rolled earth embankments separated by high ground. The larger, primary, embankment crosses the Chariton valley embankment and the smaller embankment crosses Buck Branch to the northeast of the Chariton embankment. Total project length is 10,600 feet (8,160 feet Chariton embankment, 1,960 feet Buck Branch embankment), the crest elevation is 946.0 ft, and the maximum height crest to streambed is 102 feet (75 feet Buck Branch embankment). Both embankments are similarly zoned and include random fill on the upstream and downstream faces surrounding a central impervious core. The embankment has a maximum base width of 800 feet and a top width of 30 feet. The upstream face of the embankment is protected by riprap and the downstream slope is grass covered. The embankments have variable slopes on the upstream and downstream. The crest of the Dam is crossed by a hard-surfaced road. Seepage through the embankments is filtered by pervious drains on the downstream sides of the cores (below elevation 926) and includes horizontal portions that exit at the downstream toes. In addition to upstream blanketing, foundation underseepage is controlled at each embankment by relief wells

at the downstream toes. Historical seepage through the high ground between the embankments is controlled with a buried collector system. A freeboard allowance of 6 feet above the top of the design surcharge pool has been adopted by use of a sustained wind velocity of 45 miles per hour in the direction of maximum fetch. Plan and section views of the Dam are shown on Plate 2-2.

**Spillway.**
The uncontrolled spillway is located approximately 3,000 feet west of the right abutment. It is 500 feet wide at its base, 3,600 feet long, and discharges into a tributary of the Chariton River below the Dam. A concrete control sill, at elevation 926.0, is located approximately midway between the intake and outlet ends. The side slopes are 1V on 3H and the base and sides are grass, except in the vicinity of the sill where riprap protects the side slopes for a distance of 100 feet upstream and 200 feet downstream. Discharge capacity of the spillway at the top of the design surcharge pool, elevation 940.0, is 45,600 cfs. The rating curve for the spillway is shown on Plate 2-3.

**Outlet Works and Stilling Basin.**
The outlet works is composed of one 11-foot horseshoe conduit, 539 feet long with intake and outlet inverts at elevations 855.0 and 852.0, respectively, preceded by two rectangular passages, each 6 feet wide and 12 feet high. Each passage contains an emergency gate and a service gate, both hydraulically operated, in the intake tower. A small slide gate, 2 feet by 2 feet, also hydraulically operated, is incorporated in each service gate to control low flows. The control valves and indicators for both the service gates and the low flow gates are located in the intake tower control room, together with the hydraulic pumps, and control valves. Hydraulically operated indicators are provided for precise knowledge of the various gate openings at all times. Manually operated hanger devices are provided to hold the gates in open position for extended periods of time. The outlet works discharge into a concrete stilling basin. The base of this structure is at elevation 835.5 and extends for a distance of 81 feet. Two rows of staggered baffle blocks, 3 feet high and 3 feet 9 inches square, are provided as energy dissipaters. Concrete training walls extending to elevation 864.0 form the sides of the basin. Rating curves for the outlet works are shown on Plate 2-4. Plate 2-5 illustrates the outlet works and intake tower.

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**Stilling Basin Modification.**
Observation of stilling basin activities during the passage of flows most frequently experienced at Rathbun Dam, 200 to 2,000 cfs, disclosed poor flow conditions to exist within the basin. Model studies made by USACE Waterways Experiment Station confirmed the poor flow conditions. It was found that within the range of discharges mentioned above, flow separated from the sidewalls and eddies developed in the basin due to high tailwater. It was also found that currents near the bottom of the channel were in an upstream direction. It is known that rocks are at times thrown into the basin. With flows moving in an upstream direction and the eddy movement previously referred

to, riprap pulled from the downstream channel, along with debris collected from other sources, is moved around over the bottom slab causing a considerable amount of wear. To counteract these conditions, a repair plan was chosen in which a concrete overlay was placed on the stilling basin floor. The overlay was of constant slope, beginning about 26 feet downstream of the end of the conduit and extending downstream for about 78 feet. The overlay covers the downstream two-thirds of the transition slab and the upstream one-third of the basin slab. At the junction of the transition and basin slabs, the overlay is slightly over six feet thick. In addition to the overlay, the end sill of the stilling basin was raised ten feet to block the upstream movement of riprap. The modification apparently does not improve the hydraulic characteristics of the basin, but it does prevent riprap from being pulled into the basin. In addition, the raised sill provides a considerable amount of sacrificial concrete for anticipated future erosion. The modification was constructed in two separate contracts, the first in 1978 and the second one in 1988. The stilling basin modification is shown on Plate 2-6.

During the flood event of 2010, additional riprap was placed around the stilling basin to facilitate a release of 3,000 cfs. The riprap material maintained the stability of the stilling basin even though the water overtopped the training walls. After the flood events, a concrete slab was constructed around the basin and the outlet channel riprap was extended downstream. A description of the 2010 event is provided in section 4-06 (j).

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**2-04. Related Control Facilities.**

Facilities for releasing up to 13 cfs for the State Fish Hatchery are incorporated within the outlet works through a separate conduit. The conduit is an 18 inch diameter steel pipe with cement mortar lining, and is encased in concrete. The inlet, with invert elevation 887.0, is located at the upstream end of the center pier of the intake tower. The upstream valve for emergency closure is exposed and operable within the gate chamber. If it becomes necessary to bulkhead the inlet, the trash screen may be removed and stoplogs installed through the platform. Progressing downstream from the valve, the pipe is embedded in concrete between the gate bonnets above the dividing pier, then emerges and piggybacks on top of the conduit section encased with 12 inches of concrete. Releases to the hatchery are regulated from a valve pit located in the parking area near the stilling basin.

**2-05. Real Estate Acquisition.**

Lands acquired for Rathbun Reservoir were obtained pursuant to the "Joint Policies of the Departments of the Interior and Army, Relative to Reservoir Project Lands" as published in the Federal Register of 22 February 1962 and in compliance with ER 405-2-150, paragraph 13. In general, fee title was acquired to elevation 931.0, or 300 feet horizontally from full pool elevation 926.0 (whichever is the greater) blocked out along practical property subdivision lines. Flowage easements were acquired in remote areas

of the reservoir where it was a financial advantage to the Government to acquire easements. In other areas, perpetual and assignable easements were acquired for road rights-of-way. In all, a total of 33,908 acres were obtained in fee and 2,164 acres were acquired in easements.

**2-06. Public Facilities.**

Federal, State, and local interested agencies have conducted investigations and prepared recommendations regarding developments for purposes of recreation and fish and wildlife enhancement at Rathbun Reservoir. Design Memorandum No. 5C, Master Plan, dated March 1970, shows one State park, nine recreation areas, and one concession area, totaling altogether 4,835 acres, proposed for initial and ultimate development. Public use facilities available at the Rathbun Project are shown on Plate 2-7.

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# 3 - HISTORY OF PROJECT

## 3-01. Authorization.

Construction of Rathbun Reservoir was authorized by the Flood Control Act of 1954 (Public Law 83-780) substantially in accordance with recommendations by the Chief of Engineers as presented in House Document No. 561, 81st Congress, 2d Session, for the purposes of flood control, silt control, low-flow supplementation, and other conservation purposes. Capacity of the project for all purposes totaled 483,000 AF.

## 3-02. Planning and Design.

Federal participation in the field of water resources began with establishment of the Federal Extension Service in 1915. The basic flood control report on the Missouri River and Minor Tributaries (including the Chariton River) was made in 1932 under the provisions of House Document No. 308, 69th Congress, and was printed as House Document No. 238, 73rd Congress. Channel improvements and related works on certain reaches of the Chariton River in Missouri were recommended in 1942 in House Document No. 628, 78th Congress, and authorized by the Flood Control Act of 1944, Public Law 78-534. House Document No. 561, 8lst Congress, dated April 1950, contained the recommendation for Rathbun Reservoir. Construction of the reservoir was authorized by the Flood Control Act of 1954, Public Law 83-780. Public Law 89-298, Flood Control Act of 1965, authorized the measures recommended in House Document No. 238, 89th Congress, consisting of flood control improvements along Mussel Fork and Shoal Creek, major Chariton River tributaries

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## 3-03. Construction.

Construction began September 26, 1964 and closure of the Dam was made on September 29, 1967. Filling of the pool and multipurpose operations at the project began November 21, 1969, and the multipurpose pool (MPP) first filled October 10, 1970.

## 3-04. Related Projects.

**a. U.S. Army Corps of Engineers Local Protection Projects.** The Chariton River flood control project, authorized by the Flood Control Act of 1944, included three sections of channel improvement: Chariton County Unit, Macon-Adair Counties Unit, and Reinhart Ranch Unit, as well as tieback levees at the mouth of the river. These improvements, except the tieback levees, were initiated in 1948 and completed in 1952. The cost of the project, revised in 1959, was $4,313,000 of which $4,050,000 was Federal cost for construction and $263,000 was the cost of lands and damages to be borne by local interests.

1. Chariton County Unit. This unit consisted of channel cutoffs, channel blocks, and improvements to the then existing channel from the mouth of the Chariton River to the vicinity of Missouri State Highway No. 129 bridge, a distance of approximately 20 miles. The project included a cutoff which moved the mouth of the Chariton River upstream from Missouri River mile 227.2 to 238.8 (1960 mileage adjustment). Federal construction was completed in August 1950 and the unit transferred to the Chariton River Drainage District No. 4 of Chariton County for maintenance and operation in September 1950.

2. Macon-Adair Counties Unit. This unit consisted of channel cutoffs, channel blocks, and improvement of the then existing channel of the Chariton River from a point south of Gifford, Missouri, upstream to the vicinity of Novinger, Missouri, a distance of about 17.5 miles, and similar improvements along the lower reaches of Goose Creek and Spring Creek. Most of the cutoffs were pilot channels and their enlargement was slow during the drought years of initial project operation. Federal construction was completed and the project transferred to the Chariton River Drainage District of Adair County, Missouri, for maintenance and operation, in September 1952.

3. Reinhart Ranch Unit. This unit consisted of channel cutoffs, channel blocks, and channel improvement for approximately 4 miles upstream from the Adair County line in Schuyler and Putnam Counties, Missouri. It also included channel excavation for Lost Creek and Cat Creek. The cutoffs were constructed as pilot channels which have since eroded to design capacity. Federal construction was completed and accepted for operation and maintenance by the Worthington Drainage District of Schuyler County, Missouri, in September 1952.

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4. Tieback Levees. The authorization for the Chariton River improvement provided for tieback levees along both banks of the Chariton River across the Missouri River floodplain. Construction of these levees was completed in 1967.

**b. Other Agency Local Protection Projects.**

1. Federal. In the Chariton River basin, the U.S. Soil Conservation Service (renamed Natural Resources Conservation Service in 1994) had two watershed projects. The Honey Creek Pilot Watershed Project encompasses a drainage area of 14.25 sq. mi. along Honey Creek in southeastern Lucas County, Iowa. The improvements include 28 flood water retarding structures designed to detain approximately 2 inches of runoff from 45 percent of the watershed area. This pilot project was completed in 1958. The Moulton Watershed Project covers an area of 11.37 sq. mi. in southeastern Appanoose County, Iowa, and was constructed under the provisions of the Watershed Protection and Flood Protection Act of 1954. The work plan included three floodwater retarding structures, to detain from 2.5 to 3 inches of runoff from 6.91 sq. mi. of watershed area, and eight grade stabilization structures.

Other federally financed water resource projects in the basin are those of the Work Projects Administration which provided small water conservation ponds.

2. Non-Federal. Local interests, through drainage district organizations, have improved sections of river channel in the Chariton River basin. Thirteen drainage districts, located along the mainstem of the Chariton River or on adjacent tributary reaches, have been organized since 1904 and have spent over $800,000 on local projects. These projects are located between the mouth and a point a few miles south of the Macon-Adair County line and were completed prior to 1931. Later, one straightening project extended from Novinger to the Adair-Schuyler County line and another, several miles in length, extended downstream from U.S. Highway 136. However, due to lack of coordination works by the various districts, these projects did not connect. Prior to the completion of the Federal portion, flooding in unimproved reaches was aggravated by upstream improvements. The Federal improvements have been located largely in the reaches between locally constructed works and have served to make a complete project. In general, the channel improvements and occasional levees constructed by the districts and individuals have been reasonably successful in reducing local flooding.

**3-05. Modification to Regulation.**

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**a. Regulation Plans Assumed for Project Planning.** House Document No. 561 recommended 327,000 AF as the flood control storage allocation for Rathbun Reservoir. This figure was based on a study of floods occurring in the 1926 to 1946 period. The flood of May, June, and July 1935 was the largest observed during the years studied. Later studies showed that the period from 25 May to 30 June 1947 had a larger volume of runoff per square mile at Novinger and Keytesville on the lower Chariton River than occurred during the 1935 flood period. Additional studies of the 1947 flood in the upper basin, as well as analyses of floods occurring after 1947, reaffirmed and supported the need for 327,000 AF of flood storage space and the recommended allocation for flood control was not changed. No operating plan for regulation of the flood control storage was submitted.

**b. Regulation Plans Assumed During the Design Stages.** The plan of operation for flood control during the design stages, as outlined in Design Memorandum No.2, Hydrology, was as follows:

1. Releases from the reservoir to be dependent on stages of the Chariton and Missouri Rivers downstream from the reservoir. During periods of high stages downstream, substantially all flows would be stored, and on falling stages, releases would be made at approximately channel capacity to empty the reservoir as quickly as possible without causing damage.

2. In addition to the above, no releases would be made to contribute to more than 7,000 cfs at Novinger or Keytesville.

3. No releases would be made to contribute to more than 200,000 cfs at Boonville while the stage is rising or stationary. Releases may be made with falling stages at Boonville.

**c. Preliminary Reservoir Regulation Manual - 1968.** In this WCM, general criteria for flood control regulation of the reservoir were as follows:

1. Flood control storage space will be reserved for the control of floods.

2. Downstream channels will be used judiciously for the release of water accumulated in flood control space, recognizing the need for passing releases plus downstream tributary runoff without damage to adjacent property, insofar as practicable.

3. In determining releases, consideration will be given to the occupied flood control storage space in Rathbun Reservoir together with the runoff potential of respective uncontrolled contributing areas and travel times to downstream flood-damage centers.

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4. Seasonal hydrologic characteristics will be recognized in determining reservoir releases.

5. Surcharge storage space will be used only to control floods in excess of flood pool capacity.

6. When climatic and downstream conditions permit, and water is available, releases will be made periodically at channel capacity for the purpose of cleaning out the channel and maintaining a precedent for use of the channel for reservoir regulation.

7. Regulation of Rathbun Reservoir for local flood control purposes will be subordinate to the safety of the structure.

**d. Chariton River Basin, Lake Regulation Manual, Rathbun Lake, Iowa, dated May 1974.** This WCM set forth the criteria, schedules, and procedures used to govern the storage and release functions of Rathbun Reservoir as constructed. Consideration continued to be given to downstream channels, unoccupied flood control storage space in the reservoir, the runoff potential of respective uncontrolled contributing areas, travel time to downstream flood-damage centers, and seasonal hydrologic characteristics. Application of the criteria and techniques set forth in the 1974 WCM appeared to be satisfactorily meeting the objectives for flood control

regulation. Complaints from the public, however, indicated quite clearly that observance of the designated storage and release schedules was not providing the most satisfactory overall results as far as all interested parties were concerned. The complaints included reports of overbank flows, high water table, lack of drainage, and accelerated erosion. In an effort to provide regulation more acceptable to all concerned, some revisions to the general plan were made. Portions of the above-referenced criteria were retained; other portions were deleted or significantly revised. A brief discussion of the revisions is presented in the next subsection.

**e. Chariton River Basin, Lake Regulation Manual, Rathbun Lake, Iowa, dated September 1980.** This WCM provided for a revised operation method to account for downstream concerns. The revised method generally reduced the permitted Rathbun Reservoir releases. In addition, the releases were further reduced during planting and harvesting periods. Specifically, the maximum outflow from the reservoir during the months of April, May, and June was reduced to 800 cfs for planting. The release was also reduced to 800 cfs during September, October, and November for harvesting. The maximum outflow during July and August was set at 1,200 cfs as it was a less critical period for downstream farmers. For the period December through March, the release was set at 1,500 cfs as there was no reason for severely limiting downstream flows. At water surface elevations between 921.1 and 926.0 (top of the flood control pool) the maximum release was always 1,500 cfs regardless of the time of year.

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**3-06. Principle Regulation Problems.**

Historically, the downstream channel capacity has been the most restrictive factor in project regulation. In general, regulation criteria state that downstream channels will be used judiciously for the release of water accumulated in flood control space, recognizing the need for passing releases plus downstream tributary runoff without damage to adjacent property, insofar as practicable. To accomplish this objective, techniques have been developed by which outflow is scheduled to evacuate flood impoundments while giving the maximum possible consideration to all interests affected by the reservoir's operation. In addition to damage caused by out of channel flow, downstream farming interests are affected by long term in-channel releases that do not permit adequate draining for crop production.

Shortly after construction of Rathbun Dam farming encroached on the lowest lying areas of the Chariton River bottom in the Dean and Sedan Bottoms reaches. Farmers in those areas stated that Rathbun Reservoir releases at these design levels were contributing to wet farming conditions and flooding of low lying fields. Flooding problems were documented in 1973, 1974, 1978, and 1979 Memorandums-for-File. Partial restrictions on releases were first attempted in 1973, and the restrictions were formalized in a 1980 revision of the WCM.

Many of the downstream agricultural lands that were a factor in the 1980 WCM revision (over 6,500 acres) are no longer in agricultural production, but instead have been enrolled in the Natural Resources Conservation Services (NRCS) Wetland Reserve program. The Iowa Department of Natural Resources (IDNR) has also made sizeable land acquisitions in that area and now manages their lands for wetlands and wildlife.

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# 4 - WATERSHED CHARACTERISTICS

## 4-01. General Characteristics.

The Chariton River headwaters are in Clark County in extreme south-central Iowa. From its source, the river flows southeasterly about 70 miles to near the Iowa-Missouri State line and thence southerly through Missouri for 111 miles to its confluence with the Missouri River near Glasgow, Missouri, at river mile 238.8 (1960 mileage). The Chariton and Little Chariton Rivers were originally one drainage system, but now, the two rivers are separate tributaries due to a cutoff of the Chariton River through which it discharges into the Missouri River at a point about 12 miles upstream from the mouth of the Little Chariton. The Chariton River basin contains about 2,390 sq. mi., of which 925 sq. mi. are in Iowa and the remaining 1,465 sq. mi. are in Missouri. The Chariton River basin is somewhat banana-shaped with a maximum width of about 25 miles and a length of about 160 miles. The Chariton River profile elevations are shown on Plate 4-1.

## 4-02. Topography.

The outstanding topographic feature of the Chariton River basin is the broad level plain which has been extensively dissected and eroded by numerous streams. The Chariton River itself has cut a deep valley through which, in its natural state, winds in a tortuous course over a floodplain varying from one-quarter to three miles in width. The basin is well drained except for bottom lands located along the mainstem.

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## 4-03. Geology and Soils.

The Chariton River basin is located in the Dissected Till Plains Section of the Central Lowlands Province. The underlying formations are sedimentary deposits which are covered by a mantle of loess and glacial till. The land, originally in plains, has been dissected by erosion, leaving the original surface on comparatively narrow stream divides. Below these flat ridge tops, the slopes are mostly covered with trees and shrubs. The major soils are developed from Peorian loess and old glacial drift with several minor series developed from shale, sandstones, and limestone. The areas of flatlands are mostly in cultivation with corn, soybeans, small grains, and hay as the principal crops. Areas too steep for cultivation are used mostly for pasture. Many of the streams are bordered by terraces and floodplains of considerable width, however, repeated loss of crops due to recurring floods has made farming of these areas risky.

## 4-04. Sediment.

In 1970-1971, 30 sedimentation ranges were established in Rathbun Reservoir and 10 degradation ranges below Rathbun Dam. A reservoir sediment survey is made periodically (10 to 20 years) to determine the location and progress of sediment accumulation and to provide the data necessary for recompilation of capacity tables and reallocation of storage when deemed necessary. Periodic resurveys of selected

degradation ranges downstream from the Dam provide channel cross section and profile data indicating any changes in channel characteristics.

The 1999 sediment survey found more space in the Rathbun Reservoir pool than in the 1963 original capacity table estimates, which reflected the lake condition when the pool first began filling in November 1969. Intermediate surveys of the lake sediment ranges showed sediment accumulation on cross section plots. The larger overall space computation derived from the 1999 lake survey was due to a change in measurement and computational methodology compared to traditional methods using only the sediment range data. For the 1999 survey, the entire lake was digitally surveyed using total lake bathymetry. In addition, the land portions of the reservoir sediment ranges were surveyed using traditional survey techniques. A GIS digital terrain model was developed from this survey data. The 1999 area/capacity table was computed using this digital model. The GIS analysis of the pool was checked using separate digital surveys of the sediment ranges. As a result, the original 1963 pool capacity data is considered in error, and the rate of sedimentation is currently undetermined. The area/capacity tables dated 2000 computed from the 1999 sediment survey are now used for day-to-day operations and shown in Exhibit D.

A bathymetric survey of the multipurpose pool only was conducted in May 2010 before the major 2010 flood event. The survey methodology was similar to that for the 1999 pool survey, but it was only intended to monitor sediment accumulation in the multipurpose pool. The 2010 survey showed that the estimated multipurpose pool capacity at the time of the survey was 210,700 AF. Although this is a slight reduction in the capacity of 221,360 AF found with the 1999 survey, it still appears to demonstrate a greater capacity than the 205,359 AF initial pool capacity estimate. The results did not justify a complete recomputation of the operational pool capacity tables, and the 1999 tables continue to be used for day-to-day operations. Future bathymetric surveys should provide a better estimate of actual sedimentation rates. The lake schematic provided in Plate 1-1 shows the results of the 1999 and 2010 lake surveys along with the space distribution to the various pool allocations.

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**4-05. Climate.**

The climate of the Chariton River basin is humid with wide variations in temperature and rainfall including occasional high winds and cyclonic disturbances. Rainfall is usually of short duration and high intensity over small areas or of light to moderate intensity for longer durations over large areas. Average annual precipitation varies from about 32 to 36 inches from north to south. At Chariton, Iowa, the maximum annual precipitation recorded was 55.9 inches in 1902 and the minimum was 13.8 inches in 1910. About 70 percent of the rainfall occurs during the 6-month growing season, April through September. The average annual snowfall of about 25 inches generally occurs during the period November through March and normally contributes little to flood flows. One

exception was the snowmelt of 1960 which is discussed later in this section. The mean annual temperature is 52.5 degrees Fahrenheit (deg F) with a record high of 116 deg F occurring at Macon, Missouri, in 1936, and the lowest, minus 31 deg F at Chariton, Iowa, in 1912. Table 4-1 shows climatologic data for Des Moines, Iowa, which is 65 miles northwest from Rathbun Dam and considered representative of the Chariton River basin. The maximum daily precipitation values since 1879 are also included in Table 4-1. Note that the daily values exceed the average monthly totals for every month except May. The maximum daily precipitation values were provided by http://w2.weather.gov/climate/local_data.php?wfo=DMX. The remaining data was provided by http://www.ncdc.noaa.gov/cag/time-series/us/13/USW00014933. Des Moines, Iowa, climatologic data has also been included in Plate 4-2.

**Table 4-1: Precipitation and Temperature – Des Moines, Iowa**

| Month | Average Precipitation (inches) | Max Daily Precipitation (inches) | Low Temperature Degree F | High Temperature Degree F |
|---|---|---|---|---|
| January | 1.11 | 2.13 | 11.4 | 28.8 |
| February | 1.17 | 1.76 | 16.9 | 34.7 |
| March | 2.27 | 2.44 | 27.3 | 46.1 |
| April | 3.27 | 3.80 | 39.8 | 61.1 |
| May | 4.14 | 3.48 | 51.3 | 72.2 |
| June | 4.47 | 5.48 | 61.1 | 81.6 |
| July | 3.72 | 4.32 | 65.8 | 86.0 |
| August | 3.91 | 6.18 | 63.7 | 84.0 |
| September | 3.05 | 4.87 | 54.1 | 75.8 |
| October | 2.37 | 3.67 | 43.1 | 64.6 |
| November | 1.80 | 3.18 | 29.1 | 47.1 |
| December | 1.24 | 1.48 | 17.2 | 33.6 |

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Personnel at the project collect daily pan evaporation in inches at the project during periods of the year when freezing is not expected to occur. Generally pan data is collected from early March through October of each year. The volume of water evaporated from the reservoir is calculated by multiplying the pan evaporation value by the surface area of the reservoir and a pan coefficient. The pan coefficient varies by month and corresponds to the following values provided in Table 4-2 for Rathbun Reservoir:

**Table 4-2: Pan Evaporation Coefficients Rathbun Reservoir**

| Month | Pan Coefficient |
|---|---|
| January | .87 |
| February | .68 |
| March | .53 |
| April | .45 |
| May | .45 |
| June | .47 |
| July | .56 |
| August | .73 |
| September | .97 |
| October | 1.10 |
| November | 1.13 |
| December | 1.06 |

During the times of the year when the evaporation pan is not utilized, the daily pan evaporation is estimated depending on the month and the percent of ice cover on the reservoir. The total reservoir daily evaporation can be calculated by multiplying the inches of evaporation shown on Table 4-3 reduced to a daily value times the pan evaporation coefficient and reservoir surface area. During months when little ice on the reservoir is anticipated, only a single monthly evaporation value is provided.

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**Table 4-3: Estimated Evaporation Winter Season – Monthly Total (Inches) Rathbun Reservoir**

| Ice Cover % | 0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.93 | 0.90 | 0.87 | 0.84 | 0.81 | 0.78 | 0.75 | 0.72 | 0.69 | 0.66 | 0.63 |
| February | 1.03 | 1.00 | 0.97 | 0.94 | 0.91 | 0.88 | 0.85 | 0.82 | 0.79 | 0.76 | 0.73 |
| March | 1.55 | 1.52 | 1.49 | 1.46 | 1.43 | 1.40 | 1.37 | 1.34 | 1.31 | 1.28 | 1.25 |
| October | 4.00 | NO | ICE | | | | | | | | |
| November | 2.05 | NO | ICE | | | | | | | | |
| December | 0.89 | 0.86 | 0.83 | 0.80 | 0.77 | 0.74 | 0.71 | 0.68 | 0.65 | 0.62 | 0.59 |

## 4-06. Storms and Floods.

Historical records show that the Chariton River basin has experienced moderate floods nearly every year, and that more than one flood a year is not unusual. As an example of the frequency with which some areas have been flooded, records for the Chariton River gaging station at Novinger, Missouri, show that flood stage was exceeded 140

times during the 84 year period October 1930 to October 2014, (no record for the years 1953 and 1954). Major floods were known to occur in 1892, 1903, 1909, 1917, 1926, 1927, 1928, 1929, 1931, 1932, 1935, 1943, 1946, 1947, 1960, 1967, 1973, 1993, and 2010. In addition, although of less extensive nature, above flood stage flows occurred during the years 1939, 1944, 1945, 1950, 1959, 1961, 1965, 1978, 1981, 1982, 1992, 1996, 1998, 2008 and 2013. The keeping of flood records began in the Chariton River basin with the establishment, by the U.S. Geological Survey (USGS), of a gaging station at Elmer, Missouri, in 1921. Damage surveys have been made for the major floods in the basin since 1941. Major floods for which records are available are described in the following paragraphs. Flood damages prevented are indicated for the year in which the event occurred.

**a. Flood of May-June 1935.** Above normal rainfall occurred during the months of May and June in the Chariton River basin causing one of the largest known floods in the downstream reach. During the period 25 May to 2 June, two large centers in the vicinity of the basin were experienced. One 9-inch center was located east of Novinger, Missouri, and one 7-inch center was located at Linneus, Missouri. At Brunswick, Missouri, 2.03 inches were recorded on 28 May, followed by another 2.83 inches on 2 June. Although the Centerville, Iowa, gage was not established and the Novinger discharge did not reach flood stage, the gage near Keytesville, Missouri, located 5.25 miles upstream from Mussel Fork Creek, recorded a stage corresponding to a discharge of 18,000 cfs. Due to the location of the storm little if any damages would have been prevented by Rathbun Reservoir.

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**b. Floods of May and June 1943.** The storm period of May 1943 consisted of two intense periods of rainfall, 6-11 May and 13-20 May. The first period centered at Warner, Oklahoma, where unofficial reports placed the 6-11 May total at 25 to 30 inches of rain. The second center was located over Joplin, Missouri, with a total of 16.4 inches of rain reported. General rains associated with these two intense centers spread over large areas of Kansas, Oklahoma, Missouri, and Arkansas, with total for the 6-20 May period ranging from 4 to 8 inches over the Chariton River basin. Flooding was experienced on the Chariton River from the vicinity of Centerville, Iowa, to the mouth. Experienced stages exceeded flood stage by as much as 7 feet with discharges of 9,600 cfs near Centerville, 10,600 cfs at Novinger, and 13,000 cfs near Keytesville. Two storm periods, 3-12 June and 13-17 June, again produced heavy precipitation over northern Missouri and southern Iowa. Within the Chariton River basin and its immediate vicinity, total rainfall amounts for the 3-17 June period ranged from 6 inches at Chariton, Iowa, to 10 inches at Linneus, Missouri. As a result of these intense and prolonged rains, overflows again occurred on the Chariton River from near the headwaters to the mouth. Peak stages, with associated discharges, were 19.8 feet with 6,800 cfs near Centerville, 24.1 feet with 10,000 cfs at Novinger, and 21.9 feet with 12,000 cfs near Keytesville. Flood damages were not determined for the May event, but in June the total damage, about 98 percent of which was agricultural, amounted to $533,000. Due

to the location of the May storms, little if any damage could have been prevented by Rathbun Reservoir. However, the June storms were centered farther north and, had Rathbun Reservoir been in existence, the total damage could have been reduced by about one-third.

**c. Flood of June 1946.** Extremely heavy rainfall in southern Iowa and northern Missouri caused severe overflow on the Chariton River from the headwaters to the mouth. The plotted accumulated total rainfall for the 5-day period of 15- 19 June indicates a 10-inch center over Bloomfield, Iowa, east of Rathbun, Iowa. At Chariton, Iowa, on the north edge of the basin, a total of 4.10 inches was recorded on 18 June followed by 1.50 inches on 19 June. The peak discharges in the river were 21,700 cfs near Centerville, and 15,500 cfs at Novinger. The estimated damages in the basin were $2,029,360 to agriculture, $116,850 to transportation and utilities, $2,000 to levees, and $2,100 for flood expenditures. The total estimated damage was $2,150,310. Had Rathbun Dam been in existence during the flood, $678,000 in damages would have been prevented.

**d. Flood of June 1947.** The 1947 flood was the largest historical event prior to the construction of Rathbun Dam. It extended over the entire length of the Chariton River and adjacent streams. The month of June began with a major storm in the four-state region of Nebraska, Iowa, Kansas, and Missouri. An exceptional number of storms occurred with high precipitation in at least five major fronts. During the period 25 May to 30 June, a 21-inch center over Novinger and an 18-inch center over Brunswick, Missouri, were experienced. At Chariton, Iowa, the total reported rainfall was 4.25 inches on the 5th, 2.26 inches on the 21st, 1.13 inches on the 23rd, and 1.13 inches on the 29th of June. The recorded peak discharges near Centerville, at Novinger, and near Keytesville were, respectively, 20,300 cfs, 22,500 cfs, and 25,600 cfs. The total estimated flood damage in the Chariton River basin during June was approximately 7 million dollars. Had Rathbun Dam been in existence during the flood, $1,383,000 in damages would have been prevented.

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**e. Flood of May-July 1951.** The 1951 flood on the Missouri River below the Kansas River exceeded any that had occurred since 1844. However, runoff on the Chariton River basin was minor. The maximum discharges experienced along the mainstem during the flood period were 4,780 cfs near Centerville, Iowa, on 12 May; 10,200 cfs near Keytesville, Missouri, on 27 June; and 8,340 cfs at Novinger, Missouri, on 23 July.

**f. Flood of March 1960.** Snowmelt in the Chariton River basin generally contributes little to flood flows. Normally, the snowmelt runoff progresses from south to north with diurnal pauses as the melt refreezes at night. This diurnal effect reduces the rate of contribution to downstream points on streams which drain from north to south, such as the Chariton River. The spring of 1960 was not normal. Above normal

precipitation occurring since October of the previous year had saturated the basin soils and had built up a snow cover of 2 to 3-foot depths by the third week in March. A warming trend which began in the southwestern fringes of the basin on 26 March had progressed northward and eastward to embrace the entire Chariton River basin by 29 March. Daytime temperatures as high as 70 deg F and nighttime temperatures above freezing produced a rapid ripening of the snow cover and almost continuous snowmelt. The resulting runoff brought creeks and rivers out of their banks overnight. No significant rainfall occurred in the early part of the runoff period. However, during the period 30 March through 1 April, approximately one inch of rain fell over the upper basin greatly aggravating the flood situation. This snowmelt flood was the second largest of record in flood volume and peak discharges in the downstream reaches. Peak discharges recorded near Rathbun, at Novinger, and near Prairie Hill were 21,800 cfs, 22,000 cfs, and 21,500 cfs, respectively. Total damage incurred during this flood was estimated at $365,000; of this total, about $266,000 was agricultural, $42,500 transportation and utilities, and $57,000 levee repair. Had Rathbun Dam been in existence during the flood, $293,000 in damages would have been prevented.

**g. Flood of June 1967.** The weather patterns which caused the June 1967 floods were very similar to those which caused the record floods of 1951. Successive frontal systems, generally oriented north and south, moved from west to east across the district. Squall lines preceding these frontal passages produced strong winds, violent thunderstorms, and torrential rains. Total precipitation amounts over the Chariton River basin for the period 8-24 June ranged from 4 inches near the mouth to 8 inches above Rathbun Dam. Peak discharges on the Chariton River were 7,600 cfs near Rathbun, Iowa; 16,000 cfs at Novinger, Missouri; and 19,000 cfs near Prairie Hill, Missouri. A stage of 20.4 feet on Mussel Fork came within 0.3 foot of equaling the maximum of record on this stream. The associated discharge was 4,200 cfs. Total damages on the Chariton River mainstem amounted to $200,900 and on Mussel Fork, about $301,000. Channel improvements on the Chariton River were credited with preventing damages in the amount of $350,000. Had Rathbun Dam been completed, about $128,000 in damages on the mainstem could have been prevented.

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**h. Floods of March-October 1973.** The month of March 1973, was unusually warm, cloudy, and rainy. Never had less snow fallen in Iowa during a March. Since moisture fell almost entirely as rain, this was the rainiest March in 101 years of Iowa State records. Above Rathbun Dam, rainfall for March totaled 5.5 inches at Osceola. Below the Dam, 6 inches were recorded at Centerville. Rathbun Reservoir gained 43,800 AF of storage in the flood pool and reached elevation 909.0 by the end of March. April's most notable weather was the snowstorm of 8-10 April. Snow depths varied from 10 to 15 inches in the Chariton River basin. Centerville, Osceola, and Rathbun Dam recorded 7.2 inches, 3.4 inches, and 3.6 inches of total precipitation, respectively, for the month of April. Rathbun Reservoir gained an additional 100,000 AF of floodwaters and reached elevation 915.7, or 45 percent of the flood pool storage occupied, by the

end of April. No releases were made due to downstream flooding conditions. The month of May had severe storms and tornados causing flooding conditions throughout the Missouri River basin and its tributaries. Rathbun Dam recorded 7.14 inches, Centerville 9.34 inches, and Osceola 7.05 inches of rainfall during the month of May. Rathbun Reservoir reached a maximum elevation of 918.15 ft on 9 May which represents 57 percent of the flood pool storage occupied. The month of June was sunny, dry, and warm. However, windstorms associated with destructive thunderstorms occurred periodically throughout the month, causing localized flooding in some areas. Rathbun Dam recorded 4.2 inches of precipitation and Chariton 5.4 inches during June. The month of July was cool and wet. Rainfall over all of southern Iowa was more than twice the normal amount. Rathbun Dam recorded 6.6 inches and Centerville (below Dam) recorded 8.7 inches. Chariton and Osceola (above Dam) recorded 7.0 inches, and 6.5 inches, respectively. July rainfall occurred during the periods 1-4 and 19-30 July. Additional rainfall occurred during 8-14 and 22-24 August. Chariton and Osceola recorded 3.9 inches and 3.6 inches, respectively, while at the Dam 2.9 inches were reported. Rainfall continued throughout September. Rathbun Dam recorded 8.6 inches and the basin above the reservoir averaged above 5 inches. Rainfall continued into the first 2 weeks of October. At Rathbun Dam, 5.5 inches of precipitation were recorded with 3.7 inches reported above Rathbun Reservoir. After reaching the maximum elevation of 918.15 ft on 9 May, releases of 1,200 to 1,500 cfs during June, July, August, and September evacuated the pool to elevation 904.54, or just 0.54 feet into the flood pool on 24 September 1973. Rainfall during late September and early October again raised the pool elevation to 913.28 on 19 October. Reservoir releases were limited to 10 cfs during the period 1-20 October due to flooding conditions on the lower Missouri River. During the period of March through October 1973, Rathbun Reservoir inflow totaled about 562,000 AF while outflow totaled about 444,000 AF. The peak mean daily inflow was 10,150 cfs on 28 May. Releases varied from 0 to 1,500 cfs. Rathbun Reservoir was credited with preventing damages in the amount of $3,295,000 during the spring floods of March and April and nearly $4,100,000 during the September-October events.

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**i. Floods of July-September 1993.** Precipitation was significantly above average during the winter of 1992-1993. Persistent rains and early snowmelt culminated in high spring runoff. During the summer of 1993 a large stationary high pressure area in the upper atmosphere was situated over the southeastern United States, while a large low pressure system sat over the northern Rockies. These two systems resulted in a flow of warm humid air from the Gulf of Mexico and a large number of thunderstorms. Rainfall amounts recorded at the Rathbun Project Office were 5.45 inches in May, 4.24 inches in June, 14.26 inches in July, 4.19 inches in August, and 5.46 inches in September. An outlet works discharge of 1,500 cfs was initiated at noon on 24 July 1993 as the pool level neared the top of the flood control zone and crest of uncontrolled spillway at elevation 926.0 ft. The maximum pool elevation obtained at Rathbun Reservoir was 927.2 ft on 28 July, shattering the old

record of 924.5 ft on 22 June 1982. Even though water was 1.2 feet deep in the uncontrolled spillway, the USGS measured a flow of only 7 cfs. The long spillway was choked with grass, cattails, weeds, and debris, which impeded flow. The outlet works discharge was increased to 1,800 cfs on 28 July to more quickly lower the surcharge pool. The pool was lowered to the top of flood control on 5 August for a total surcharge operation of 12 days. A 34,500 AF of surcharge storage was utilized, resulting in a total of 107.1% of the flood control pool. Rathbun Dam was credited with preventing $31,498,000 in damages.

**j. Floods of June-July 2010.** The year 2010 was a historically wet year. Total measured precipitation at the project office for the 2010 water year (October 2009 to September 2010) was over 72 inches, whereas the typical amount is about 39 inches. Rathbun Reservoir crested at elevation 926.69 ft on 24 July 2010. The reservoir elevation was 0.69 feet over the design spillway crest, but discharge though the emergency spillway was restricted by vegetation and only minor drainage occurred through the left side of the spillway for a few days. At one point in the drainage channel about 3 feet wide and 0.5 feet deep, the discharge velocity was estimated at about 9 feet per second, providing a drainage of about 13 cfs. The 13 cfs spillway flow is pictured in Figure 4-1.

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**Figure 4-1: Uncontrolled Spillway Flow July 2010**

The crest elevation was 0.47 feet below the July 1993 record pool elevation of 927.16 ft. Rathbun Dam was credited with preventing $7,171,300 in damages. A hydrograph of the 2010 event is provided in Figure 4-2.

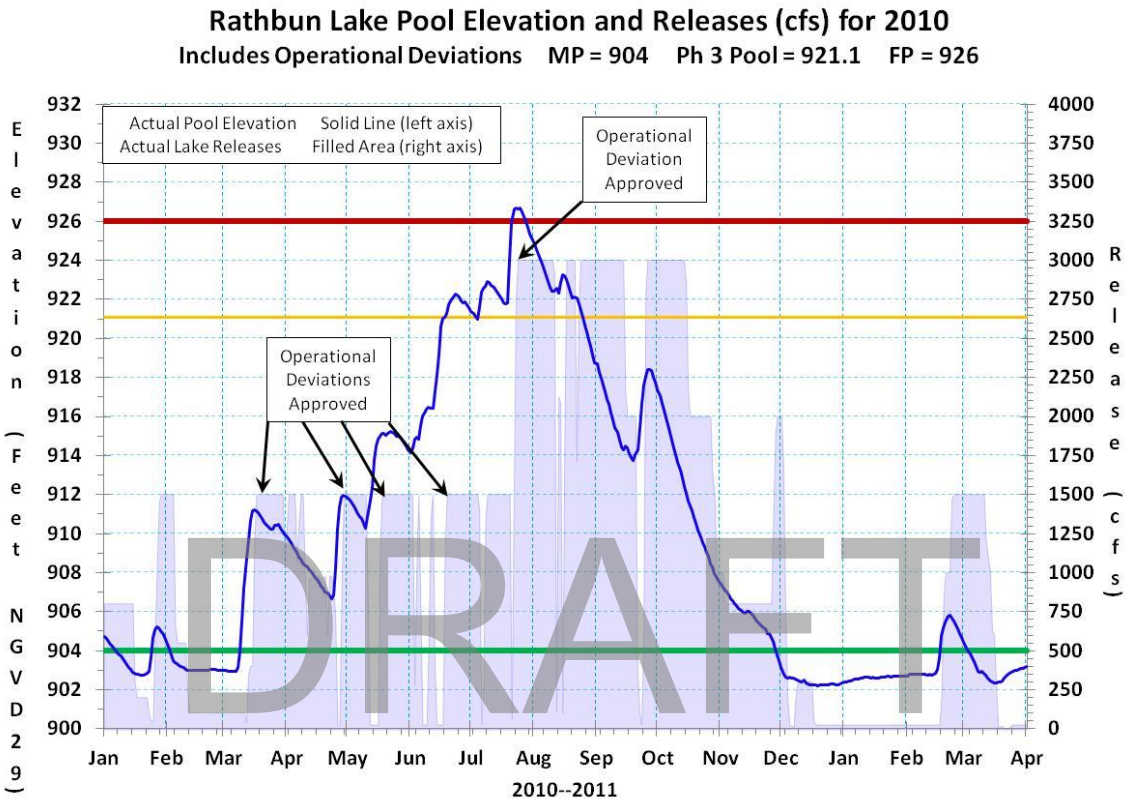


**Figure 4-2: Rathbun Reservoir Actual Pool Elevation and Releases for 2010**

On 23 July 2010, a request was approved for outlet works discharge of 3,000 cfs. The deviation request was pursued to reduce the possibility of uncontrolled spillway discharge and in consideration of dam safety with a full flood pool. The WCP included a maximum discharge of 1,500 cfs for pool levels between 921.1 and 926. The deviation resulted in a maximum release of 3,000 cfs for 64 of the next 83 days. Previous discharges had not exceeded 1,800 cfs with the exception of a 3,000 cfs test discharge conducted on 14 December 1993.

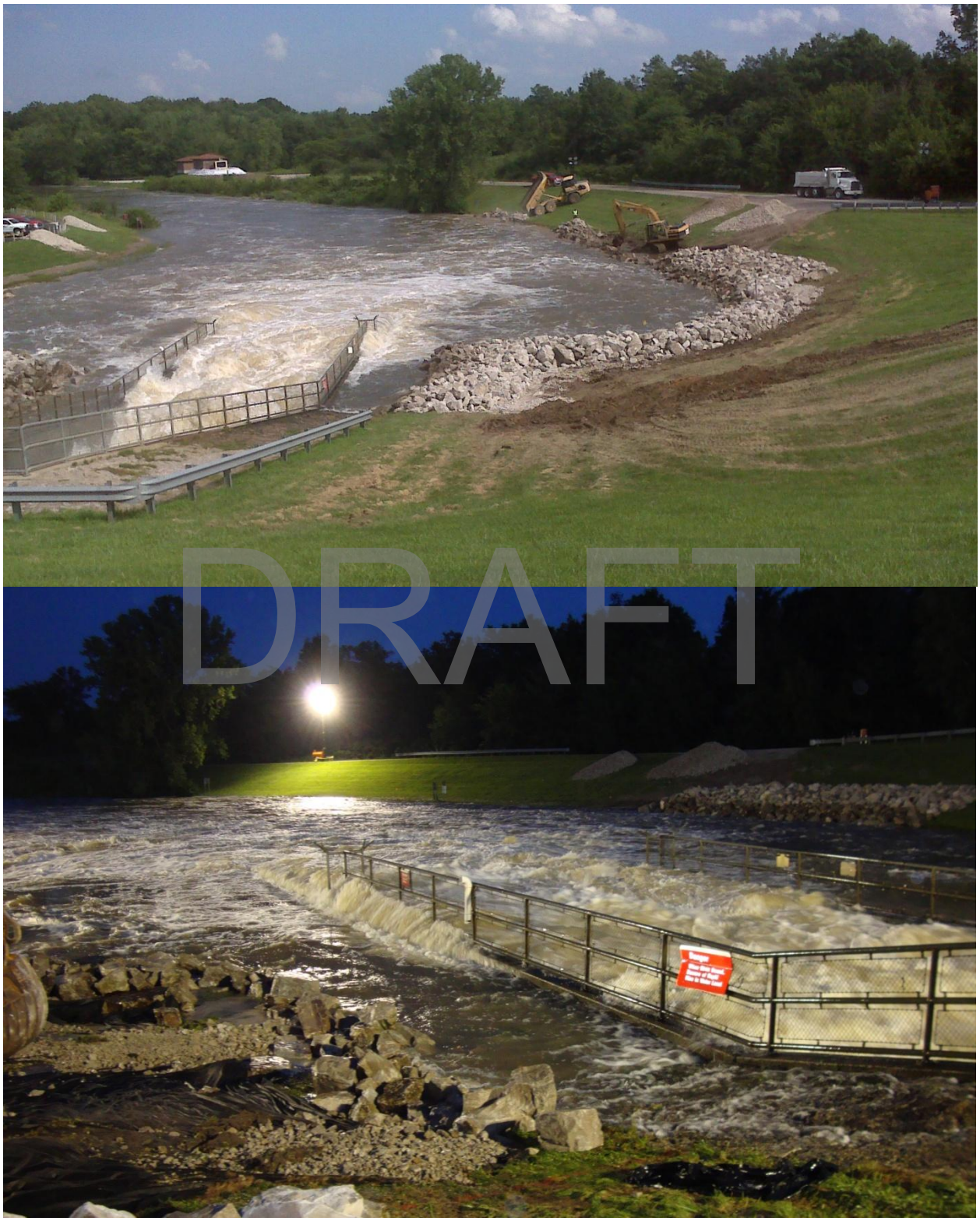
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**Figure 4-3: 3,000 cfs Release Through Outlet July 2010**

Several modifications were completed after the 2010 high pool. A Riprap overlay was completed at the outlet works during the high pool event. A concrete apron in place of grouted riprap was completed in December 2010 around the stilling basin to prevent surge erosion and to accommodate releases up to 3,000 cfs. After the pool was drawn down to multipurpose level, seepage at abandoned relief well #4 has been controlled with a sand filter; and a drain modification was completed at the Buck Branch left abutment.

## 4-07. Runoff Characteristics.

The Chariton River basin is subject to considerable fluctuation in natural flows. Flood runoff in the basin is frequent and has contributed to most of the major floods on the Missouri River downstream from the mouth of the Chariton River. The average annual runoff near Rathbun, Iowa, for the 76 years from 1939 through 2014 is 273,407 AF, or the equivalent of 9.3 inches over the 549 sq. mi. of drainage area above Rathbun Dam. Reservoir inflow has been trending higher as noted in the below Figure 4-4.

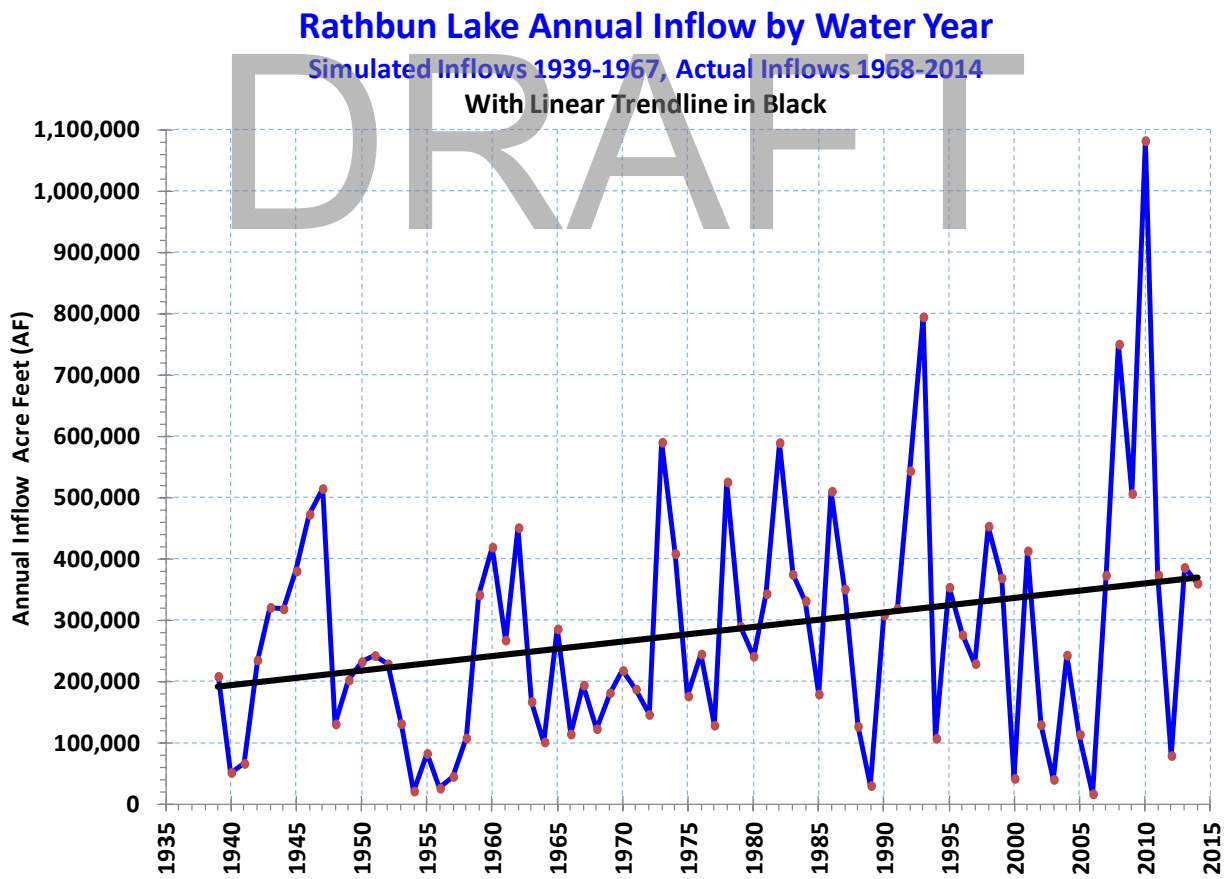


**Figure 4-4: Rathbun Reservoir Annual Inflow (AF) by Water Year**

The trend for increasing inflow is likely due to increased rainfall. The land use upstream of Rathbun Dam has not significantly changed in a way that would dramatically increase runoff. However, the annual precipitation in the area has experienced an upward trend. The following Figure 4-5 has obtained from the National Centers for Environmental Information, a component of the National Oceanic and Atmospheric Administration (http://www.ncdc.noaa.gov/cag/time-series/us/13/USW00014933). Annual precipitation at Des Moines has been increasing since 1946 at a rate of 1.31 inch each decade.

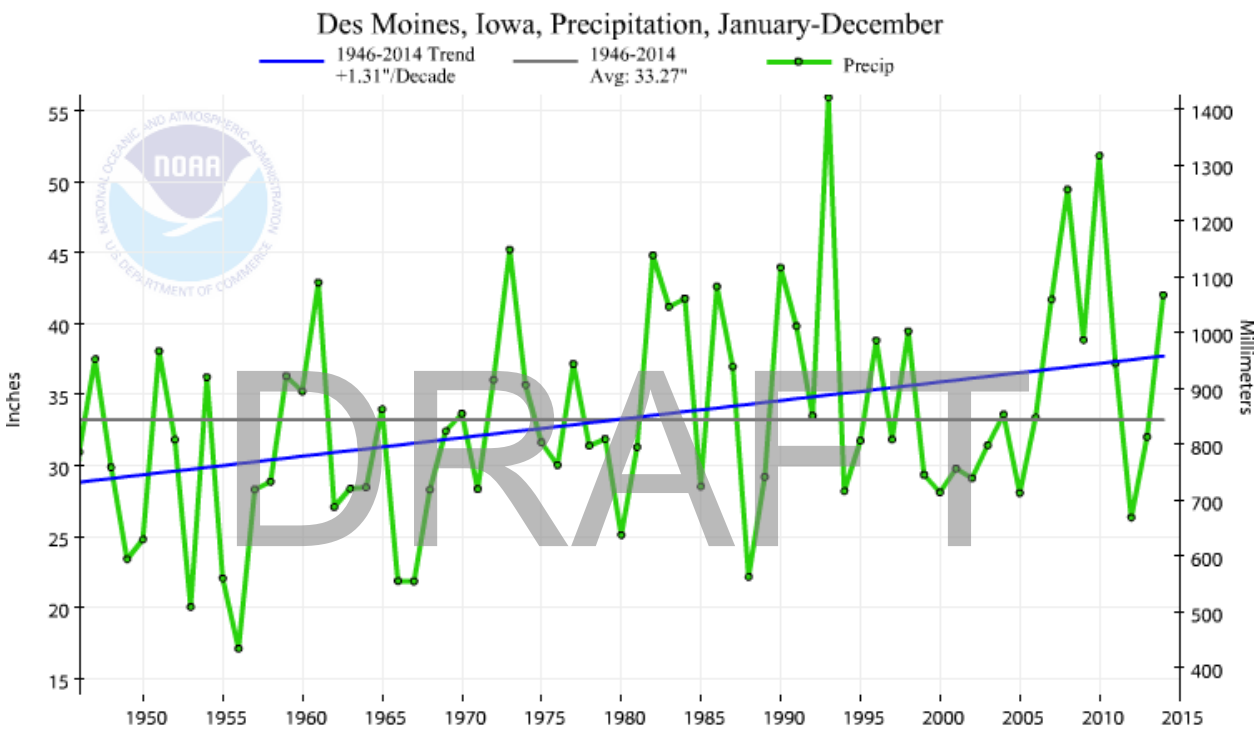


**Figure 4-5: Des Moines Annual Precipitation Trend**

The affect on lake operation decisions is noted, however the trend associated with the increased inflow is low (R^2= 0.0662). Reservoir operation changes cannot be made to accommodate this trend because of 1) the observed data is too limited, and 2) the statistical confidence and reliability in the trend associated with the observed data is too low. Until the trend is better understood and more prevalent, it is not believed sufficient to dictate changes in reservoir operation.

Prior to establishment of the Rathbun (near) gage, runoff data were obtained by use of the gage near Centerville, Iowa, about 14 miles downstream. The monthly inflow values are provided in Table 4-4 at the end of this chapter.

**4-08. Water Quality.**
The principal chemicals that may adversely affect water quality in the Chariton River are sulphates and chlorides. U.S. EPA has established drinking water standards of 250 parts per million (ppm) as the maximum desirable concentration for each. Iowa has established water quality standards for acute and chronic levels of chloride and sulfate based on hardness dependent upon the use of the water (aquatic life needs, waste water, drinking water, etc.). Chemical analyses are available for water samples collected by the USGS near Prairie Hill, Missouri, drainage area 1,870 sq. mi., during 1970 and 1971. Sulphates ranged from 32 to 110 ppm, chlorides from 3 to 16 ppm, and hardness from 86 to 260 ppm, which indicates maximum concentrations of sulphates, chlorides and hardness are well within safe limits as set by EPA standards and below chronic and acute criteria set by Iowa standards.

**4-09. Channel and Floodway Characteristics.**
Farmers along the Chariton River have experienced flooding and drainage problems almost from the very beginning of settlement in this area. Efforts to alleviate some of the problems were initiated as far back as the early 1900s when local farmers united to form drainage districts. As a result of this united effort, channel straightening was accomplished, first by local interests and later as Federal projects filled in the gaps, from near the mouth of the Chariton River to U.S. Highway 136 near Livonia, Missouri, and from the Missouri-Iowa State line north to Sedan, Iowa. Drainage systems, including in some places underground clay tiles, were installed in a few locations to help drain the fields. The clay tiles, however, never proved totally successful due to the flatness of the topography adjacent to the stream and the poor natural drainage characteristics of the valley soils.

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The improvements referred to above have proven beneficial in draining the lower part of the Chariton River basin. However, between Livonia, Missouri, and Rathbun Dam, two reaches still remain in which the channel is tortuous, with flat slopes and heavily timbered banks and through which will pass a very limited flow. One reach is a stretch of about 8 miles between Livonia and the Missouri-Iowa State line known as the "Missouri Narrows." In this reach, the river travels some 21 river miles to move about 6 map miles downstream. In the second unimproved reach, extending from near Centerville, Iowa, to Rathbun Dam, the river travels some 17 river miles to move 5 map miles downstream. With the advent of large mechanical equipment suitable for earthmoving and land clearing and its availability to the ordinary farmer, the practice of clearing and leveling formerly timbered and/or rough areas has become quite commonplace. Some of these areas are marginal in their ability to produce crops because they are low and frequently wet. The cleared materials have been placed along the riverbanks in many locations, only to be carried away by the next high flow, with the result that logjams downstream are a frequent occurrence. Subsequent to

straightening of the Chariton River channel between Sedan and the Missouri Narrows, much timber and debris was placed in the old channel. In certain areas, the old channel was completely filled, resulting in the elimination of natural drainage and promoting, in many areas, the tendency toward pools of standing water. The slope of the streambed ranges from about 1.1 feet per mile in unimproved sections to 2 feet per mile in straightened and improved channel sections. The channel varies in width from 50 to 300 feet and streambanks are 10 to 25 feet high. The floodplain along the mainstem ranges from 0.25 to 3 miles in width. Streambed elevations range from about 600 ft at the mouth to about 1100 ft., at the headwaters.

As of 2014, the National Weather Service (NWS) flood stage designated for the Moulton streamgage is 36 feet, equivalent to a river discharge of about 11,700 cfs. The NWS would normally consider flood stage in rural areas as the bankfull capacity, overtopping of which will result in some damages to farm fields or county roads. This may be true at and near the Moulton gage, but this has long been known to be too high for the entire reach from the Dam down to the Missouri Rebels Cove Conservation Area. Field examinations have consistently shown that farmland and farm access road flooding begin at much lower river discharges. Early design documents prior to the construction of Rathbun Dam estimated that the Chariton River channel capacity down to Centerville was about 4,000 cfs. Field surveys in the 1970s after the Dam was completed estimated a lowest bankfull capacity in the reach from the Dam down to the State Line at 2,000 to 3,000 cfs. The Moulton seasonal control point flows for the 1980 revision of the Water Control Manual were established in the 800 to 1,500 cfs range due to the frequency of high inflows from uncontrolled tributaries, poor field drainage with higher river flows, and problems with farmland access over low water crossings.

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Since the 1970s, most but not all of the lowest flood-prone farmland in the first reach from the Dam down to Livonia was removed from production through the NRCS Wetlands Reserve Program (WRP) and Emergency Wetlands Reserve Program (EWRP) programs and private/public land purchases. Much of this converted land is now managed as wetlands and wildlife habitat, particularly in the Iowa Sedan Bottoms reach from RM 119.8 downstream through the Missouri Rebels Cove area (RM 99).

In 2010, NWK Water Management staff completed detailed water surface, bankline, and thalweg profile surveys of the channel and surrounding floodplain conditions with steady Rathbun Dam releases of 3,000 cfs and 2,000 cfs. Local inflows downstream were minimal at the time of the surveys. The high releases were needed following the major flood of 2010 resulting in the lake rising above the designated top of flood pool and into surcharge.

Water Management completed another land survey of floodplain conditions in 2013 with a test release of 2,500 cfs. No farmland inundation was noted at this level. This survey verified that from the dam down to Rebels Cove the minimum channel capacity at which

some farmland flood damage is experienced is at least 2,500 cfs. Some narrow bands of riparian woodland can be flooded at lower flow levels, but this is considered non-damaging. Farmers have installed drain tiles in many floodplain fields and in some locations they have noted that land drainage is reduced as flows increase above 800 cfs. Although no farmed acreage is flooded until flows are above 2,500 cfs, the drainage problems increase the time needed to dry out the fields following a flood or heavy rainfall. Wetland managers and owners state that wetland infrastructure can utilize river flows for inundating wetlands when the flows are in the range of 2,000 to 2,700 cfs, depending on the location.

There was no evidence of overbank farmland flooding during the 2,000 cfs river profile survey, although as noted above wet fields due to poor drainage were evident. Field drainage problems were most noticeable along the left bank in the reach from RM 137.4 to 135.6 upstream of the Hwy 5 Bridge and again along the left bank in the reach from RM 118.0 to 115.8 in the vicinity of Sedan Bottoms. A farmer stated that poor drainage can also be a concern during moderate river flows along farm tracts on the right bank from RM 132.2 to 131.1. He also noted that a walnut orchard along the right bank at RM 131.4 can be damaged by root saturation and bank erosion during sustained high releases of 2,000 to 3,000 cfs. Local inflows from uncontrolled tributaries can result in flooding during severe rainstorms even without minimum releases from Rathbun Dam. The major uncontrolled tributaries on the Iowa side include Walnut Creek (Chariton River confluence at RM 137.9) and Cooper Creek (Chariton River confluence at RM 129.2).

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Bank measurements during the 2010 and 2013 river surveys indicated that farmland flooding begins with flows above 2,500 cfs from the Dam down to just below the State Line (RM 111.5). The initial areas affected include a tract of low-lying pasture along the right bank from RM 140.2 to 139.9, and row crop farm land (corn, soybeans) along the left bank in the reaches from RM 137.4 to RM 136.4, in the vicinity of RM 132 just upstream of the 493rd Street Bridge, and east (left bank) of the managed wetlands downstream of Sedan Bottoms from about RM 118.0 to just above the State Line (RM 111.5).

At a river flow of 3,000 cfs some farmland flooding was documented particularly in the reaches above the Hwy 5 Bridge at RM 135.6 and from RM 118.0 to 115.8 in the Sedan Bottoms area. A rough field estimate indicated about 500 acres of farmland could be flooded at this river level. At higher flows, the acreage flooded gradually increases, but specific acreages could not be determined. The 2010 peak flows at the Moulton gage ranged from 7,790 cfs to 14,500 cfs, and the river surveys noted large additional acreages of row crops and pasture that had obviously been inundated and killed prior to the Rathbun Dam late summer and fall high releases.

Based on the 2010 and 2013 river surveys, it is estimated that infrastructure, primarily county roads and bridges, is affected at river flows beginning at about 4,000 cfs. A 0.2 mile section of 461st Street at RM 139.6 near the Darby Bridge would be overtopped at a flow near this level. However, alternate access is available to the fields and improvements on either side of this section, and this section of the river is mainly affected by releases from the dam. More substantial overtopping of County Road 300th Avenue south of 590th Street from RM 114 to RM 112 begins at river flows above about 5,000 cfs. This section of road provides access to a number of public and private fields and wetlands and two homes. One home is used seasonally or as a rental, and there is no other access to it. The other home is a permanent residence with alternate access from a hillside farm road. An abandoned section of 590th Street west of 300th Avenue would be overtopped at some level between 3,000 cfs and 5,000 cfs, but it is only used for wetland access. 285th Avenue west of the Sedan Bottoms Bridge at RM 118 would be overtopped at around 7,000 cfs. This is also the lowest active bridge, with a low steel equivalent to a flow around 8,300 cfs. The abandoned Mud Bridge west of 590th Street at RM 114.2 and the abandoned railroad bridge at RM 115.3 have lower substructures, but they are no longer maintained. The Darby Bridge at 461st Street at RM 139.6 has a slightly lower substructure than the Sedan Bottoms Bridge, but like the road it is only affected by releases from the dam. There were no residences or actively used outbuildings or businesses that appeared to have been flooded even by the high flows during the summer of 2010. A pole barn and other outbuildings in the vicinity of RM 139 near the Darby Bridge were at a level that would be flooded with a river flow of around 5,000 cfs, but again this area is upstream of any substantial inflow creeks and only affected by releases from the Dam.

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The Missouri Rebels Cove Conservation Area begins just below the State Line at about RM 109.5 and extends to about RM 98.9, the lower extent of thedetailed 2010 river surveys. The 2010 surveys noted that the channel capacity gradually increases through the Rebels Cove reach, with an estimated channel capacity in the range of 5,500 cfs to 6,500 cfs at the lower end. The estimated channel capacity at the Livonia river gage (RM 91.8) is 7,000 cfs or more. The channel downstream of Livonia has mostly been straightened and channelized, and the channel capacity increases rapidly. At the Novinger river gage (RM 73.1), the NWS shows a flood stage of 20 ft, about 17,500 cfs with current rating curves. The NWS states that at this level farm fields along the river begin to flood. The moderate flood stage at Novinger is 23 ft, about 21,700 cfs with the current rating curves. The NWS states that at this level moderate flooding of farmland occurs. At the Prairie Hill river gage near the Chariton River mouth, the NWS shows a flood stage of 15 ft, about 13,100 cfs with current rating curves, with damage to farm fields along the river. The moderate flood stage at Prairie Hill is 19 ft, about 22,900 cfs with current rating curves. The NWS states that at this level farmland and secondary roads in the floodplain are under water.

The average rate of water travel for flood peaks on the Chariton River below Rathbun Dam is about 70 miles per day, although water travel times vary considerably with rate of flow and channel condition. Plate 4-3 indicates the flood peak travel time in days from Rathbun Dam to the mouth of the Chariton River. Experience has indicated that travel time of discharges less than bankfull will be about twice the travel time observed for flood discharges, about 30 to 40 miles per day. The below Table 4-4 lists the results of a travel time study for a 1,300 cfs discharge.

**Table 4-4: Rathbun Reservoir Downstream Travel Time**

| | Travel Time Minutes From Rathbun Dam | Travel Time Hours From Rathbun Dam | Travel Time Hours Between Stations | Distance From Rathbun Dam in Miles |
|---|---|---|---|---|
| **Centerville (Hwy 5)** | 308 | 5.1 | 5.1 | 6.0 |
| **Moulton (Co. Rd.)** | 1028 | 17.1 | 12 | 21.8 |
| **Coal City (Co. Rd.)** | 1375 | 22.9 | 5.8 | 29.7 |
| **Lavonia (Hwy 136)** | 2230 | 37.2 | 14.3 | 48.9 |
| **Novinger (Hwy 6)** | 2865 | 47.8 | 10.6 | 67.2 |
| **Yarrow (Co. Rd. N)** | 3300 | 55 | 7.2 | 78.2 |
| **Elmer (Co Rd. J)** | 3720 | 62 | 7 | 88.9 |
| **New Cambria (HWY 36)** | 4325 | 72 | 10 | 103.4 |
| **Prairie Hill (Hwy 129)** | 5025 | 83.7 | 11.7 | 120.8 |

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**4-10. Upstream Structures.**
There are no regulated flood control structures upstream of Rathbun Dam.

**4-11. Downstream Structures.**
There are no regulated flood control structures downstream of Rathbun Dam on the Chariton River.

## 4-12. Economic Data.

**a. Population.** The population of Appanoose County, Iowa is estimated to be 12,739 in 2014. The population is slowly declining with a total of 13,721 in the 2000 census and 12,887 in the 2010 census. The current per capita income is $22,820 per year. The county includes about 5,600 households with a median household income of $37,592 and average household income of $51,715. (http://www.appanoosecounty.org)

**b. Agriculture.** Agriculture is important to the economic fabric of Appanoose County and Iowa. Appanoose County's 731 farms cover 197,904 acres of land, which accounts for 60 percent of the surface land in the county. Crop and livestock production are the visible parts of the agricultural economy, but many related businesses contribute as well by producing, processing and marketing farm and food products. These businesses generate income, employment and economic activity throughout the region. Appanoose County farmers harvested 28,387 acres of corn and 24,189 acres of soybeans, and produced 1,817 hogs and 28,626 head of cattle in 2007. Farms on average are smaller in Appanoose County, at 271 acres, than the statewide average of 311 acres. Sales per farm in Appanoose County were $51,821 in 2007 (Iowa State University Extension).

**c. Industry.** Appanoose County was once a major coal mining region. In recent decades, the state has made a mostly unsuccessful effort to develop manufacturing as an alternate form of employment. A Rubbermaid plant was the county's largest private employer until the company announced, in June 2006, that the plant, located in the Centerville industrial park, would relocate to Winfield, Kansas in October of that year. Unemployment in Appanoose County has consistently ranked among the highest in the state of Iowa.

**d. Flood Damages.** As of October 2014, the Rathbun Project has prevented $160,880,400 in damages since MPP operation began on October 29, 1961. Damages prevented are "fair shared" with other flood control projects in the Missouri River Basin. The average annual damages prevented have been $2,979,300.

## 4-13. Stage-Damage Curves.

Stage-damage curves are shown on Plate 4-4.

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## Table 4-5: Monthly Rathbun Reservoir Inflow Acre-Feet

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1939** | 797 | 571 | 89468 | 36730 | 2103 | 17342 | 5064 | 24827 | 252 | 95 | 153 | 129 | 177531 |
| **1940** | 99 | 234 | 8097 | 8624 | 17106 | 849 | 403 | 7631 | 607 | 77 | 149 | 234 | 44110 |
| **1941** | 881 | 8694 | 2467 | 1587 | 1127 | 25581 | 2949 | 186 | 12641 | 28435 | 34303 | 14795 | 133646 |
| **1942** | 24992 | 11722 | 17798 | 2991 | 5225 | 34455 | 19093 | 5219 | 2823 | 2479 | 12258 | 21809 | 160864 |
| **1943** | 9069 | 18800 | 10737 | 10848 | 76198 | 88297 | 6327 | 13885 | 5115 | 462 | 1184 | 783 | 241705 |
| **1944** | 1184 | 4953 | 26297 | 100736 | 60110 | 60632 | 581 | 9348 | 7371 | 16850 | 5153 | 21771 | 314986 |
| **1945** | 3866 | 45077 | 50978 | 49260 | 85560 | 39283 | 5506 | 438 | 3178 | 6290 | 2993 | 5859 | 298288 |
| **1946** | 68092 | 8585 | 83365 | 15787 | 9566 | 114587 | 43770 | 31490 | 16189 | 19319 | 9495 | 6071 | 426316 |
| **1947** | 10102 | 6559 | 36417 | 109529 | 26408 | 210402 | 7900 | 298 | 260 | 177 | 1343 | 2531 | 411926 |
| **1948** | 696 | 28844 | 61895 | 5564 | 8045 | 861 | 1166 | 651 | 290 | 125 | 426 | 188 | 108751 |
| **1949** | 3098 | 24708 | 41687 | 12752 | 3550 | 40805 | 25075 | 17697 | 3622 | 1664 | 873 | 1323 | 176854 |
| **1950** | 9808 | 32996 | 23542 | 11106 | 22919 | 85308 | 6591 | 3116 | 200 | 127 | 145 | 163 | 196021 |
| **1951** | 242 | 24756 | 18353 | 46138 | 52067 | 48998 | 12462 | 3939 | 726 | 9219 | 7307 | 2765 | 226972 |
| **1952** | 9501 | 6859 | 66800 | 16199 | 15999 | 52269 | 2152 | 6994 | 436 | 141 | 2517 | 1488 | 181355 |
| **1953** | 1234 | 13664 | 33355 | 38284 | 11473 | 8317 | 1884 | 139 | 56 | 111 | 99 | 117 | 108733 |
| **1954** | 81 | 115 | 349 | 3457 | 2908 | 7898 | 151 | 2323 | 274 | 14886 | 89 | 171 | 32702 |
| **1955** | 1234 | 18419 | 14983 | 8652 | 4507 | 964 | 6434 | 173 | 69 | 65 | 60 | 61 | 55621 |
| **1956** | 61 | 188 | 119 | 63 | 71 | 248 | 1539 | 19333 | 113 | 22 | 60 | 125 | 21942 |
| **1957** | 65 | 186 | 286 | 21200 | 11613 | 14208 | 5968 | 1012 | 1075 | 319 | 1202 | 2057 | 59191 |
| **1958** | 1218 | 13682 | 14247 | 4512 | 8807 | 1825 | 26585 | 32353 | 19250 | 4671 | 9785 | 1648 | 138583 |
| **1959** | 1289 | 38363 | 76543 | 58549 | 104130 | 34449 | 8065 | 15664 | 12554 | 20287 | 2862 | 11006 | 383761 |
| **1960** | 53499 | 10362 | 93895 | 87544 | 107831 | 15878 | 9160 | 2805 | 2698 | 710 | 11953 | 1670 | 398005 |
| **1961** | 857 | 19881 | 104816 | 22898 | 7599 | 4320 | 21168 | 1545 | 69682 | 35550 | 145976 | 8763 | 443055 |
| **1962** | 18028 | 63333 | 95158 | 10645 | 19129 | 42471 | 2499 | 6609 | 2446 | 28124 | 13436 | 2497 | 304375 |
| **1963** | 1531 | 9884 | 86403 | 9632 | 11284 | 936 | 1295 | 226 | 1500 | 85 | 434 | 147 | 123357 |
| **1964** | 323 | 345 | 1170 | 16388 | 5699 | 51636 | 4558 | 371 | 19553 | 770 | 579 | 1133 | 102525 |
| **1965** | 15820 | 18764 | 56498 | 90965 | 5530 | 7831 | 694 | 167 | 86606 | 3104 | 1789 | 14128 | 301896 |
| **1966** | 14845 | 17623 | 7775 | 6607 | 30504 | 15190 | 1115 | 770 | 292 | 131 | 97 | 323 | 95272 |
| **1967** | 553 | 1119 | 2386 | 24831 | 14327 | 144135 | 3189 | 1825 | 607 | 13845 | 7964 | 4453 | 219234 |
| **1968** | 10066 | 3907 | 3699 | 68887 | 4403 | 2132 | 2112 | 536 | 417 | 595 | 734 | 456 | 97944 |
| **1969** | 35703 | 17425 | 19597 | 21323 | 18159 | 10017 | 42804 | 8013 | 6268 | 2559 | 6546 | 1944 | 190358 |
| **1970** | 6853 | 2886 | 7359 | 34553 | 33194 | 6744 | 1577 | 45025 | 68213 | 50976 | 7527 | 11584 | 276491 |
| **1971** | 3709 | 52523 | 29475 | 5306 | 13329 | 3570 | 4503 | 1567 | 2926 | 2440 | 5514 | 8807 | 133669 |
| **1972** | 1567 | 7359 | 5613 | 19230 | 35872 | 11851 | 5851 | 11048 | 30526 | 1279 | 15233 | 15263 | 160692 |
| **1973** | 38817 | 60031 | 99096 | 132071 | 100722 | 38282 | 31637 | 17395 | 40166 | 97985 | 5018 | 32172 | 693392 |
| **1974** | 58692 | 18070 | 25438 | 26936 | 49528 | 67221 | 23227 | 3243 | 645 | 3521 | 5951 | 7170 | 289642 |
| **1975** | 5217 | 9041 | 45571 | 34453 | 13666 | 37111 | 6863 | 2896 | 4265 | 387 | 5157 | 12113 | 176740 |
| **1976** | 367 | 10314 | 41911 | 84259 | 33263 | 47306 | 12595 | 2579 | 893 | 1557 | 0 | 0 | 235044 |
| **1977** | 0 | 3777 | 13837 | 9929 | 6030 | 2045 | 2807 | 37994 | 50091 | 74883 | 35023 | 8422 | 244838 |
| **1978** | 2095 | 3330 | 75857 | 118133 | 81272 | 42483 | 42298 | 3652 | 36282 | 1430 | 14263 | 7026 | 428121 |
| **1979** | 3749 | 7541 | 147868 | 36099 | 28203 | 23236 | 16899 | 1081 | 2093 | 536 | 3023 | 2033 | 272361 |
| **1980** | 1448 | 9659 | 19319 | 15878 | 1146 | 118879 | 5236 | 13597 | 49259 | 2003 | 2479 | 26400 | 265303 |
| **1981** | 1210 | 12774 | 5534 | 33441 | 4007 | 68658 | 173653 | 8846 | 3660 | 5564 | 20896 | 7448 | 345691 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1982** | 4066 | 60307 | 93888 | 37567 | 82433 | 25101 | 191405 | 25527 | 35127 | 47147 | 29980 | 1291 | 633839 |
| **1983** | 10076 | 37388 | 37755 | 102535 | 12347 | 12972 | 1577 | 2073 | 1170 | 3461 | 30595 | 12843 | 264792 |
| **MONTH** | **JAN** | **FEB** | **MAR** | **APR** | **MAY** | **JUN** | **JUL** | **AUG** | **SEP** | **OCT** | **NOV** | **DEC** | **TOTAL** |
| **1984** | 6476 | 29901 | 37240 | 78615 | 62876 | 57401 | 10830 | 123 | 565 | 6694 | 4780 | 8162 | 303663 |
| **1985** | 3203 | 37438 | 33421 | 4532 | 6337 | 14965 | 11028 | 34829 | 13488 | 94324 | 30496 | 4869 | 288930 |
| **1986** | 18496 | 21372 | 45788 | 23405 | 129867 | 7081 | 30545 | 26281 | 77504 | 74596 | 7904 | 15550 | 478389 |
| **1987** | 5365 | 3481 | 45917 | 29702 | 27134 | 13309 | 32737 | 66426 | 28056 | 1745 | 32787 | 50697 | 337356 |
| **1988** | 6575 | 13666 | 7408 | 6317 | 4393 | 1701 | 194 | 1765 | 2413 | 83 | 2846 | 241 | 47602 |
| **1989** | 1220 | 589 | 1678 | 1061 | 5377 | 2180 | 1111 | 3233 | 9957 | 1874 | 179 | 30 | 28489 |
| **1990** | 3104 | 2571 | 24407 | 17266 | 82464 | 79717 | 83416 | 11881 | 1022 | 2162 | 4979 | 4655 | 317644 |
| **1991** | 1974 | 26460 | 41406 | 142029 | 76722 | 15065 | 714 | 1607 | 714 | 2850 | 6655 | 6665 | 322861 |
| **1992** | 6159 | 23187 | 15682 | 102735 | 3560 | 1636 | 58444 | 25528 | 290226 | 2132 | 58364 | 49310 | 636963 |
| **1993** | 13577 | 26043 | 80857 | 78011 | 73271 | 35772 | 317013 | 36585 | 20936 | 2440 | 813 | 4284 | 689602 |
| **1994** | 1289 | 13597 | 21074 | 9402 | 18625 | 29613 | 4017 | 670 | 853 | 972 | 2747 | 2231 | 105090 |
| **1995** | 1250 | 4602 | 5205 | 55874 | 177719 | 52502 | 43378 | 694 | 1021 | 754 | 774 | 843 | 344616 |
| **1996** | 4532 | 20202 | 11445 | 4592 | 183104 | 44430 | 1448 | 1716 | 1835 | 6833 | 4502 | 2489 | 287128 |
| **1997** | 2013 | 56499 | 28790 | 51164 | 40731 | 14331 | 3511 | 9382 | 2162 | 22413 | 6119 | 24228 | 261343 |
| **1998** | 27640 | 30813 | 92598 | 88988 | 85400 | 53425 | 10701 | 3451 | 7140 | 53207 | 35762 | 6942 | 496067 |
| **1999** | 10969 | 17732 | 31061 | 85041 | 64502 | 52790 | 5574 | 3322 | 1666 | 684 | 1388 | 190 | 274919 |
| **2000** | 254 | 3550 | 190 | 428 | 407 | 22086 | 6684 | 1964 | 3481 | 2826 | 526 | 1388 | 43784 |
| **2001** | 4574 | 53524 | 103339 | 38231 | 68370 | 125157 | 7170 | 4314 | 3273 | 12793 | 1150 | 2668 | 424563 |
| **2002** | 714 | 3025 | 5098 | 21293 | 72050 | 6456 | 2817 | 803 | 61 | 1107 | 113 | 65 | 113602 |
| **2003** | 61 | 1488 | 2212 | 2747 | 17207 | 8936 | 2102 | 115 | 3501 | 793 | 9659 | 3759 | 52580 |
| **2004** | 2777 | 13418 | 57441 | 3779 | 23068 | 33283 | 11821 | 74588 | 8093 | 1131 | 922 | 1874 | 232195 |
| **2005** | 2529 | 34899 | 3798 | 43607 | 3679 | 15084 | 4314 | 734 | 567 | 119 | 809 | 180 | 110319 |
| **2006** | 103 | 194 | 1912 | 2856 | 6109 | 355 | 99 | 3009 | 300 | 1577 | 811 | 2380 | 19705 |
| **2007** | 5693 | 30506 | 26023 | 81808 | 76978 | 13309 | 329 | 131591 | 1880 | 22869 | 813 | 34423 | 426222 |
| **2008** | 28592 | 16721 | 86707 | 111431 | 60198 | 129987 | 192010 | 15987 | 50400 | 24278 | 33094 | 52383 | 801788 |
| **2009** | 10423 | 6754 | 96545 | 46364 | 61845 | 51045 | 34235 | 81461 | 7974 | 58755 | 37969 | 29980 | 523350 |
| **2010** | 40483 | 7567 | 132506 | 92451 | 113361 | 191567 | 184612 | 54516 | 138555 | 7309 | 13932 | 4684 | 981543 |
| **2011** | 5888 | 47283 | 28600 | 45763 | 78212 | 131734 | 4356 | 4089 | 1519 | 2270 | 4550 | 8877 | 363141 |
| **2012** | 3009 | 5266 | 10437 | 13593 | 13763 | 15070 | 91 | 1102 | 515 | 3866 | 1759 | 1479 | 69950 |
| **2013** | 1336 | 3939 | 32945 | 182952 | 122202 | 31030 | 585 | 2467 | 1183 | 3035 | 1648 | 99 | 383421 |
| **2014** | 206 | 26025 | 8196 | 34897 | 43543 | 67634 | 11187 | 86295 | 77125 | 51864 | 2049 | 6627 | 415648 |
| **AVERAGE** | **8647** | **17736** | **38390** | **40969** | **40158** | **39556** | **24667** | **14298** | **17901** | **12800** | **10178** | **8098** | **273407** |

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# 5 - DATA COLLECTION AND COMMUNICATION NETWORKS

## 5-01. Hydrometeorological Stations.

**a. Facilities.** Upstream USGS rated gages are located near Chariton, Iowa on the Chariton River (06903400) and near Promise City on the South Fork Chariton River (06903700). Downstream USGS rated gages are located directly downstream of the Dam (0603880), near Moulton, Iowa (06904010), at Livonia, Missouri (06904050), at Novinger, Missouri (06904500), and near Prairie Hill, Missouri (06905500). A gage is also located at the dam for reporting lake elevation information (06903880). These gages are monitored in real time by the NWK Water Management Section. Stage-discharge relationships, as determined from streamflow measurements, are maintained for each of these stations by the USGS. The NWK Water Management Section applies USGS shifts to the base curves to ensure that the flows correspond to the changing hydraulic conditions at the gage site. Chariton is the only real time automated National Weather Service (NWS) precipitation station within the Chariton basin. There are many other Coop gages in the basin with data reported real-time to the NWS during floods and daily otherwise. A NWS precipitation gage is monitored at the Rathbun Project Office by Corps personnel.

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**b. Reporting.** Data from the river gages are collected by satellite Data Collection Platform (DCP) at the sites. The DCP transmits 15 minute data every hour via Geostationary Orbiting Environmental Satellite (GOES). The data is received and reviewed in the NWK Water Management Section. An additional DCP at the Rathbun Project Office collects data for reservoir pool elevation, precipitation, and wind speed and direction on an hourly basis and transmits every four hours.

**c. Maintenance.** A cooperative stream gaging program is maintained by the USGS and USACE. USACE pays the USGS to maintain the DCP and associated equipment in the Chariton basin. The USGS ensures that the gages are functioning correctly, and conducts flow measurements to ensure that the rating curve reflects current conditions at all the gage sites. During periods of data collection and transmission problems, the NWK Water Management Section contacts the USGS office at Council Bluffs, Iowa, or Rolla, Missouri to arrange for repair.

## 5-02. Water Quality Stations.

**a. Facilities.** The nearest water quality recording station is located at Prairie Hill, Missouri, 122.7 miles downstream of Rathbun Dam.

**b. Reporting.** Water quality data are stored on the U.S. Geologic Survey database and are not stored by the NWK Water Management Section. Data may be obtained on the USGS website:
http://nwis.waterdata.usgs.gov/mo/nwis/qwdata/?site_no=06905500

**5-03. Sediment Stations.**

**a. Facilities.** In 1970-1971, 30 sedimentation ranges were established in Rathbun Reservoir and 10 degradation ranges established downstream of Rathbun Dam at the locations shown on Plate 5-1. 9 of the 10 degradation ranges are resurveyed every 5 years and provide channel cross section and profile data indicating any changes in channel characteristics. A reservoir sediment survey is made periodically (10-20 years) to determine the location and progress of sediment accumulation and to provide the data necessary for computation of capacity tables and reallocation of storage when deemed necessary.

**b. Reporting.** Reporting is performed as necessary.

**c. Maintenance.** Sedimentation and degradation ranges are maintained by NWK. The degradation ranges were last surveyed in 2011 as part of the last periodic inspection. The current operational area capacity tables were generated as provided in Exhibit D.

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In recent years, the pool sedimentation has been monitored with total lake digital bathymetric surveys. This methodology does not require surveys of the sedimentation ranges themselves, although comparable cross sections can be derived using GIS techniques. The last survey of the sedimentation ranges was done as part of a total lake survey in 1999. The flood pool portions of the sedimentation ranges were also surveyed at that time with traditional land survey techniques. The data was then used to compute area-capacity tables that as of 2015 continue to be used operationally. These tables are provided in Exhibit D.

In 2010 the multipurpose pool was again surveyed with total lake bathymetry. The sediment ranges themselves were not resurveyed. The data was used to compute a capacity table of the multipurpose pool only using GIS techniques, but this survey was only intended to monitor sediment accumulation. Future sediment surveys will likely use similar methodologies. When it becomes necessary to re-compute the operational area capacity tables covering the entire project, the bathymetric surveys can be combined with LiDAR or similar remote sensing data for the land portions of the project.

**5-04. Recording Hydrologic Data.**
Data from the DCP is reviewed for completeness and accuracy daily by the NWK Water Management Section personnel. Daily 6:00 a.m. gage height readings, the 6:00 a.m. flow, and raw hourly gage height data are stored in the Corps Water Management System (CWMS). This data are used to prepare project forecasts for inflow and Rathbun Reservoir pool elevations. Data are maintained indefinitely in the CWMS database for use in subsequent studies and reports.

**5-05. Communication Network.**
Communication facilities at Rathbun Reservoir are local and long distance telephone service. Contact can also be made by e-mail. Maintenance of the telephone lines is the responsibility of the company leasing the lines to the Government. Project computers are a part of the NWK network. To alert the public of impending gate changes, a warning horn is located in the downstream area of the project.

**5-06. Communication With Project.**

**a. Regulating Office With Project Office.** Gate orders for Rathbun Dam are made via telephone to project personnel, and then followed by a formal gate order signed by the chief of the Hydrologic Engineering Branch. The project reporting instructions, described in paragraph 5-07 of this WCM are communicated directly to the NWK Water Management Section either by telephone or electronically. Generally the regulating office coordinates reservoir operation activity with the IDNR, the NWS, the USGS, the Iowa State Patrol, the Iowa Department of Transportation (Iowa DOT), and local sheriff and police agencies as needed.

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**b. Between Project Office and Others.** On occasion, project personnel may be responsible for coordinating with the IDNR, the NWS, the USGS, the Iowa State Patrol, the Iowa DOT, and local sheriff and police agencies. The project office may also communicate with various press outlets on routine matters. Unusual issues should be referred to the regulating office for resolution.

**5-07. Project Reporting Instructions.**
Daily reservoir data from Rathbun Reservoir will be submitted to the NWK Water Management Section. This daily reservoir condition information includes pool elevation, 24 hour precipitation, 24 hour pan evaporation, wind travel in miles, current wind speed and direction, 24 hour wind peak, water temperature, air temperature (high, low and current), ice conditions, and the current release from the project. The reports may be provided electronically or by telephone.

**5-08. Warnings.**
The communities downstream from and surrounding Rathbun Reservoir are affected by major changes in reservoir levels and release rates. The damtender releases

information on current regulation activities to nearby radio stations, newspapers, organizations, and individuals concerned with water management. Prior to making a gate change, a horn is blown to give warning to people immediately downstream of Rathbun Dam. Project personnel also observe the area to assure everyone in the downstream area has taken appropriate action regarding the rising water. The NWS offices in Des Moines, Iowa, and Pleasant Hill, Missouri, are responsible for issuing flood warnings.

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# 6 - HYDROLOGIC FORECAST

## 6-01. General.

Hydrologic forecasts are necessary for predicting streamflow above and below Rathbun Dam to determine if and when releases should be made. The upstream forecasts are also used to predict the inflow to Rathbun Reservoir and provide pool elevation forecasts to the project office. The pool forecasts are used to determine whether some public facilities around the reservoir shore may become unusable. In addition, the predicted release forecast for Rathbun Dam is provided to the NWS for their use. Plate 6-1 shows the unit hydrograph for Rathbun Dam and downstream gages.

**a. Role of U.S. Army Corps of Engineers, Kansas City District.** Hydrologic forecasts are made by the NWK Water Management Section for use in the regulation of reservoirs for flood control and other authorized purposes, and for the benefit of USACE constructed projects and flood-mitigating activities. As distinguished from the NWS which prepares weather and flood forecasts for the public, the NWK Water Management Section furnishes historic, current and forecasted information on reservoir levels and releases; historic and current river gage stage readings; current river flow information for rated stations; and information on observed conditions such as temperature, evaporation or ice conditions at the reservoirs or rivers within NWK. This information is available from the NWK Water Management Section by telephone. NWK also maintains a website at http://www.nwk.usace.army.mil/Locations/WaterManagement.aspx with information and links to other data sources.

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**b. Role of Other Agencies.** The NWS in Des Moines, Iowa, is the official Federal Agency for providing river forecast information to the public. NWK, by way of the network connection and current file transfer process, obtains this information from the NWS. The NWS issues routine and special reports including the following information:

1. Weather forecasts (daily, severe weather and extended). These forecasts are issued a minimum of twice per day, and more often if weather conditions dictate. All forecasts are distributed by internet.

2. Quantitative precipitation forecasts are issued twice a day in the form of digital maps and distributed by internet.

3. Three-day river stage forecasts for the Missouri River and tributaries are issued each morning. Afternoon and evening updates are made if conditions warrant.

4. Urgent priority messages such as flood or severe weather warnings, watches, forecasts and statements are issued by internet throughout the day as conditions warrant.

## 6-02. Flood Condition Forecasts

**a. Requirements.** The regulation of Rathbun Reservoir requires a thorough analysis of weather and river conditions throughout the Chariton River Basin and the extrapolation of these conditions as far as possible into the future. Flood condition forecasts are necessary whenever substantial rainfall has occurred on the basin above or below Rathbun Dam. Modeling runoff based upon rainfall gage information from downstream tributaries facilitates appropriate reductions in flood control releases.

**b. Methods.** The NWS River Forecast Center (RFC) uses the NWSRFS API-based model and 6-hour unit hydrographs to provide daily inflow forecasts for Rathbun Reservoir and for the uncontrolled areas below the Dam. Reservoir inflow forecasts are based on the actual six-hour change in volume of storage at the project and the upstream rated gages on the South Fork Chariton River (06903700) and the Chariton River (06903400). These two gages measure the flow from 350 sq. mi. of the 549 sq. mi. drainage basin above Rathbun Dam. The RFC uses a SAC-SMA rainfall-runoff operation and routes the water using Tatum, lag k, and Muskingum operations. The NWK Water Management Section then inputs forecasted inflows and potential release rates to a Corps-developed computer model which calculates the pool elevation forecast. Forecasted pool elevations are then provided to project personnel and others in NWK on the local area network (LAN), email or NWK's intranet home page. http://www.nwk.usace.army.mil/Locations/WaterManagement.aspx

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NWK is coordinating with stakeholders for placement of reporting rain gages in Walnut and Cooper creeks. HEC-HMS modeling of uniform rainfall events, in ½-inch increments up to 4 inches, will be applied over the Chariton Basin. The design storm hydrograph used to size the Rathbun Reservoir flood control pool will be utilized to produce a family of runoff curves. These curves will then be incorporated into the WCP, in section 7-05 c. This family of curves will permit water management staff to initiate timely reduction in flows at Moulton, based on concurrent arrival of water from Walnut and Cooper creeks.

## 6-03. Conservation Purpose Forecasts.

**a. Requirements.** Release and elevation forecast are performed daily by the NWK Water Management Section. Forecasts are particularly relevant during fish spawning season or special recreation events. NWK provides the NWS a 15 day release forecast for their use.

**b. Methods.** Forecasts for conservation purposes during non-flood periods are calculated in the same manner as flood condition forecasts. The minimum release from Rathbun Reservoir is normally 11 cfs for Chariton River water quality. The IDNR may request larger releases during certain times of year through their WLMP. The releases would be limited to a few hundred cfs, unless a large release was needed for a short time such as for swift water rescue training. Any planned deviations will be thoroughly evaluated and coordinated with State, local, and Federal interests to determine the effects on fish and wildlife, and impacts to the other purposes of the project. In addition, releases up to 13 cfs may be made for the State Fish Hatchery.

## 6-04. Long Range Forecasts.

**a. Requirements.** The regulatory decision involved in evacuating stored floodwater, sustaining yield during low flow periods, and maintaining constant or slowly changing pool levels for conservation purposes is dependent on accurate estimates of the water volume that will pass through the reservoir.

**b. Methods.** Reliable methods for long-range runoff forecasts are not presently available. The NWS publishes an "Average Monthly Weather Outlook" semi-monthly which may be used as an estimate of the trend of the weather, but should not be given too much weight for one forecast, especially for a specific point. As required, generally during times of drought, long-range pool forecasts can be prepared based on the historical monthly inflows to the project.

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## 6-05. Drought Forecasts.

**a. Requirements.** Drought forecasts become particularly relevant when storage allocation amounts become critically low. Paragraph 7-12 defines all of the requirements for the Rathbun Reservoir drought contingency plan as specified in the Rivers and Harbors Act of 1970. Drought contingency plans are generally incorporated in an effort to improve environmental quality and to ensure that water is available for downstream rural water districts, farmers and municipalities. The NWS Climate Prediction Center issues seasonal drought forecasts each spring that may be used to predict water supply shortages.

**b. Methods.** Drought forecast methods are generally produced in the same manner as those for flood condition forecasts. Reservoir recharge time may be based on different percentages of average inflow.

# 7 - WATER CONTROL PLAN

## 7-01. General Objectives.

The Congressionally authorized purposes for the Rathbun Project as specified in the original project authorizing documents are flood control, navigation, water quality, recreation, and fish and wildlife. Water supply was added as a beneficial purpose in 1985 with a reallocation of 15,000 AF within the MPP. Although authorized, Rathbun Dam has never been operated for navigation support. The WCP seeks to balance all project purposes for Rathbun Reservoir in order to obtain optimum development and utilization of the basin water resources. The plan gives appropriate consideration to all applicable Congressional Acts relating to operation of Federal facilities and to public input from basin interests, in accordance with ER 1110-2-240 (Water Control Management). It is intended for use in day-to-day, real-time water management decisions.

## 7-02. Constraints.

Physical limitations are the primary factors constraining the project from balancing the project purposes. There are three main constraints on Rathbun Reservoir: limited release capabilities of the outlet works, seepage through the Dam during high water events, and seasonally limited release schedule.

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**a. Outlet Works.** The outlet works were initially designed for an intended maximum capacity of 5,680 cfs capacity through the service gates. However, release limitations were put in place prior to the completion of the dam. A 3,000 cfs test release was conducted on December 14, 1993 (NWK-ED-GD 1110-2-1150a, September 25, 2010). The stilling basin walls overtop at an approximate release rate of 1,800 cfs (USACE-NWK, July 2011).

Consequently, during the high water event of 2010 there was a historical basis for concern with regards to increasing releases above 1,500 cfs, the highest non-surcharge release allowed in the previous WCM. Improvements were made to the outlet channel in 2010 during the high water event that improved release capability to accommodate higher flows. Riprap was placed in the stilling basin and behind the wing walls of the outlet. The performance of the outlet structure was evaluated and shown to be safe for a release of at least 3,000 cfs (NWK-ED-GD 1110-2-1150a, September 25, 2010).

The magnitude of allowable pressurization in the conduit is not known. Conduit discharges causing the downstream hydraulic jump to shift upstream toward the conduit may pressurize flow through the conduit. However, prolonged 3,000 cfs releases in 2010 were closely monitored and verified that the hydraulic jump remained downstream of the conduit. Close monitoring , per the Rathbun Dam Surveillance Plan (DSP) will be necessary during releases of 3000 cfs or more to assure the hydraulic jump does not

move upstream inside the conduit. The DSP will be updated per recommendations from the next risk assessment.

Rathbun Dam currently supports a normal minimum release of 11 cfs for downstream water quality purposes, usually from the low flow gates. The water quality release can be increased if necessary to support channel flows needed for the Rathbun Rural Water Association (RRWA) water supply river intake immediately downstream of the dam. Since releases to the fish hatchery intake are non-consumptive and reenter the river downstream of the RRWA intake, they contribute to the minimum desired river flows. Low reservoir levels below 898.8 ft (NVGD29) reduce the efficiency of the RRWA water supply intake within the reservoir. In the event of the pool level falling below the lake water supply intake, the RRWA river intake can be utilized, although as the customer water demand grows the river intake may not be able to supply peak demands in the future. The river intake has a lower capacity than the lake intake, which is 17.5 million gallons per day.

**b. Seepage.** Seepage through sand layers in all four abutments of the Dam during high pool events presents a dam safety challenge during prolonged high pools . Remedial measures that include buried drains at the Chariton Valley and Buck Branch left abutment were installed to mitigate seepage concerns observed during the 2010 high pool event (USACE-NWK, July 2011). Limiting the frequency and duration of high pool events reduces the risk associated with seepage in the abutments.

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**c. Release Rate History.** The seasonal release rates in effect with the 1980 WCM revision were established in an attempt to balance downstream channel capacity and adjacent land use constraints with the available flood control pool capacity and the frequency of filling to the top of the flood control pool.

During the construction of the Dam, a test release was made in late April 1968. The channel reconnaissance that took place the day after the release revealed that the capacity of the Chariton River downstream of Rathbun Dam was significantly less than has been estimated. Previously it had been estimated that the channel capacity at Centerville, Iowa was as high as 5,000 cfs. As a result of the test release it was seen that a sustained controlled release of 2,300–2,400 cfs resulted in considerable flooding over the first 1.5 miles below the Dam and additional flooding in the vicinity of the State line. Based on this, the usable channel capacity for reservoir regulation in this reach was tentatively estimated to be 1,500 cfs. The discharge at which flood damages would become appreciable was estimated to be 2,000 cfs.

The 1980 WCM revision defined a restrictive release rate schedule that was more sensitive to seasonal downstream land use, primarily agricultural, than to pool elevation, see (USACE-NWK, Lake Regulation Manual, Sep 1980).

A significant change has occurred in land use since the early 1980s. As a result of the 1985 Farm Bill, as amended, the NRCS began to offer a new conservation easement program known as the WRP. This program allowed flood prone lands to be placed under easement for the restoration of wetlands in order to increase wildlife habitat and to improve water quality. The first applications in Appanoose County began receiving funding following the major 1993 flood. This flood also led to additional Department of Agriculture funding to accelerate the enrollment of flood prone lands into a permanent easement program called the EWRP, paralleling the WRP program. By 1998, 4,127 acres in the Sedan Bottoms area alone had been enrolled in EWRP; and by 2007, a total of 2,478 acres had been enrolled in WRP. Additional low-lying farm acreage has been purchased by private conservation organizations and most of this has been turned over to the State of Iowa. As of 2012, 5,589 acres of the easement and purchased lands had been incorporated into the Sedan Bottoms Wildlife Management Area (RM 114.3 to 119.8), managed by the IDNR. Large portions of the additional low-lying lands down to the state line (RM 111.5) are managed as wetlands by the private owners. A 2007 NRCS report estimated that a total of 4,838 acres of the lowest lying flood prone crop lands in the Chariton River floodplain are no longer used for agricultural production. As a result of the WRP/EWRP enrollments and private purchases, it appears that most, but not all of the low-lying farm lands are no longer affected by high flows. As a result of the WRP/EWRP enrollments and land purchases, most of the lowest farm lands relative to river flows have been removed from commercial production.

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Detailed Corps river profile surveys in 2010 and 2013 with releases varying from 2,000 to 3,000 cfs showed that initial flooding of remaining farmlands (pasture, row crops) in the first reach from the Dam down to the state line now begins with a river discharge of between 2,500 cfs and 3,000 cfs. At a river discharge of about 3,000 cfs, flooded farmlands total an estimated 500 acres. Field inundation increases as flows increase. The first county road overtopping begins at a discharge of 4,000 cfs, becoming significant at flows over 5,000 cfs. Bridges and inhabited structures are not overtopped until flows are well above 10,000 cfs, although the lowest support girders begin to be impacted at flows around 8,300 cfs and approaches are affected by lower flows. Downstream local inflows from tributary creeks can add substantially to Rathbun Dam releases. Major tributaries include Walnut Creek, which enters the Chariton River at RM 137.9, and Cooper Creek, which enters the river at RM 129.2.

## 7-03. Overall Plan for Water Control.

The WCP for Rathbun Reservoir is flexible and has been revised to allow the water control managers to make more appropriate adjustments based on hydrologic conditions in the Chariton River both upstream and downstream of the reservoir. This revision incorporates three significant elements. Two improvements to the WCP include

increasing allowable flood control release rates and a flexible range to implement WLMPs. Increases to the allowable flood control release rates provide an improved ability to regulate the reservoir and balance both upstream and downstream purposes. The ability to implement a flexible WLMP further improves the range of ways in which all authorized purposes can be balanced. A third improvement to the WCP allows more responsive regulation adjustments due to real-time conditions downstream (Section 7-05 c.). Uncontrolled tributary creeks can add substantial river flow between the Dam and the Moulton river gage downstream. Faster responses to storm runoff can reduce excessive flooding events downstream. NOTE: The 2015 WCM may be subject to changes based on future Risk Assessments that may update hydrologic modeling and/or the understanding of project risks associated with various pool levels described in the 2015 WCM.

**7-04. Standing Instructions.**

During flood periods, the lake will be regulated in accordance with the normal regulations for flood control operations as directed in section 7-05. The NWK Water Management Section will issue instructions for the storage and discharge of floodwater as described in paragraph 5-06. In the event communication with the NWK is disrupted, the pool level management will become the responsibility of the damtender and will be regulated in accordance with paragraph 7-05 and Exhibit B of this Manual. In addition, the damtender will immediately make every effort to reestablish communications with NWK. The damtender will make daily observations of the weather station and pool level data and report those observations as directed in paragraph 5-07 and repeated in Exhibit B. Should an emergency situation occur in which communication is not lost, such as inoperable gates, a drowning accident, or excessive trash in gates, the NWK Water Management Section will be notified immediately.

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**7-05. Flood Control Operations.**

A flood control plan for the regulation of Rathbun Reservoir was developed according to the preferred alternative outlined in the Rathbun Reservoir WCM Revision Environmental Assessment (EA). A summary and graph of allowable flood control releases follows in paragraph c and Table 7-1. An explanation and graph of the range of allowable WLMP criteria is found in paragraph b and Figure 7-3. This is a seasonal reservoir target pool elevation plan which is developed by USACE Water Management with input from various stakeholders on an annual basis. The USACE Water Management team reviews and takes into consideration all stakeholder WLMP proposals and comments prior to implementation of the final annual WLMP. The WLMP represents a plan of operation for the coming year. All WLMPs are subject to the hydrologic events that occur and may not represent actual lake operation. However, the plan provides a goal for operating the lake and will be followed as circumstances allow. In paragraph d, methodology is outlined for using precipitation gages in the basin as operational tools for flood risk reduction. Table 7-3 presents the maximum release rate changes allowed.

Paragraph e addresses the outlet works and surcharge operation. Evacuation of stored flood waters should be conducted in an immediate but prudent manner. In most cases, releases to evacuate stored flood waters can be made over a period of about 10 days. There will be, however, times when it is prudent to shorten or lengthen this period of time to lessen downstream flood risk or maintain project integrity.

**a. Seasonal Guidelines.** Zones have been established by seasonal guidelines in Rathbun Reservoir called Phase I, Phase II, and Phase III.

The dividing lines between these zones or phases vary seasonally and are referred to as seasonal guidelines. Similar guidelines have been developed for the other storage projects in NWK and serve to maintain a balance of the accumulated storage. Downstream control points have flow values corresponding to the three phases in the reservoir. Paragraph 7-05.b addresses the rates of release for the various phases. Figure 7-1 depicts the relationship between reservoir flood control zones or phases and the corresponding downstream control point flows. This illustrates that as the pool rises the urgency to release the water increases, thus the allowable flow at downstream control points also increases.

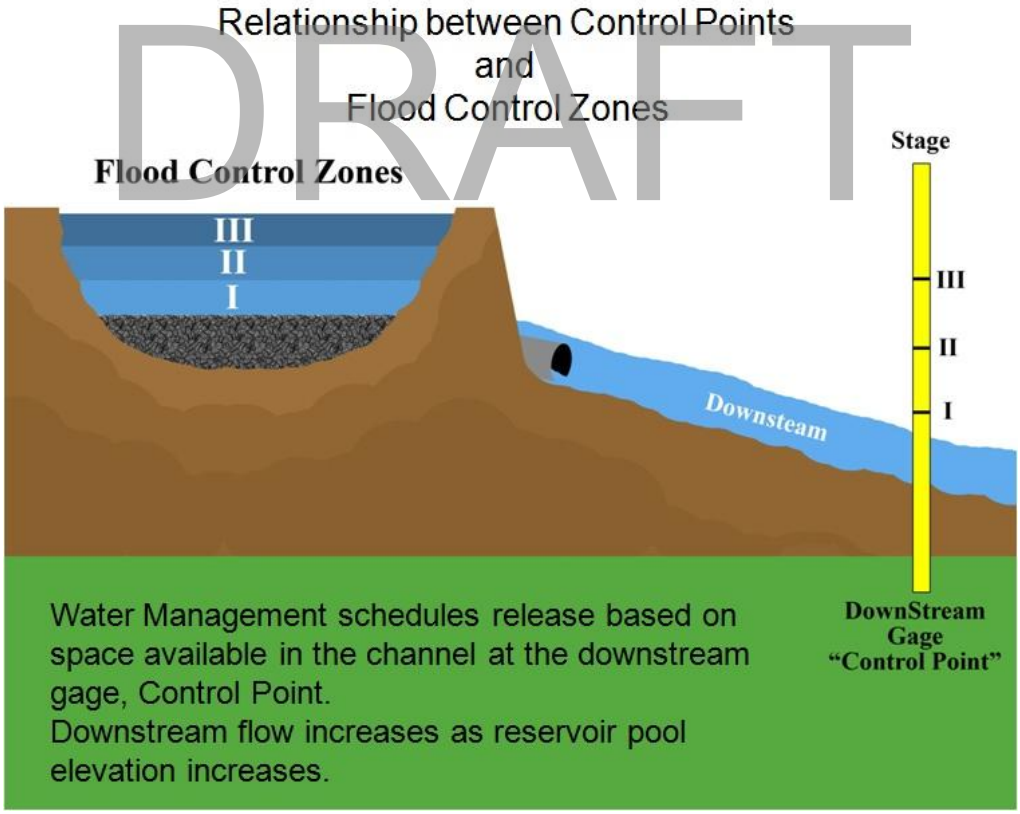


**Figure 7-1: Relationship Between Reservoir Phases/Zones and Downstream Control Points**

Developed guidelines are unique to each particular project. In construction of the guidelines for Rathbun Reservoir, the runoff-volume frequency data were computed, using the natural inflows to Rathbun Reservoir from January 1970 through December 2013. The natural inflow is calculated and saved as official pool records in accordance with both ER 1110-2-240 Para 13.d. and The Missouri River Basin Master Manual states in Para 7-04.25.. The computed 10 percent chance inflows were tabulated as shown on Plate 7-1. The inflow values account for releases necessary to evacuate the flood storage, up to a maximum of 10 days at the Phase I release rate for the 1-month inflow volume as well as for a 30-day evacuation period at a Phase I release rate for the 3-month inflow volume. Positive differences resulting from this subtraction were tabulated as storage required. The percent of flood pool used was determined by dividing the storage required by the total flood control storage available. The percent of flood pool used was then plotted for each month as shown on Plate 7-2. Since Phase III was initially assigned the upper 10 percent of the flood control pool during the major flood season, the 90 percent line was used as a base in plotting the storage requirements. The Phase I-II dividing line was constructed to encompass the plotted points. The transition period immediately preceding and immediately following the major- flood season is shaped to generally follow the increase and decrease in flood potential as evidenced by the location of the plotted points. The finally developed guidelines applicable to Rathbun Reservoir are shown on Plate 7-2.

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Two statistical analyses were completed to compare the 1980 and 2015 WCPs using historical daily inflows to derive the pool elevations. The first analysis resulted in a pool duration curve, shown as Figure 7-2. The 2015 curve represents a range of elevations per the WLMP (see Figure 7-3) and the phased releases (see Figure 7-2). The analysis indicates that, based on historical daily inflows, the Rathbun pool elevation would have reached the spillway crest (elevation 926 ft) 0.7% of the time if the 1980 WCP would have been strictly followed, and never reached if the 2015 WCP would have been followed. Based on the historical pool records, elevation 926 was exceeded in 1993 and 2010, however during both years the 1980 WCP was not strictly followed; Rathbun releases were sometimes reduced below the 1980 WCP releases to lessen downstream flooding.

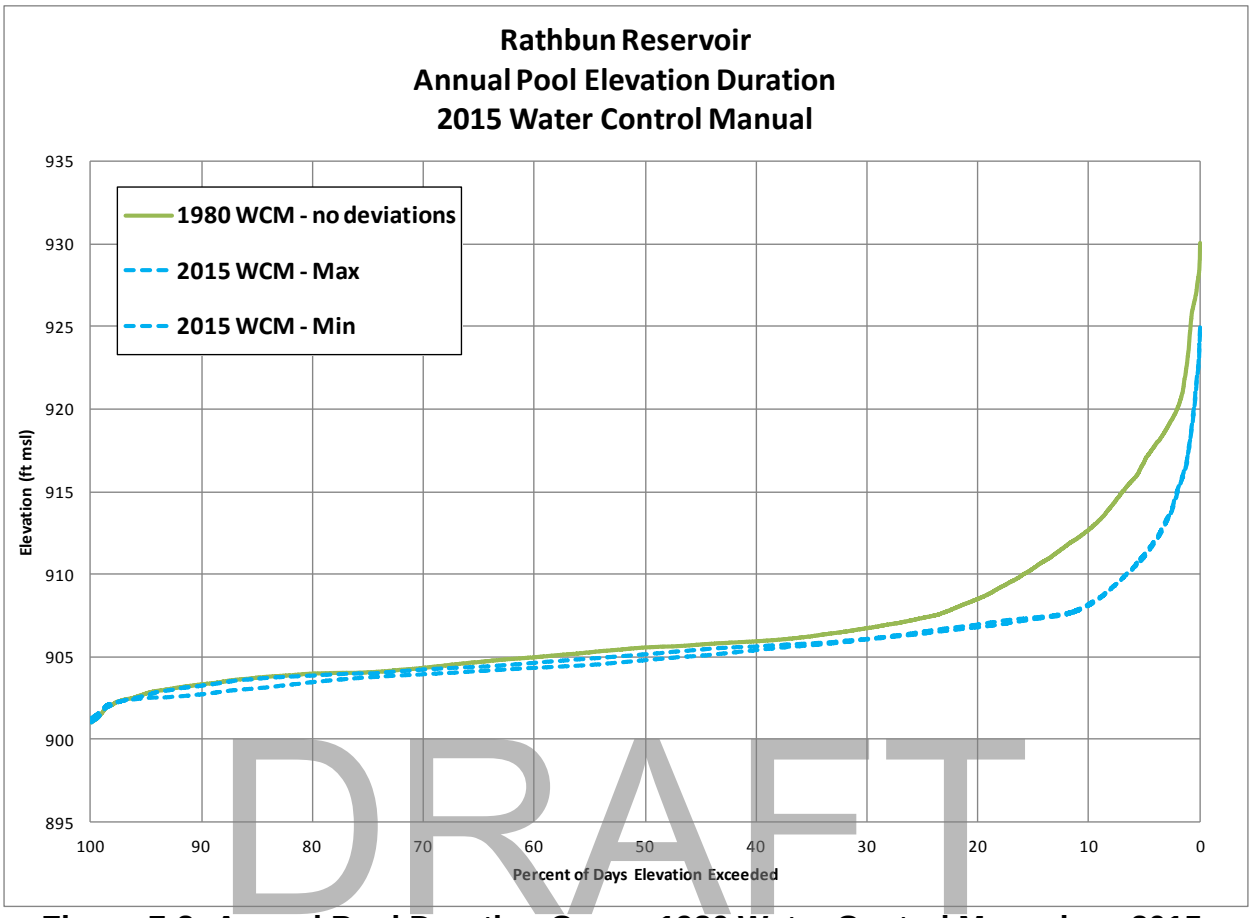


**Figure 7-2: Annual Pool Duration Curve, 1980 Water Control Manual vs. 2015 Water Control Manual**

The second analysis resulted in a pool probability curve, shown as Figure 7-3. The analysis indicates that, based on historical daily inflows, the Rathbun pool elevation has about a 1% probability of exceeding elevation 926 ft in any given year under the 2015 WCP as compared to about a 3% probability of exceeding elevation 926 ft in any given year under the 1980 WCP.

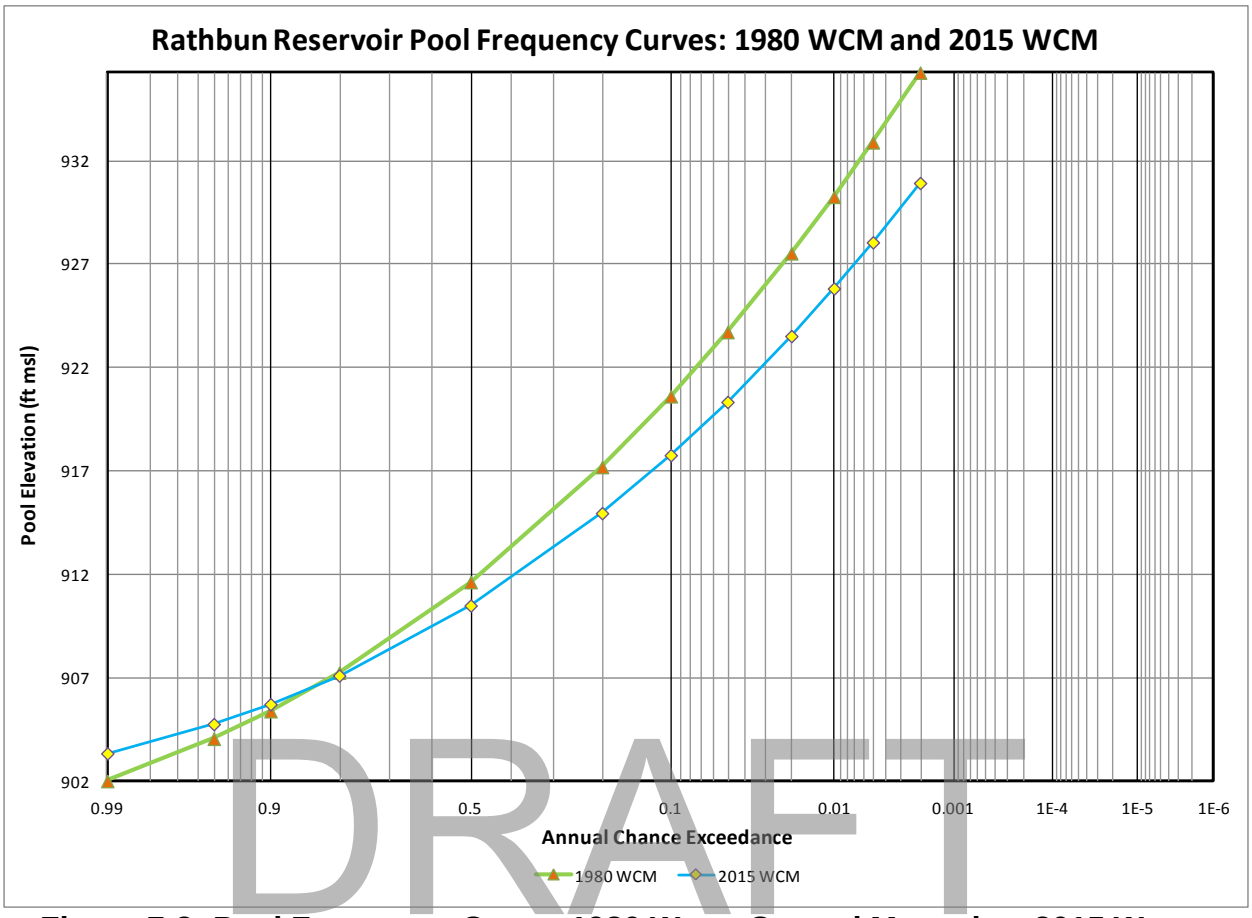


**Figure 7-3: Pool Frequency Curve, 1980 Water Control Manual vs 2015 Water Control Manual**

**b. Release Rates Schedule.** The basic plan for flood risk management is defined by flood action phases or zones within the available flood control storage of the pool. Regulation of the allocated flood control space is intended primarily to reduce downstream flooding within the constraint of minimizing the probability of filling to the top of the flood control pool and rising into the surcharge zone. As an increasing amount of storage in the flood control pool is filled, the probability of filling to the top of the pool increases, reducing the flexibility of flood control options and gradually shifting operational focus from reducing downstream flooding to reducing the probability of filling the flood control pool. Should the reservoir level rise above the top of flood control pool, preservation of the project integrity becomes the primary concern and releases will be made as directed by surcharge operating criteria, see section 7-05 e. There are three flood zones or phases defined within the flood control pool. These phase zones are shown in Figure 7-4. Below is a detailed description of the flood risk management regulation based on these phase zones. The regulation of this gated flood control dam is accomplished by the adoption of flood protection levels for each characterized damage-reach downstream from the Dam. These levels, which are defined by channel

conditions, farming practices and improvements located along the water-course, were evaluated by field reconnaissance and then related to a key river gage within each reach for the purposes of reservoir regulation and the evaluation of damages.

It has been the practice within NWK to select three protection levels designated as Phases I, II, and III, with each level representing a balance of downstream and upstream flood control benefits. At the downstream index or control point gage, the Phase II level corresponds generally to zero damage within the reach. Phase I defines a lower stage than Phase II providing some safety factor or allowance for downstream uncontrolled inflows and forecast uncertainty. Phase III is a higher stage at the downstream control point corresponding to a higher flow which will result in some damages. The specific Phase III stage is established as a level for which some regulation can be obtained without completely filling the flood control pool more frequently than desired. Discharges corresponding to the stage selected for each particular protection level are determined by stage discharge relationships and are referred to as "Regulating Discharges."

Channels are not usually filled to capacity, and a margin is provided to accommodate local inflows. This margin is represented by the Phase I stage and discharge.
A tabulation of the regulating discharges for those gages pertinent to the regulation of Rathbun Reservoir is presented in Table 7-1. This manual revision reflects changes in land use downstream of the Dam, allowing an increase in flood control releases. Section reconnaissance performed through 2013 (see 7-02) assessed channel conditions to be significantly improved through a reduction in low-lying tilled acreages, with the lowest farmland now converted to wetlands. At that time, it was determined that Phase I/II/III flow limits at Moulton could appropriately be 2,000/2,500/4,000 cfs, respectively. Farmland flooding begins at flows above 2,500 cfs. At 3,000 cfs, approximately 500 acres of agricultural land is inundated, but definite acreages were not determined. County road overtoppings begin at 4,000 cfs, becoming significant at flows over 5,000 cfs. Bridges begin to be impacted at flows over 8,300 cfs.

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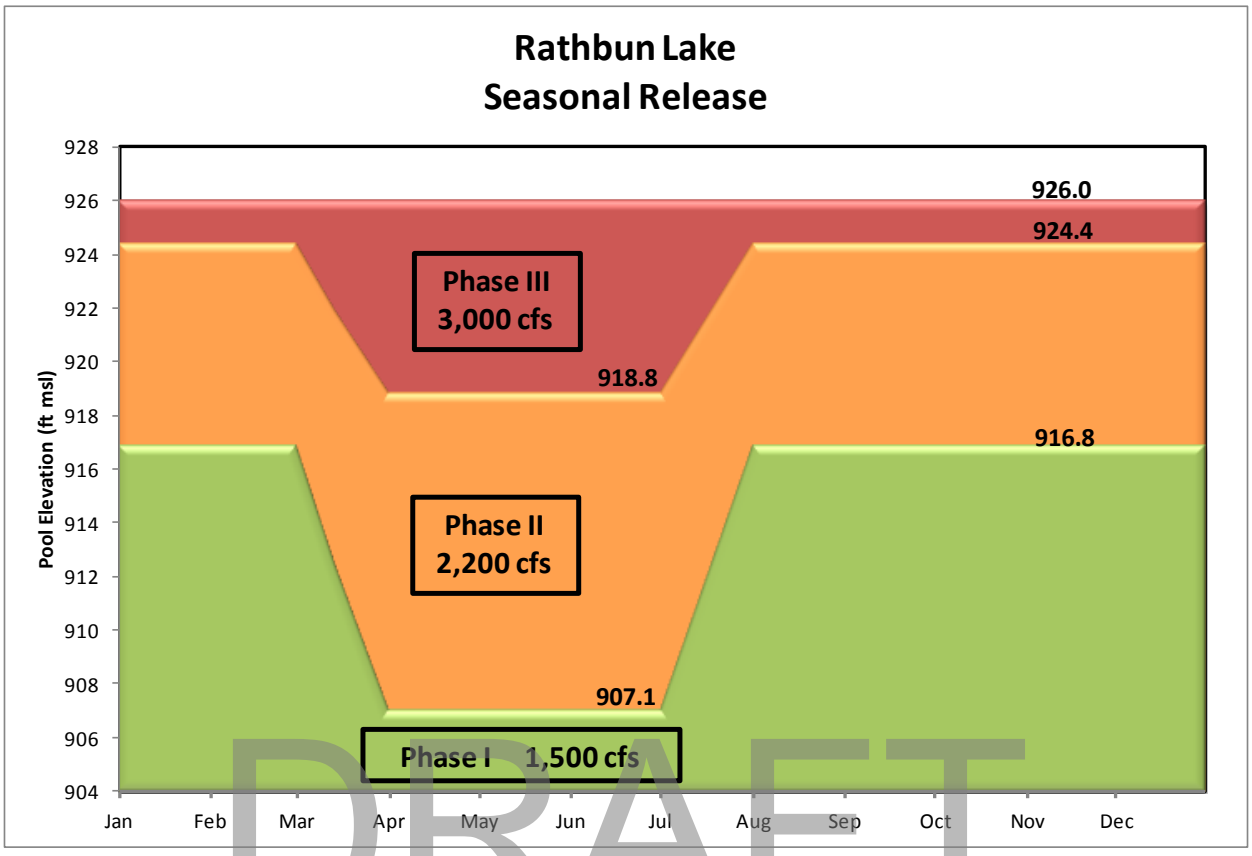


**Figure 7-4: 2015 WCM Release Rates Schedule**

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**Table 7-1: Maximum Flow Targets at Downstream Control Points**

| Stream & Gage | Reach | | Phase I | Phase II | Phase III |
|---|---|---|---|---|---|
| Chariton River | From | To | Discharge (cfs) | Discharge (cfs) | Discharge (cfs) |
| Moulton | Dam | Livonia | 2,000 | 2,500 | 4,000 |
| Novinger | Livonia | Novinger | 8,000 | 13,000 | 21,000 |
| Prairie Hill | Novinger | Mouth | 8,000 | 13,000 | 23,000 |

The following are examples of how these pool phase releases and control point phase limits are implemented. If the pool rises into Phase II and flows downstream at Moulton are rising above 2,500 cfs, the water manager shall reduce the controlled release from Rathbun Reservoir to low flow. Conversely, if the flows at Moulton have peaked above 4,000 cfs and are receding the water manager shall increase the controlled release from Rathbun Reservoir such that the timing and amount of the controlled release shall not exceed the downstream control point flow limit as shown in Table 7-1 that corresponds to the reservoir's pool elevation phase as seen in Figure 7-4.

**c. Water Level Management Plan.** In order to meet the management objectives and considerations, regulation for each year will be refined based on an evaluation of the current and anticipated hydrologic conditions and local input received during development of the annual Water Level Management Plan. Many variables impact the annual planning process when developing the WLMP. Some of those variables are long range meteorological forecasts for the basin, hydrological experiences from prior years, current year's snowpack conditions, fish and wildlife variations, and condition of shore line. Exhibit C outlines a sample of the process to be followed annually to gather and organize input for the development of the upcoming year's WLMP.

The WLMP envelope shown in Figure 7-5 defines a range of possible target pool elevations that may be used to create the annual WLMP. The range of elevations provides more flexibility to meet the needs of various authorized purposes such as fish and wildlife as well as recreation. The WLMP range improves the ability to target seasonal pool fluctuations for creation of shoreline waterfowl hunting habitat as well as improve habitat for fish and wildlife around the reservoir. The seasonal fluctuations support diverse wetland vegetation. It is anticipated that the WLMP will fluctuate to some degree from year to year to allow for each of the various authorized purposes to benefit equitably.

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Typically Rathbun Project will be regulated based on periods of each year. For the project, the regulation year can be divided into four main periods roughly corresponding to the four seasons. Multipurpose pool elevation is 904.0 ft, and the target pool elevations are between 902.5 and 905.6. The upper elevation limit, 905.6 ft, of the WLMP occupies 5 percent of the flood control pool. Should hydrologic conditions occur during the March-April (Period 3: Spring) fish spawning period, such as wet soil conditions and persistent rainfall, releases should be made to increase the pool level only to the lower end of the band (e.g. 904.0 ft).

Period 1: Fall. Commence holding lake inflows except for minimum releases until the pool elevation is no lower than 904.0 ft and no higher than 905.6 ft. A higher pool elevation is beneficial for flooding shoreline vegetation around the pool and to improve waterfowl hunter access. Lake storage can also provide a buffer for the special release desired for the downstream wetlands, described later. Fall inflows are often minimal in many years, but historically there have been a few flood events.

Period 2: Winter. Commence release of water from fall level to an elevation no higher than 904.0 ft and no lower than 902.5 ft. A drawdown below MPP can reduce winter ice damage to riprap and other shoreline structures and to allow for additional buffer storage for spring rain and snow melt runoff. In most years, the drawdown will be completed before the lake ices over. If the drawdown is not completed by that time, it may be possible to evacuate excess storage in the spring before the walleye spawn begins.

Period 3: Spring. Begin storing inflows while maintaining the required water quality release at minimum. Target pool elevations are not to exceed 905.6 ft or be below 904.0 ft. The rate of the pool rise can be variable, based upon predetermined targets for the given water year. It is desirable to restrict maximum releases to 400 cfs during the active walleye spawn period from about March 25 to April 20 to protect broodstock spawning on and near the face of the dam. If this release restriction results in the pool rising above the spring target elevation, then releases will be increased in accordance with flood control criteria. This desirable maximum release may be affected by future fisheries research and any installation of fish barriers at the intake. Research is currently ongoing regarding this issue. Once the spring target pool elevation is reached, the pool will be maintained at that level for the remainder of the spring period.

Period 4: Summer. The pool elevation may be maintained at a target elevation between 904.0 ft and 905.6 ft during this period as needed to improve recreational opportunities and improve the probability that storage will be available later in the year for fall needs. The target elevation may also be adjusted in response to hydrologic conditions. Releases above the normal minimum requirement should not cause the pool to fall below the MPP elevation of 904.0 ft.

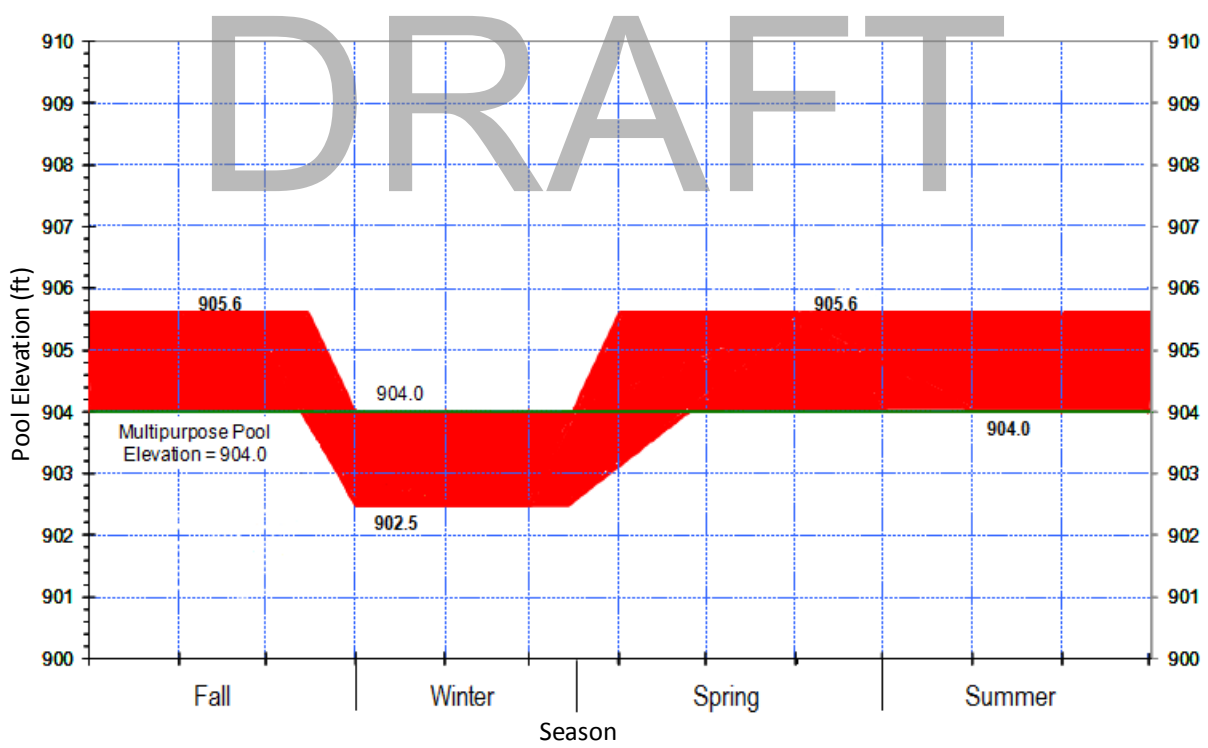


**Figure 7-5: Envelope of Permissible Water Level Management Plan**

Fall Pulse: As part of the annual stakeholder input process to the seasonal WLMP, IDNR and Missouri Department of Conservation (MDC), representing Sedan Bottoms Wildlife Management Area and Rebel's Cove Conservation Area respectively, may exercise the option to jointly request a fall pulse for downstream wetland recharge. A formal request for a fall pulse does not necessarily guarantee that said request can or will be accommodated. This joint request and interagency evaluation will include a 30 day comment period following a USACE press release describing the estimated magnitude and scheduled dates for the release. It is anticipated that the pulse will occur in late fall and last three to four days excluding ramp up and ramp down. The timing of the pulse release shall be coordinated with downstream farmers in an effort to allow ease of access to their lands for field work and harvesting and to limit any potential damage caused by the pulse. In addition to a public notice, the damtender will send notification within one week of implementation to known downstream stakeholders to ensure they are aware and ask for documentation of any impacts (negative or beneficial) from all impacted by the pulse.

Water from the pulse can be beneficial in wetting and refilling public and private wetlands throughout the reach from the Dam down through Sedan Bottoms and Rebel's Cove, thereby increasing downstream fish, wildlife and recreation benefits. The pulse is discretionary and not mandated by any biological opinion. At the conclusion of each fall pulse, the requesting agencies will document all impacts and make them available during the following year's annual stakeholder coordination meeting.

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Water for the pulse release may be taken from a combination of flood control and multipurpose storage, will not exceed a target flow of 2,700 cfs at the Moulton gage, will require normal ramp up and slower ramp down release changes to minimize bank sloughing concerns, and will be completed over a period not to exceed 8 consecutive calendar days. No deviation is required to implement the Fall Pulse. However, the District will provide notification to the Chief of the Missouri River Basin Water Management Office prior to the start of the event. The requested fall pulse will take place only to the extent that water in storage is available and include a consideration of hydrologic conditions relative to flooding potential and drought impacts. The resulting reservoir elevation at the conclusion of the fall pulse will not be targeted to be lower than the planned winter drawdown elevation.

A test pulse of 2,500 cfs was conducted in 2013, resulting in a positive impact to downstream fish and wildlife and recreation resources. Hydrologic conditions were favorable, and consequently there were no observed or reported flooding impacts to private lands, public utilities or roads over the course of this release. The test demonstrated the value of a near steady-state pulse of water with sufficient magnitude to overtop most wetland control structures and sufficient duration to fill constructed ditches and wet the ponds.

The damtender will compile all feedback received from the state agencies and downstream stakeholders to document: downstream impacts, benefits to authorized purposes, lessons learned, and how implementation can be improved in future years.

**d. Downstream Considerations.** While Rathbun Reservoir is operated for downstream control points, primarily the river gage at Moulton, Iowa, there is potential for high inflows from Cooper and Walnut Creeks which are ungaged and unregulated. These two tributaries enter the Chariton River downstream of the Dam and, upstream of the Moulton gage.

Backwater effects from controlled releases from Rathbun Dam can result in local private land inundation near the Cooper and Walnut Creek confluences with the Chariton River when outflow from both the creeks and reservoir are high. In addition, the uncontrolled inflow can add to Rathbun releases and overtop downstream Chariton River banks or add to downstream flooding. These two tributaries are flashy in nature, meaning they rise and fall quickly in response to a rain event. It is important to downstream stakeholders that USACE take these tributaries into consideration when making flood pool releases and responding to uncontrolled inflows below the dam. Historically, this has been difficult to accommodate, since in prior years it was necessary to wait until significant rises were noted at the Moulton gage, lacking other definite data. Unfortunately, by the time Rathbun Dam releases are reduced in response to a rise in the Moulton gage, upstream flooding due to the uncontrolled inflows is sometimes already imminent or occurring.

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It is the policy of USACE to regulate releases from dams based on current streamflow and rainfall data measured on the ground. Forecasted rainfall events are not deemed sufficiently accurate to provide for regulation decisions. If a rainfall event occurs at a slightly different location than forecasted, any reservoir regulation based on that forecast can contribute to increased downstream flooding, or unnecessary flood zone storage.

Field studies indicate that real-time rain gages strategically located within downstream tributary drainages could provide the means for reducing outflows from Rathbun Dam. For this purpose, USACE is coordinating the placement of rain gages in the Cooper Creek and Walnut Creek basins. Real-time rainfall data will be compared with rainfall-runoff curves developed by applying 1/2 inch increments of rainfall to the Standard Project Storm hydrograph within HEC-HMS. In this manner, real-time precipitation data will be used to forecast minimum expected, downstream tributary inflows to the Moulton gage. These flows will serve as a basis for reducing Rathbun Dam flood control releases, in accordance with longstanding stakeholder concerns related to these two downstream tributaries.

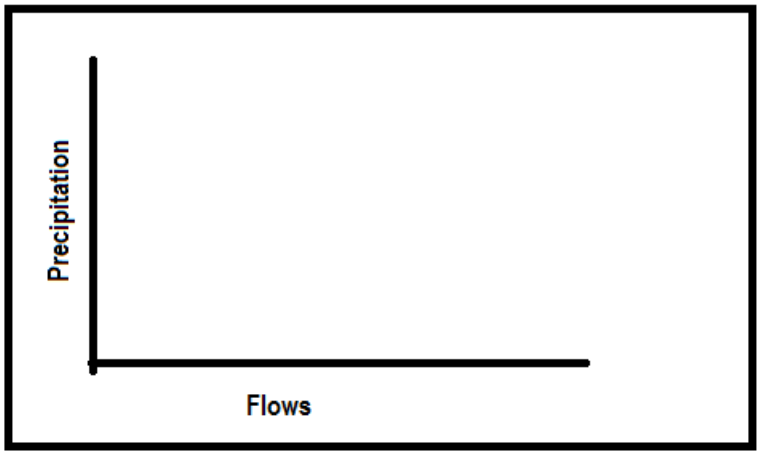


**Figure 7-6: Placeholder for chart depicting inches precipitation vs. inflows: Cooper and Walnut Creeks**

**e. Outlet Works and Surcharge Operating Criteria.** Normal flood control regulation of Rathbun Reservoir is accomplished in the storage space allocated for that purpose with the release of accumulated floodwaters being made through the river outlet works. It is possible, however, to experience a flood or series of floods the volume of which would exceed the capacity allocated for flood control.

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In the event that the spillway experiences flow, all efforts will be made to prevent overtopping of the dam and ultimately to avoid dam failure. Such extreme flood events are rare yet gravely serious. The urgency to evacuate the flood control pool is paramount. Spillway flows will likely cause at least minimal flooding damage downstream. However, this may be necessary in order to avoid overtopping or even dam failure.

The uncontrolled spillway at Rathbun Dam has been designed to operate in conjunction with the outlet works to control flooding under such excessive inflow conditions. With the spillway crest situated at the same elevation as the top of flood control pool, discharges through the spillway will begin as the water surface rises above this level. As the reservoir continues to rise, spillway discharges will occur up to the design capacity, but at less than inflow rates, with the excess inflow being temporarily stored in the surcharge pool. The spillway design thus assures that outflow from the project will not exceed the peak flow that would have occurred from the same flood under natural conditions.

With the lake water surface at or below elevation 926.0 ft (top of flood control pool), discharges will be determined by use of the criteria described in the preceding paragraphs. Outflow will not exceed 3,000 cfs as efforts are made to prevent the

conduit from becoming pressurized (by the hydraulic jump drifting upstream of the outlet into the stilling basin) and protect the downstream interests. Should the lake elevation exceed the top of the flood control pool, the project is operated independently of conditions downstream or at related projects in the Missouri River basin system and regulation is geared toward safety of the structure.

Since development of a significant amount of flow through the spillway normally would take several hours, discharges through the outlet works are continued as the lake level enters the surcharge zone. As the water level continues to rise above the spillway crest, however, the outlet works gates are gradually closed to continue relatively non-damaging releases for as long as possible. Should the lake elevation rise above 929.8 ft (the elevation at which outflow through the spillway alone will be approximately 3,000 cfs) the outlet works gates may be gradually reopened to restore full release capability of the project during the event of a major spillway flood. Monitoring of the stilling basin area will be critical during this time to ensure the conduit does not become pressurized during releases through the outlet works during a coincident spillway discharge. It may be necessary to completely close the outlet works during a sizeable spillway discharge.

**7-06. Recreation.**

USACE operates to accommodate recreation at Rathbun Reservoir to the extent practical while balancing recreation with other beneficial purposes and operating criteria. The multipurpose pool currently has 32,000 AF allocated for this beneficial use. The allocation ensures that drawdowns related to other project purposes, such as water quality releases, water supply, etcetera, will not completely empty the pool. Recreational activities available at the reservoir include day uses like swimming and boating, overnight camping, fishing and hunting. Crappie and walleye fishing in particular attracts anglers to the area. The state of Iowa has invested heavily in the Honey Creek State Park and Resort. All of these activities are optimized when the pool is maintained near the multipurpose pool level, with decreases in visitation noted during very high or very low inflow years. For additional information on recreational facilities and impacts to these facilities refer to Paragraph 2-06, Public Facilities, and Paragraph 8-03, Recreation.

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**Table 7-2: Recorded Total Visitor Hours at Rathbun Reservoir from Annual Reports**

| Year | Recorded Visitor Hours |
|---|---|
| 2013 | 7,049,884 |
| 2012 | 7,049,884 |
| 2011-2010 | 5,286,294 |
| 2010-2009 | 9,042,059 |
| 2009-2008 | 8,062,059 |

**7-07. Water Quality.**
Rathbun Reservoir has 68,000 AF of multipurpose storage above elevation 885.0 ft allocated for the benefit of water quality. Inflows to the reservoir and storage in this space currently support minimum releases to the Chariton River averaging 11 cfs. At this time resource and public health agencies believe this is sufficient to maintain reasonable water quality in the river immediately below the dam and contributes to other beneficial purposes such as the in-stream fishery. Yield studies conducted at the time of the 1985 pool storage reallocation indicated that this space allocation can support releases of up to 33 cfs through a 50 year drought event. Increases to current minimum releases can be implemented as the basin develops and as recommended by the federal and state agencies responsible for public health, consistent with the storage allocated for this beneficial purpose. Increases to average minimum releases will likely result in increased drawdowns, dependent on reservoir inflows and releases for other project purposes. Section 8-04 Water Quality gives a brief overview of how regulation of the reservoir could impact water quality.

**7-08. Fish and Wildlife.**

**a. Fisheries.** The IDNR operates the Rathbun Fish Hatchery; an intensive warm water production facility. Channel catfish and walleye are the primary fish species raised at the hatchery. Muskellunge are overwintered and other species may be raised based on stocking requests. Fish produced at this facility are stocked statewide in Iowa farm ponds, rivers and more than 250 lakes and reservoirs. Annually, more than 200,000 large fingerling catfish, 100,000 small fingerling catfish, 50 million walleye fry, 225,000 two-inch walleye fingerlings and 175,000 eight-inch walleye fingerlings are produced at the hatchery. In addition, more than 75,000 four- to six-inch catfish are provided for county conservation boards and cities each year for their caged catfish rearing programs.

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**b. Fish Hatchery Diversion.** The IDNR, in association with the U.S. Fish and Wildlife Service (USFWS), has indicated a need for a constant flow of up to 13 cfs to supply fish rearing ponds below Rathbun Dam. This flow is provided through separate valved pipe. Since this flow is non-consumptive and is returned to the Chariton River below the RRWA river intake and the USGS outlet gage, a reservoir storage allocation in addition to that required for water quality was not requested or provided. At the time the project was designed, the USFWS also requested that a minimum average annual flow of about 33 cfs be maintained immediately below the dam to enhance the downstream fishery. At this time the 11 cfs average minimum release from the dam combined with the fish hatchery return flow is sufficient to meet current needs.

**c. Wildlife Conservation Areas.** Both IDNR and Missouri Department of Natural Resources (MDNR) have established wildlife conservation areas along the Chariton River downstream of Rathbun Dam. IDNR established the Sedan Bottoms

Wildlife Management Area in Appanoose County, Iowa. The Sedan Bottoms is a 5,589 acre management area consisting of uplands, timber and marsh areas supporting various fish and wildlife species. MDC manages the Rebel's Cove Conservation Area in Putnam and Schuyler Counties, Missouri. It is a 4,235 acre area consisting of forest, grassland, old fields, cropland and wetlands. It features boat ramps, a pavilion, fishable ponds, and intermittent and permanent streams.

**7-09. Water Supply.**

Water supply storage was added to Rathbun Reservoir in 1985 through a 15,000 AF reallocation within the MPP. A total of 15,000 AF is currently allocated for water supply. In October 1986 RRWA contracted for 3,340 AF of space. An additional 3,340 AF increment was contracted by RRWA in May 1989. 8,320 AF of water supply storage remains available, although RRWA was given the right of first refusal in any future storage contracting through Section 3070 of the Water Resources Development Act of 2007.

RRWA provides water to nearly 16,000 rural families, farms and communities. Their service area includes all or parts of Appanoose, Clarke, Davis, Decatur, Des Moines, Henry, Jefferson, Lee, Louisa, Marion, Monroe, Van Buren, Mahaska, Wapello, Warren, Washington and Wayne counties in Iowa as well as rural water districts in Putnam, Mercer and Schuyler counties in Missouri.

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The primary intake for the RRWA water supply is located on Rathbun Reservoir and can operate at pool elevations between 898.8 and 940.0 ft NGVD29. The in-reservoir intake structure was entered into service in January 2013 and is designed to withdraw up to 17.5 MGD. The original intake structure, located immediately downstream of the Rathbun Reservoir outlet works, remains in service as an auxiliary intake. It has a supply capacity of 8.5 MGD, which would require a minimum flow of 13 cfs in the channel with maximum withdrawal. RRWA improved their maximum treatment plant capacity to 14.5 MGD. Their 2006 peak demand was 10 MGD and is projected to increase.

**7-10. Hydroelectric Power.**

Rathbun Dam is not authorized for hydroelectric power supply. A 1989 study in response to a preliminary FERC permit application indicated the development of such a facility would not be feasible from a dam safety perspective, in addition to environmental objections and conflicts with other project purposes.

**7-11. Navigation.**

Navigation is an authorized purpose of Rathbun Reservoir. Navigation difficulties during the 1963 season pointed to the need for low-flow supplementation along the Mississippi River. Also, in certain areas, navigation difficulties along the lower Missouri River could be avoided if water could be furnished from lower Missouri River basin reservoirs.

There is a total of 74,000 AF allocated in the MMP for navigation support on both the Missouri and Mississippi Rivers. This allocation has never been fully developed within the WCP and water for this purpose has never been called into service.

**7-12. Drought Contingency Plans.**

**a. General.** Section 216 of Public Law 91-611 (84 Stat. 1830), River and Harbors Act of 1970, gives to Water Managers the authority to review the operation of USACE projects constructed for flood control, navigation, water supply and related uses and to report to Congress on the advisability of modifying the structures, or their operation, in an effort to improve the quality of the environment in the overall public interest.

**b. Project Flexibility Within Existing Authority.** The following are observations and recommendations concerning flexibility under existing authority for Rathbun Reservoir.

1. Regulation Flexibility. The invert elevation of the intake tower is at an elevation 855.0 ft, a distance of 49 feet below the top of the MPP at 904.0 ft. Discharges greater than 780 cfs can be achieved for all pool elevations in excess of 863.0 ft.

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2. Storage Use Flexibility. Storage for drought alleviation is not an authorized project purpose. Limited withdrawal of water from Rathbun Reservoir for drought relief and certain emergency conditions does, however, fall under the heading of “other beneficial purposes”.

(a) Drought Contingency Emergency Withdrawals. The following procedures developed for the emergency withdrawal of water under drought conditions apply to all individuals, groups of individuals, organizations or political subdivisions not currently holding a water supply contract with the United States. Water withdrawals under this authority are intended for domestic purposes or for the watering of livestock. This is considered a temporary use of multipurpose storage and not a permanent right such as that granted under a water supply contract for allocated water supply storage.

Emergency water withdrawal procedures are prescribed by the NWK Emergency Management Office in compliance with Section 6 of the 1944 Flood Control Act PL 78-534. Specific authority permitting temporary withdrawal of water from Corps projects is contained in 31 USC483a, as described in EM 1110-2-3600, Section 2-5. As of 2015, the Emergency Management Procedures required a Governor’s declaration of a drought emergency for the counties surrounding the reservoir, State approval of an emergency withdrawal request by an individual, and then submittal of the request to the Emergency Management Office for issuing the permit. The permit will describe specific withdrawal

procedures (lake withdrawal point, quantity, time frame, payment). IWR Report 96-PS-4, Water Supply Handbook, states that the minimum cost is $50 per agreement per year, but actual costs will depend on a current determination of costs of storage and administration. An Emergency Management permit applicable to Kansas City District lakes is limited to a maximum withdrawal of 50,000 gal.

(b) Requests for Small Amounts of Water Over Short Periods of Time. The IWR Water Supply Handbook in accordance with the updated ER 1105-2-100 states that the District Commander has authority under the 1944 Flood Control Act to enter into temporary agreements for surplus water with local agencies for domestic, municipal and industrial water supply usage. Crop irrigation is excluded. The Rathbun Rural Water Association was granted a surplus water contract during the 1988-90 drought while they were considering the purchase of an additional space increment under their permanent water supply contract. Requests for surplus water contracts (sometimes referred to as water withdrawal contracts) are currently processed through the NWK Planning Branch.

(c) Emergency Water for Disaster Relief. The 1941 Flood Control Act, PL 84-99, PL 93-251, PL 95-51, subsequent Executive Orders, and enabling legislation for the Federal Emergency Management Agency (FEMA) provide authority for other kinds of drought relief that may or may not include emergency withdrawals from USACE lakes, depending on the specific situation. Examples are emergency water deliveries, construction or repair of water wells, emergency pumps, and other assistance. Typically, water provided under any emergency terms is considered to be a last resort after State and local resources are exhausted. For instance, farmers on rural water systems or municipal water supply would normally not be eligible for water unless restricted by the water supplier from using water for livestock watering. Farmers that use wells or cisterns as their normal source of supply should be encouraged to take advantage of rural water hauling points for treated water that are available in most communities.

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3. Rights to Use of Water. No specific rights have been established for the use of surplus flows impounded in Rathbun Reservoir. Once the storage is released into the river, it becomes subject to the water administration and laws of the State.

**7-13. Flood Emergency Action Plans.**

Normal flood control regulation of Rathbun Reservoir is accomplished by specific regulation orders to the Operations Project Manager from the NWK Water Management Section. It is conceivable, though very unlikely, that communication may be disrupted between these offices at times when events may require changes in existing releases. The Emergency Regulation portion of the Standing Instructions to the Operation Manager, presented in Exhibit B, has been developed for this contingency.

NWK has developed and maintains an Emergency Action Plan and Dam Surveillance Plan from Rathbun Dam that procedures established to detect and evaluate emergencies at the project. It also describes responsibilities and authorities for the various federal, state, and local emergency management agencies and the required coordination procedures with Project and District staff. A cooperative effort is essential to an effective flood fight or any other emergency at the project.

**7-14. Other.**
Regulation of Rathbun Reservoir for other objectives will be accomplished in accordance with the guidance provided in section 7-15, Deviation From Normal Regulation.

**7-15. Deviation From Normal Regulation.**
All deviations from the water control plan will be approved by NWD. The Chief of MRBWM has been delegated responsibility for approving most requests to deviate from a project's normal WCP. Pre-coordination of a potential deviation request should occur between the requesting office and the approving authority to ensure that a deviation is indeed necessary. Recurring deviations are sought in accordance with NWDR 1110-2-6, as described in paragraph 7-08. Possible exceptions are noted in subparagraph a., below. Deviation requests usually fall into the following categories:

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**a. Emergencies.** An emergency situation is defined as a circumstance where failure to act immediately could result in loss of life or significant property damage. Occasional non-flood emergencies can occur where deviation from the normal operating procedures would assist other interests in managing the emergency. Examples of some emergencies that can be expected to occur at a project are: drowning and other accidents, failure of the operation facilities, chemical spills, treatment plant failures or other temporary pollution problems. Water control actions necessary to abate the problem are taken immediately by the project office staff unless such action would create equal or worse conditions. In any case, the emergency is communicated to the NWK Water Management Section as soon as possible. If the water control actions taken are not covered in this WCM, these actions will be considered a deviation. NWK must inform MRBWM of its activities as soon as possible. Written confirmation of the deviation, including a description of the cause of the emergency, will be furnished to the MRBWM office by the Chief, NWK Water Management Section.

**b. Unplanned Minor Deviations.** In some instances, activities of other interests create the potential need for unplanned deviations from normal operations. Project construction and maintenance activities account for the majority of these occurrences. These activities usually require modifications to normal release procedures that are very temporary, usually from a few hours to a few days. A typical example of activities that would create the potential for unplanned minor deviations would be modifications of

bridge and utility crossings. If the proposed action is not covered by the WCM, deviation approval by the MRBWM office will be required. In evaluating requests for these types of deviations, NWK will consider upstream watershed conditions, potential flood threats, the amount of water in storage at Rathbun Reservoir and whether any alternative measures could be taken that would not require a deviation.

**c. Planned Deviations.** Detailed procedures to evaluate significant deviations requiring MRBWM approval are described in detail in NWDR 1110-2-6. Each condition should be analyzed on its merits. Sufficient data on flood potential, reservoir and watershed conditions, possible alternative measures, benefits to be expected, and probable effects on other authorized and useful purposes, together with NWK recommendation, will be presented electronically or by letter to MRBWM for review and approval. One example of a planned deviation would be scheduled dam safety work requiring release restrictions lasting weeks or months. Water level fluctuations for fish spawning management or vegetative habitat improvements are an option that will be considered each year during annual operating plan coordination meetings. All planned deviations will be thoroughly evaluated and coordinated with the affected State, local and other Federal interests.

**7-16. Rate of Release Change.**

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The sensitivity of a river reach to rapid changes of water level is dependent upon the permeability, composition, and stability of the soil making up the streambanks and adjacent floodplain. Flows at high river stages maintained over a sustained period will gradually saturate the riverbanks and cause the water table of the adjacent floodplain to rise to a level approaching that of the water surface level in the stream. When the riverbanks are steeper than the angle of repose of the saturated soil comprising the bank, a sudden lowering of the water surface causes accelerated caving of the banks due to hydrostatic pressure. Rapidly increasing flows pose a safety and damage risk to anyone in the downstream river channel. In recognition of these risks, increments have been established for each reservoir within NWK by which outflow rates can be increased or decreased. The increments result in downstream stage changes that reduce the safety risk and damages to downstream channels while providing flexibility to adjust release as needed in respond to reservoir inflows and elevations and downstream conditions. The rate of release change schedule established for Rathbun Reservoir is listed in Table 7-3. When decreasing outlet rates, all increments should be used to minimize risks. The incremental changes result in less than two feet change in stage at the Rathbun downstream gage and a stage change rate of less than 1 foot per hour at the Moulton river gage. When rain storms are occurring, it may be necessary to decrease releases to the minimum requirement in one increment in order to minimize downstream flooding. On the other hand, when the desired drawdown has been completed and minimal uncontrolled inflow is anticipated it may be possible to provide additional time between incremental changes. Missouri state agencies and regional conservation groups believe that stage changes of 1 foot per day or less are optimum.

The permissible changes in outflow rates, as listed, are pertinent to the entire range of elevations within the flood control pool but are not applicable when the water surface elevation is within the surcharge zone.

**Table 7-3: Maximum Release Rate Changes**

| Maximum Permissible Changes in Release Rates | | | |
|---|---|---|---|
| Non-Emergency Situations | | | |
| Increasing Flows | | Decreasing Flows | |
| Total Flow (cfs) | Hourly Increment (cfs) | Total Flow (cfs) | Hourly Increment (cfs) |
| - | 100 | 4,300 | 300 |
| 100 | 200 | 1,200 | 300 |
| 500 | 300 | 800 | 400 |
| 800 | 400 | 300 | 200 |
| 1,200 | 300 | 50 | 50 |
| 4,300 | 300 | - | 50 |

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# 8 - EFFECT OF WATER CONTROL PLAN

## 8-01. General.

Rathbun Reservoir is a multipurpose project constructed for the authorized purposes of flood control, water supply, water quality, navigation, recreation, and fish and wildlife. It is operated to balance the needs of all authorized purposes. The purpose of this WCP is to provide flexibility to the District Water Management staff and the damtender as they work together to regulate Rathbun Reservoir considering federal, state and local government interests as well as private stakeholders both upstream and downstream.

## 8-02. Flood Control.

**a. Spillway Design Flood.** The storm producing the inflow hydrograph used by USACE for design of the spillway at Rathbun Dam was based on data taken from the "All Season Envelope" chart accompanying Hydrometeorological Report No. 33, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 sq. mi. and Duration of 6, 12, 24 and 48 Hours." In developing the Spillway Design Flood (SDF) precipitation and response hydrograph, an initial loss of 0.40 inch and a uniform infiltration rate of 0.05 inch per hour were assumed. The excess rainfall for successive 3-hour periods was applied to a unit hydrograph developed by the procedures outlined in "Unit Hydrograph Lag and Peak Flow Related to Basin Characteristics" by Arnold B. Taylor and Harry E. Schwarz, Transactions, American Geophysical Union, Volume 33, 1952, to obtain the surface runoff from the area tributary to the reservoir. The computed spillway design flood, as adjusted to include Buck Branch, has a peak inflow of 188,200 cfs and a volume of 892,100 AF or 30.5 basin inches in a period of 6.1 days. The hydrograph for the spillway design flood is included as Plate 8-1. The SDF presented does not meet the current USACE criteria set forth in ER 1110-8-2 and may be updated in future risk assessments. New SDF may impact monitoring and perhaps other management strategies for Rathbun dam. Changes to the DSP or WLMP will be made accordingly.

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**b. Standard Project Flood (SPF).** For the purpose of representing flood discharges that might be expected from the most severe combination of meteorologic and hydrologic conditions considered reasonably characteristic of the area above Rathbun Dam, a Standard Project Flood estimate was developed in accordance with instructions contained in Civil Engineering Bulletin No. 52-8, "Standard Project Storm Determination," dated March 1952 (now EM 1110-2-1411, Rev. March 1965).

An initial loss of 1.0 inch and an average loss rate of 0.1 inch per hour were used to determine a rainfall excess of 8.6 inches. The rainfall excess applied to a composite unit graph produced a standard project flood hydrograph having a peak inflow of 79,000 cfs and a volume of 251,800 AF. This includes inflow from the Buck Creek drainage. This inflow, routed through Rathbun Reservoir with a starting pool elevation of 904.0 ft

and permitting no outflow during the flood period, resulted in a maximum water surface elevation of 921.81 ft, using reservoir capacity tables in effect at the time. The inflow and pool elevation hydrographs for this routing are presented on Plate 8-2.

The Standard Project Flood results were used to determine the starting pool elevation for routing the Spillway Design Flood described in paragraph a.

The Standard Project Flood was re-evaluated due to the updated area-capacity table and the 2015 WCM's flexible Water Level Management Plan. Using the same 215,800 AF inflow and no release with a starting pool elevation of 905.6 ft, the maximum allowable for the Water Level Management Plan, it was determined that after 150 hours of said conditions, the pool elevation would be 921.99 ft.

**c. Lake Design Flood.** Rainfall was extreme over the Chariton, the Grand and other north Missouri River basins during the months of May and June 1947. The heaviest reported precipitation occurred in the vicinity of Holt, Missouri, in the Little Platte River basin, where a total of more than 26 inches of rain fell between 25 May and 30 June. Precipitation over the Chariton River basin above Rathbun Dam site totaled generally less than 12 inches during the same period. For design of the flood control capacity of Rathbun Reservoir, the most severe storm series of this May-June event was transposed about 100 miles northeast, thus moving it from the Holt vicinity to the drainage area above Rathbun Dam site, without rotation or adjustment. Initial loss and infiltration rates over the basin, obtained from the actual May 25 - June 30, 1947 storm series, were applied to the transposed rainfall to obtain the rainfall excess. The runoff obtained by these computations amounted to 14.29 inches or 412,000 AF. The computed inflow hydrograph had a peak discharge of 38,470 cfs.

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The initial inflow hydrograph produced by the transposed May - June 1947 storm series was routed through Rathbun Reservoir while observing the following listed release criteria:

1. No releases to contribute to more than 7,000 cfs at Novinger or Keytesville, Missouri, on the Chariton River.

2. No releases to contribute to more than 200,000 cfs at Boonville, Missouri, on the Missouri River while the Boonville stage was rising Or stationary. Releases would be permitted on falling stages at Boonville.

3. Rathbun Reservoir releases during the flood period to be limited to 2,000 cfs maximum.

Uncontrolled flows at downstream points were estimated from stages observed during the actual 1947 flood event t and were believed to be reasonable. A starting pool elevation of 904.0 ft, mean sea level was observed. The routing produced a maximum water surface elevation of 925.1 ft, See Plate 8-3 for the initial hydrograph.

The area-capacity table has been updated since the initial calculations were made. The 2015 WCM has a phased release rate schedule that more accurately reflects the basin's hydrological capabilities. Therefore, the Lake Design Flood hydrograph was recalculated and plotted.

Using the 2015 phase release schedule a new hydrograph was developed. A daily average inflow value was derived from the original inflow hydrograph, ensuring the total volume remained constant. The daily average inflow was routed into the reservoir while maximum phase releases were made based on the pool elevation. The starting pool elevation was 905.6 ft, the maximum allowable for the Water Level Management Plan. Standard seasonal evaporation was assumed. The ending pool elevation on July 7, 1947 was 920.15 ft while the maximum pool elevation experienced was 921.41 ft on July 2, 1947. See Plate 8-4 for the 2015 Lake Design Flood hydrograph.

**8-03. Recreation.**

This revised water control plan is expected to reduce the frequency and duration of reservoir high pool elevations, improving access to and usage of reservoir recreation facilities. Boat ramps are expected to be accessible over 80% of the time during the recreation season (May-September). However, the increased release rates needed for flood storage evacuations could negatively impact walleye populations near the dam, particularly during the spawning season. It is hoped that the increased water level management plan flexibility and increased coordination with fish and wildlife resource agencies will mitigate these effects.

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**8-04. Water Quality.**

The increased releases expected with this revised water control plan is expected to have the potential for very minor long-term negative impacts to water quality related to the potential increase of erosion in the Chariton River downstream of Rathbun Dam. These potential increases in water turbidity and TDML's are not anticipated to change the Chariton River's 305(b) or 303(d) national and state water quality status.

Due to the increased release rates in the flood control and water level management plans it is anticipated that there will be reduced flooding and bank erosion upstream of Rathbun Dam. The reductions in silt entering the reservoir may lead to minor long-term positive impacts to the Rathbun Reservoir water quality.

**8-05. Fish and Wildlife.**
The coordination process needed for an annual operating plan will result in seasonal WLMP maximizing the fish and wildlife benefits considering all operational needs for a given year. The range of seasonal pool elevations provided within this WCM are expected to improve fish and wildlife habitat on Rathbun Reservoir. Additionally, the ability to occasionally provide a fall pulse will further enhance fish and wildlife resources along the Chariton River. Recent research by IDNR has shown that Walleye can potentially be passed even during low gated releases. However, the fish passage has been shown to increase exponentially with release in excess of 1,200 cfs, especially during the spring spawn period.

**8-06. Water Supply.**
It is not anticipated that this revised water control plan will have negative impacts to the Water Supply function. The flexibility in the plan will allow drought predictions to be factored into yearly operations to minimize the potential for drawdowns, which can impact both the water supply allocation yield and trigger more frequent accounting of contract usage. Drawdowns will probably increase in the future due to increasing basin water needs, but these are unrelated to the changes in this water control plan.

**8-07. Hydroelectric Power.**
Rathbun Reservoir is not authorized for hydroelectric power.

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**8-08. Navigation.**
There are no anticipated effects to the navigation purpose associated with this water control plan.

**8-09. Drought Contingency Plans.**
The Drought Contingency Plan is not affected by changes in this water control plan. Drought severity has not been sufficiently intense to date requiring its implementation.

**8-10. Flood Emergency Action Plans.**
Past flood events have demonstrated the need for a coordinated strategy and effective communication between the NWK Water Management Section and the other NWK elements. It is anticipated that the Emergency Action Plan, Emergency Regulation procedures and Dam Surveillance Plan discussed in Section 7-13 will assist the damtender and other project personnel in making timely decisions during a dam safety emergency or communications breakdown. Adherence to this plan by project personnel could potentially save lives and reduce property damage during an emergency situation.

## 8-11. Frequencies.

**a. Peak Inflow Probability.** The mean daily inflow into Rathbun Reservoir since October 1967 has been 437 cfs. The maximum inflow of 73,250 cfs occurred on September 15, 1992. The inflow has been zero for many days during this period. A daily frequency inflow plot has been provided as Plate 8-5. As discussed in Section 4-07, annual runoff in the Chariton Basin upstream of Rathbun Dam is highly variable and annual inflow volumes have been trending higher (See Figure 4-3).

**b. Pool Elevation Duration and Frequency.** The pool elevation duration and frequency curves in this WCM were developed based on model historic conditions and application of the revised water control plan. Plate 8-6 is a plot of the resulting pool elevation duration. The pool elevation frequency curve is plotted in Plate 8-7. The period of record (POR) used to evaluate the operational alternatives was January 1, 1950 to September 30, 2013. This is an extended data set that was statistically developed for the Missouri River Recovery Program study. The longer time series of input data provides for improved statistical analysis. The calculations of frequencies and duration used mean daily values. The plot of pool elevation ranges for the POR for the revised water control plan are shown in Plate 8-8. Plate 8-9 presents a table of annual peak discharges that could be expected with the revised water control plan with inflows from the extended POR.

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**c. Key Control Points.** Duration curves were developed for each of the Rathbun Reservoir downstream control points. The Chariton River gages include Moulton, Novinger, and Prairie Hill. Plates 8-11 to 8-25 contain the annual and quarterly duration curves.

## 8-12. Other Studies.

**a. Examples of Regulation.**

Extensive analyses were conducted in revising the Rathbun Reservoir WCP. The results of these analyses are presented in detail in the “Rathbun Reservoir WCM Revision EA.”

This review and update of the WCM examined various operational alternatives for operating Rathbun Dam and potential effects to all the authorized purposes on the reservoir and downstream conditions. Operational flexibility and improving dam safety by reducing the duration and elevation of high pools were major criteria for revising the water control plan. The analyses conducted during the review and update allowed for development of a WCP that has considerable flexibility and requires yearly stakeholder coordination.

The NWK Water Management Section utilized inflows from an extended POR (1950-2013) to test various operational scenarios. Below are examples of how the selected plan performed for the most extreme historical floods. The Historic column displays official data of record. The data presented in the 2015 WCM column are a result of simulation using the extended POR. The tables show the date on which the pool first reached 905.6 ft which is the maximum elevation allowed in the flexible WLMP, thereby representing a non-flooding pool elevation.

1. Flood of 1993. The following table summarizes possible outcomes of the 1993 flood event. For more information see Section 4-06 (i). For a plot of the event see Plate 8-26.

**Table 8-1: 1993 Flood Event**

| 1993 Event | Historic | 2015 WCM |
|---|---|---|
| **Max Pool (ft)** | 927.16 | 924.43 |
| **Max Daily Average Inflow (cfs)** | 26,750 | 26,204 |
| **Max Release (cfs)** | 1,805 | 3,000 |
| **Date 905.6 ft Reached** | 19-Nov-93 | 17-Nov-93 |

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Under the 2015 WCM, the 1993 Flood Event would have had a lower peak pool elevation, nearly three feet lower than the historic. The controlled release would be set to 3,000 cfs for roughly three days throughout the duration of the event. The pool would reach 905.6 ft on almost the same day as the historic. The reason for this is that the historic release was roughly 1,800 cfs from August through November where as the 2015 WCM controlled release varies based on the phase of the pool. The 2015 WCM would slow the controlled release from 3,000 cfs at the peak to 2,200 cfs in Phase II then to 1,500 cfs in Phase I.

2. Flood of 2008. The following table summarizes possible outcomes of the 2008 flood event. For a plot of the event see Plate 8-27.

**Table 8-2: 2008 Flood Event**

| 2008 Event | Historic | 2015 WCM |
|---|---|---|
| **Max Pool (ft)** | 925.08 | 920.13 |
| **Max Daily Average Inflow (cfs)** | 16,500 | 18,843 |
| **Max Release (cfs)** | 1,500 | 2,200 |
| **Date 905.6 ft Reached** | 27-Dec-08 | 19-Nov-08 |

With the 2015 WCM the 2008 Flood Event would have yielded in a peak pool elevation nearly five feet lower than the historic without rising into the Phase III. The pool would peak in Phase II range meaning the controlled release would not exceed 2,200 cfs. The historic event did not release above 1,500 cfs resulting in the pool elevation being higher for a longer duration of time. Using the 2015 WCM phased release rates, the pool was brought down to 905.6 ft more than a month sooner than the historic.

3. Flood of 2010. The following table summarizes possible outcomes of the 2010 flood event. For more information see Section 4-06 (i). For a plot of the events see Plate 8-28.

**Table 8-3: Revised WCM 2010 Flood Outcomes**

| 2010 Event | Historic | 2015 WCM |
|---|---|---|
| **Max Pool (ft)** | 926.70 | 924.49 |
| **Max Daily Average Inflow (cfs)** | 25,000 | 20,907 |
| **Max Release (cfs)** | 3,000 | 3,000 |
| **Date 905.6 ft Reached** | 19-Nov-10 | 20-Dec-10 |

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Using the 2015 WCM the 2010 Flood Event peak pool was more than two feet lower than the historic. In 2010 a deviation request was approved to allow the controlled release to reach 3,000 cfs much like the 2015 WCM. As a result of the deviation, the historic pool reached 905.6 ft nearly a month before the 2015 WCM. The reason is that the historic controlled release was held at 3,000 cfs from August through October despite the falling pool. The 2015 WCM lowers the controlled release from 3,000 cfs to 2,200 cfs to 1,500 cfs as the pool falls allowing the downstream flow to better reflect the conditions at the reservoir.

**b. Channel and Floodway Improvement.**

Channel and Floodway Improvement. There are currently no channelization projects in progress between Rathbun Dam and the confluence of the Chariton River. Ground and aerial reconnaissance are made as required to determine if revised channel capacities and maximum discharge limits are warranted. As of 2014, there are no FEMA flood insurance studies for rural Appanoose County or the incorporated City of Centerville.

# 9 - WATER CONTROL MANAGEMENT

## 9-01. Responsibilities and Organization.

**a. U.S. Army Corps of Engineers.** Current guidance permits the delegation of certain reservoir regulation responsibilities to the NWK District Engineer. The responsibilities for assembly and interpretation of data affecting the regulation of Rathbun Reservoir have been delegated to the NWK Commander. The Northwestern Division (NWD) Commander, through MRBWM, monitors and reviews the regulation activities performed by NWK. The responsibility for regulation and all associated activities within NWK is assigned to the NWK Water Management Section.

1. Responsibilities and Duties During Normal Operations. The NWK Water Management Section is charged with the following responsibilities and duties under general supervision of the Engineering Division.

(a) Regulation of reservoirs and dissemination of data.

(b) Investigation and refinement of regulation procedures.

1. Analysis of past floods including the calculation of stage reductions for damages prevented.

2. Reconnaissance to determine channel capacities.

3. Improvement of forecasting techniques.

4. Plan and coordinate the hydrometeorologic reporting network with the NWS and the USGS.

(c) Prepare reports on reservoir regulations.

1. Recurring reports

2. WCMs

3. Post-flood reports

2. Responsibilities and Duties During Flood Emergencies. During flood emergencies, the NWK Water Management Section is responsible for the following:

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(a) Evaluation of current hydrologic, hydraulic, and meteorological data.

(b) Presentation of storm and flood analysis to the NWK District Engineer and other interested District personnel.

(c) When necessary, furnish personnel to assist project-operating personnel in flood regulation.

(d) Regulation of reservoirs in accordance with flood control regulation schedules.

(e) Furnish information to higher authority.

1. Initial reports to the NWD Office of the Chief of Engineers by telephone.

2. Assist preparations of situation reports by the Emergency Management Office.

(f) Furnish information to the Emergency Management Office for dissemination to the general public and others.

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3. Provision for 24-hour Alert. Responsible personnel are on duty at NWK 24 hours a day whenever basin and/or project conditions warrant and during flood emergencies. Responsible personnel will be on duty or on call at the project at all times.

**Role of Damtender.** The damtender will regulate the reservoir according to instructions issued by personnel of the NWK Water Management Section. The instructions follow procedures described in Section 5-06 and Exhibit B of this WCM. His office hours are 8:00 a.m. to 4:30 p.m., Monday through Friday. His good judgment is necessary in public relations, in collecting and reporting of hydrologic data, and in compliance with directives and the Standing Instructions for impoundment and release of water. The damtender must know the intent of regulation procedures and be able to recognize and report deviations from optimum effectiveness. He must have a thorough understanding of his position to assure full effectiveness of the administrative and technical support given by NWK and NWD Offices. The damtender has many duties in regard to maintenance and operation of the project, but none of these should be allowed to detract from proper reservoir regulation and related activities.

**b. Other Federal Agencies.** No other Federal agencies are responsible for regulation activities at the Rathbun Reservoir. However, the NWS and the USGS

cooperate together with the NWK Water Management Section to accumulate rainfall and streamflow data necessary for Rathbun Reservoir regulation.

**c. State and County Agencies.** Management of the fish and wildlife resources and the State Park facilities on Rathbun Reservoir is the responsibility of the IDNR.

**d. Private Organizations.** There are no private organizations which have regulatory responsibilities at Rathbun Reservoir.

**9-02. Interagency Coordination.**
Cooperative arrangements with other Federal agencies have been established to improve efficiency and optimize flood prevention benefits. Summaries of these arrangements are provided below.

**a. Local Press and Corps Bulletins.** USACE and the NWS cooperate in forecasting river stages and streamflows. USACE provides the local press and others with NWS river stage and flood forecasts, which may be supplemented with observed river stages, observed and forecast reservoir conditions and other information on observed conditions.

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**b. National Weather Service.** NWK and the RFC in Pleasant Hill, Missouri exchange hydrometeorologic data and reports in order to prevent duplication of effort in obtaining and disseminating data. The NWS is the responsible agency for issuing public forecasts of stream stages and flood warnings. NWK furnishes current and forecast changes in reservoir releases to the Missouri Basin RFC as they occur for their use in river stage forecasting.

**c. U.S. Geological Survey.** USACE and the USGS cooperate in a program for the construction, maintenance and operation of stream gaging stations throughout NWK. During floods, USACE and the USGS coordinate field activities to maximize the number of stream discharge measurements.

**d. Power Marketing Agency.** Rathbun Reservoir does not have power generation capabilities.

**e. Other Federal, State, or Local Agencies.** NWK exchanges information with state government officials, local sheriffs, police offices and others during flood emergencies. NWK also coordinates with state agencies concerning fish and wildlife throughout normal operation.

**9-03. Interagency Agreements.**
Iowa has annually submitted a WLMP for Rathbun Reservoir. The recommendation is reviewed to insure that the projects purposes will not be adversely impacted and has typically been approved with minor alterations. Incursions into the flood control zone are limited to 5% of the total flood control storage. (elevation 905.6 ft). The current water control plan has enhanced the development and implementation of the water level management plan as described in chapter 7.

**9-04. Commissions, River Authorities and Compacts.**
No interstate river compacts or commissions have been established which currently impact the operation of Rathbun Reservoir.

**9-05. Non-Federal Hydropower.**
No hydropower facilities exist at Rathbun Reservoir.

**9-06. Reports.**

**a. Morning Reports.** Each morning, during navigation season, reports are prepared by the NWK Water Management Section to cover a period of the previous 24 hours. The reports provide data for use by personnel whose work requires knowledge pertaining to the regulation of reservoirs, field investigations, stream gaging, construction of flood control projects affected by releases from reservoirs, answering public inquiries and preparing public releases. The reports are generally available on the NWK LAN system under the Bulletin Board option. Weekend reports are prepared only during navigation season. Reports can be found at http://www.nwk.usace.army.mil/Locations/WaterManagement.aspx. These reports include a summary of reservoir conditions as of 8:00 a.m. on that date, weather forecasts including the extended outlook for the next three days, any quantitative precipitation forecasts, NWS river stage forecasts and reservoir data for the previous seven days.

**b. Monthly Reservoir Reports.** The NWK Water Management Section prepares monthly reservoir regulation tabulation summaries. These reports are a record of reservoir inflow, release, evaporation, storage and elevation for all flood control, navigation or multipurpose storage reservoirs that are under supervision of, or of direct interest to, NWK.

**c. Flood Situation Reports.** The NWK Water Management Section provides daily information to the Emergency Management Office for situation reports during floods.

**d. Post Flood Reports.** This report is prepared as soon as practicable after a flood causing major damage. The report describes flood emergency operation by USACE. It uses information compiled and prepared by the Water Management Section.

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**e. Annual Report.** An annual report is prepared by the NWK Water Management Section. The report contains a summation of the general conditions of the river basins and the individual projects in NWK for the preceding year. The report also presents the activities and accomplishments of the NWK Water Management Section for the past year. The report is forwarded to the MRBWM for inclusion in the NWD's annual report.

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## 10 - EXHIBITS

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| Sample Guidance Document for Annual Water Level Management Plan Formulation | E-10-11 |


### EXHIBIT D


| Table | | Page |
|---|---|---|
| D-1. | Rathbun Reservoir 2000 Resurvey Area in Acres | E-10-18 |
| D-2. | Rathbun Reservoir 2000 Resurvey Capacity in Acre-Feet | E-10-22 |


### EXHIBIT E


| Title | Page |
|---|---|
| WRDA 2007 Implementation Guidance for RRWA Right of First Refusal | E-10-26 |
| RRWA Water Supply Contract | E-10-30 |

**EXHIBIT A**

**SUPPLEMENTARY PERTINENT DATA RATHBUN RESERVOIR**

## I. - GENERAL INFORMATION

| ITEM | DESCRIPTION |
|---|---|
| Location of Dam | Mile 142.3 on the Chariton River and 5 miles north of Centerville in Appanoose County, Iowa |
| Purpose | Flood Control, Recreation, Fish and Wildlife, Water Supply, Water Quality, Navigation |
| Initial Authorization | Flood Control Act of 1954 Public Law 83-780 |
| Operating Agency | Corps of Engineers Kansas City District |
| Drainage Area above dam | 549 square miles |
| Guide Contour for Land Acquisition | 931.0 feet (NGVD 29) |
| Time of Water Travel | 2 days dam to mouth (high flow) |
| Closure of Dam | 29 September 1967 |
| Initial Fill to Multipurpose Pool | 10 October 1970 |
| Water Supply Contract | Rathbun Rural Water Association DACW41-86-C-0092 6,680 AF storage |

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## II. - DAM AND EMBANKMENT

| ITEM | DESCRIPTION |
|---|---|
| Type | Earthfill |
| Fill Quantity | 4,700,000 cubic yards |
| Elevation at top of dam | 946 feet, (NGVD 29) |
| Top Width | 30 feet |
| Maximum Base Width | 800 feet |
| Length | 10,600 feet |
| Damming Height | 82 feet at elev. 926.0 |
| Maximum Height above Streambed | 101 feet |
| Freeboard | 6 feet |
| Date of Closure | 29 September 1967 |
| Began Multipurpose | 21 November 1969 |
| Multipurpose Pool Initially Filled | 10 October 1970 |

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## III. - OUTLET WORKS

**River Outlet**

| | |
|---|---|
| Location | Right Abutment |
| Type | Gated Conduit |
| Conduit, Number & Diameter | 1 - 11 foot horseshoe |
| Length | 539 feet |
| Invert Elevation | |
| Intake | 855.0 feet |
| Outlet | 852.0 feet |
| Capacity at Elevation 926 | 1 gate open 4,049 cfs<br>2 gates open 5,160 cfs |
| Capacity at Elevation 940 | 1 gate open 4,450 cfs<br>2 gates open 5,680 cfs |
| Emergency Gate, No., Size, Type | 2 - 6.0 feet x 12.0 feet Hydraulic slide |
| Service Gates, No., Size, Type | 2 - 6.0 feet x 12.0 feet Hydraulic slide |
| **Low Flow Gate** No., Size, Type | 2 - 2 by 2 Hydraulic slide |
| Capacity at Elevation 886.0 | 1 gate open -- 145 cfs<br>2 gates open -- 290 cfs |
| Capacity at Elevation 904.0 | 1 gate open -- 188 cfs<br>2 gates open -- 376 cfs |

Closely regulated low-flow discharges are affected by hydraulically operated low-flow gates built into the service gates.

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## IV. - RESERVOIR

| Pool | Elevations Feet, (NGVD 29) | Current Capacity Acre-Feet | Area Acres |
|---|---|---|---|
| Surcharge | 926.0 - 940.0 | 368,859 | 31,135 |
| Flood Control | 904.0 - 926.0 | 349,173 | 22,452 |
| Multipurpose | 844.0 - 904.0 | 221,360 | 10,329 |
| Gross Storage | 844.0 - 926.0 | 570,533 | |
| Sedimentation Reserve | 24,000 Acre-Feet (one-third to flood control pool and two-thirds to multipurpose pool) | | |
| Estimated Annual Sediment Inflow | 240 Acre-Feet | Undefined (see Sec 4-04) | |

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## V. - SPILLWAY

| | |
|---|---|
| Location | Right Abutment |
| Type | Uncontrolled Notch |
| Crest Elevation | 926.0 feet, (NGVD 29) |
| Width | 500 feet |
| Discharge Capacity at elevation 940.0 | 45,600 cfs |
| Slope Sides | 1V on 3H |

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**EXHIBIT B**

**STANDING INSTRUCTIONS TO OPERATIONS PROJECT**

**MANAGER RATHBUN LAKE**

## I - GENERAL

1. Operation. The lake will be regulated in accordance with the normal regulations for flood control as directed in Chapter VII of this Manual. The Water Management Section will issue instructions for the storage and discharge of floodwater. In the event communications with NWKare disrupted, the lake will be regulated in accordance with the schedule of emergency regulations for flood control (see Chapter VII of this Manual). In addition, the Operations Project Manager will immediately make every effort to re-establish communications with NWK.

2. Data Reporting Instructions. Daily lake data from Rathbun Reservoir will be submitted to the Water Management Section (voice telephone 816-983-3545, fax 816-426-5155). The Water Management Section office is manned during normal business hours and in the morning on weekends during the navigation season. The navigation season is normally from March through November each year. Data are normally reported via e-mail. The Project personnel will provide the following reports:

a. Morning Report. Pool elevations at 8:00 a.m., the current release from the project, the time and amount of any gate operations from the previous day, precipitation and pan evaporation in inches for the preceding 24 hours, wind velocity and direction at 8:00 a.m., surface water temperature of the lake and in the outlet, and the current weather condition at the project office. Any precipitation occurring as snow should be melted and reported as inches of snow and the water equivalent. Data for nonworking days may also be read from the recorder chart and submitted the following workday.

b. Gate Operation. Date and time of gate operation, number of gates open and amount of gate opening before and after gate operation, lake elevation.Confirmation of gate changes shall be made by telephone or fax immediately after completion of the change.

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c. Schedule for Collecting Data During Floods. During flood activity more frequent readings from both hydrologic data networks and lake gages may be required for operational and administrative purposes in the Water Management Office.

d. Reporting Unusual Events. Events or conditions not normally encountered in the routine operation of the dam and lake, which might endanger the dam or necessitate temporary or permanent revision of the operating procedures, shall be reported promptly to the Water Management Section.

3. Warnings. It is the responsibility of the Operations Project Manager and project personnel authorized to make gate changes to maintain a list in current status of residents and/or property that may be endangered or inconvenienced by large and/or prolonged releases. If damaging releases are expected to occur; notification will be made by telephone or in person by Corps employees. Notification would include media such as radio, television, telephone, or use of law enforcement and civil defense agencies and their communication system. Studies have been made to determine the possible downstream flood conditions that may exist in the event of a maximum spillway release or failure of the dam at maximum pool. Approximate water surface profiles and flooded area maps giving the results of these studies are kept in the Rathbun Operation and Maintenance Manual, Volume II, Contingency Plan For Emergencies. When a gate change is made a horn is blown to give warning to people downstream of the Dam.

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4. Frequency of Gate Changes. During flood periods, gate changes may be made at any time. When the floodwaters have significantly risen into the flood control pool, gate changes can be expected two or three times daily. When the pool level is at or above the top of the flood control pool, gate changes may occur every hour. Only under the most unusual circumstances will changes be ordered more frequently than once every

hour. Gate changes during low flow operation will generally be less than once a day.

## II - REGULATION PROCEDURES

1. Regulation River Stages and Discharges. The regulation schedules provide that a release of 1500 cfs will not be exceeded insofar as practicable. Floodwaters will be released as rapidly as practicable with consideration given to minimizing flooding of low-water crossing and low-lying farmland. Factors considered in the determination of releases are: maximum inflow into the lake during a rise, general climatic conditions, season of the year with respect to

the probability of floods, status of crops in low-lying farmlands, the percent of the flood pool occupied, and the maximum non-damaging stages or discharges.

2. Normal Regulation of Flood Control Operation. Under normal procedures, the Water Management Section will issue instruction for storage and release of water for conservation and flood control. Requests for changes in gate setting will be provided with an associated gate order number. The first two digits of this number will correspond with the current calendar year with the remainder sequentially beginning with number one. The implementation of the instructions is to be confirmed back to the Water Management Section as soon as the required action is completed. Instruction originating from any other source should not be processed but should be reported to the Water Management Section. Rathbun Reservoir will be operated for optimum flood reductions on the Chariton River from the dam to the mouth.

3. Emergency Regulation. An emergency exists when hydrologic data or situation reports are due, or anticipated instructions are not received at the project, and contact cannot be made between the Operations Project Manager and responsible persons of the Water Management Section. An emergency situation can vary in degree of seriousness from a matter of inconvenience to an immediate cause for corrective action. During an emergency, the Operations Project Manager will take the following steps to regulate the lake.

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a. Action to be taken when the lake's water surface is within the surcharge pool at the time of communication failure. With crest elevation of the uncontrolled spillway at 926.0 ft., the discharge will automatically increase as the water level rises above the top of the flood control pool. The first priority for the Project Manager becomes the need for warning the Public around the lake and downstream of the impending releases. If scheduled releases of flood storage are being made through the outlet works at the time of communication failure, closure of the outlet works will be required if specific instructions to the contrary cannot be obtained from the Water Management Section, Kansas City District, within 30 minutes. The gates will be closed to release zero (0) outflow. However, should the following occur, reopening of the outflow gates will again be required.

(1) If the lake water surface rises above elevation 929.8ft. (the elevation at which the spillway alone will be discharging approximately 3,000 cfs.), the outlet works gates may be gradually reopened so that full release capability of the project is utilized for protection of the structure in the event of a major spillway flood. (CAUTION: When pool elevations are at 929.8 or below, under no conditions will the outlet works be opened to exceed an outflow rate of 3,000 cfs because the hydraulic jump may drift upstream from the

stilling basin into the conduit, resulting in a pressurization of the pipe. When the spillway is operational, outlet works releases should be carefully monitored to ensure the conduit does not become pressurized due to changed tailwater conditions)

b. When the lake is stationary or falling in the flood control or surcharge pool.

(1) If less than 48 hours has elapsed since the start of an emergency, maintain current gate settings.

(2) After the 48-hour period, proceed as follows:

(a) With the water surface in the surcharge pool, release the greater of either spillway discharge or 1,800 cfs.

(b) With water surface at the top of flood-control pool, hold the pool stationary by making releases equal to the inflow, provided the total outflow does not exceed 1,800 cfs. Should the pool start to rise again, refer to the criteria for a rising pool.

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4. During Emergency Events. The Operations Project Manager may temporarily deviate from the current release rates in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of dam or to avoid serious hazards to life. Such actions shall be immediately reported by the fastest means of communication available. Continuation of the deviation will require the express approval of the Water Management Section.

5. Role of Operations Manager. The Operations Manager will regulate the lake according to instructions issued by personnel of the Water Management Section. The instructions follow procedures described in Section VII and Exhibit B of this Manual. His office hours are 8:00 a.m. to 4:30 p.m., Monday through Friday. His good judgment is necessary in public relations, in collecting and reporting of hydrologic data, and in compliance with directives and the Standing Instructions for impoundment and release of water. The Operations Manager must know the intent of regulation procedures and be able to recognize and report deviations from optimum effectiveness. He must have a thorough understanding of his position to assure full effectiveness of the administrative and technical support given by the District and Division Offices. The Operations Manager has many duties in regard to maintenance and operation of the project, but none of these should be allowed to detract from proper lake regulation and related activities.

## EXHIBIT C

## SAMPLE GUIDANCE DOCUMENT FOR ANNUAL WATER LEVEL MANAGEMENT PLAN FORMULATION

### Purpose

A process to develop the annual Water Level Management Plan (WLMP) for Rathbun Reservoir is part of the revised Rathbun Lake Water Control Manual (WCM) (2015). The purpose of the stakeholder and public input as well as the meeting is to get input on the proposed seasonal pool elevation targets and release criteria that are intended to maximize project benefits for the year. The public and stakeholders will be notified of past year conditions and WCM performance, current lake conditions, forecast conditions for the year and proposed management and any particular demands imposed by project maintenance and basin construction contracts. Public, agency and stakeholder input will help USACE make the final decision on how the lake is operated each year.

### Annual Process

Each January or February the Rathbun Reservoir Project Manager will send a notification to affected stakeholders information on the proposed lake operation for the following year and offer 30 days for input. During this time the Project Manager will schedule and host a meeting with a delegate from each of the stakeholders associated with the reservoir's authorized purposes to solicit individual input. The following groups will typically be included among the invitees:

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1. USACE Rathbun Reservoir Project staff
2. USACE Kansas City District Engineering Division staff from water management and dam safety
3. USACE Missouri River Basin Water Management
4. Local and state agency stakeholders, one delegate each
5. Regional business and property associations, one delegate each

At the end of the 30 day review period the Rathbun Reservoir Project Manager will send a follow-up notification informing the public and stakeholders of the final planned operation.

### Water Level Management Plan

In order to meet the management objectives and considerations, regulation for each year will be refined based on an evaluation of the current and anticipated hydrologic conditions and local input received during development of the annual operating plan. Typically Rathbun Project will be regulated based on periods of each year. For the project, the regulation year can be divided into four main periods roughly corresponding to the four seasons.

Period 1: Fall. Commence holding reservoir inflows except for minimum releases until the pool elevation is no lower than 904.0 ft and no higher than 905.6 ft. A higher pool elevation is beneficial for flooding shoreline vegetation around the pool and to improve waterfowl hunter access. Reservoir storage can also provide a buffer for the special release desired for the downstream wetlands, described later. Fall inflows are often minimal in many years, but historically there have been a few flood events.

Period 2: Winter. Commence release of water from fall level to an elevation no higher than 904.0 ft and no lower than 902.5 ft. A drawdown below MPP can reduce winter ice damage to riprap and other shoreline structures and to allow for additional buffer storage for spring rain and snow melt runoff. In most years, the drawdown will be completed before the reservoir ices over. If the drawdown is not completed by that time, it may be possible to evacuate excess storage in the spring before the walleye spawn begins.

Period 3: Spring. Begin storing inflows while maintaining the required water quality release at minimum. Target pool elevations are not to exceed 905.6 ft or be below 904.0 ft. The rate of the pool rise can be variable, based upon predetermined targets for the given water year. It is desirable to restrict maximum releases to 400 cfs during the active walleye spawn period from about March 25 to April 20 to protect broodstock spawning on and near the face of the dam. If this release restriction results in the pool rising above the spring target elevation, then releases will be increased in accordance with flood control criteria. This desirable maximum release may be affected by future fisheries research and any installation of fish barriers at the intake. Research is currently ongoing regarding this issue. Once the spring target pool elevation is reached, the pool will be maintained at that level for the remainder of the spring period.

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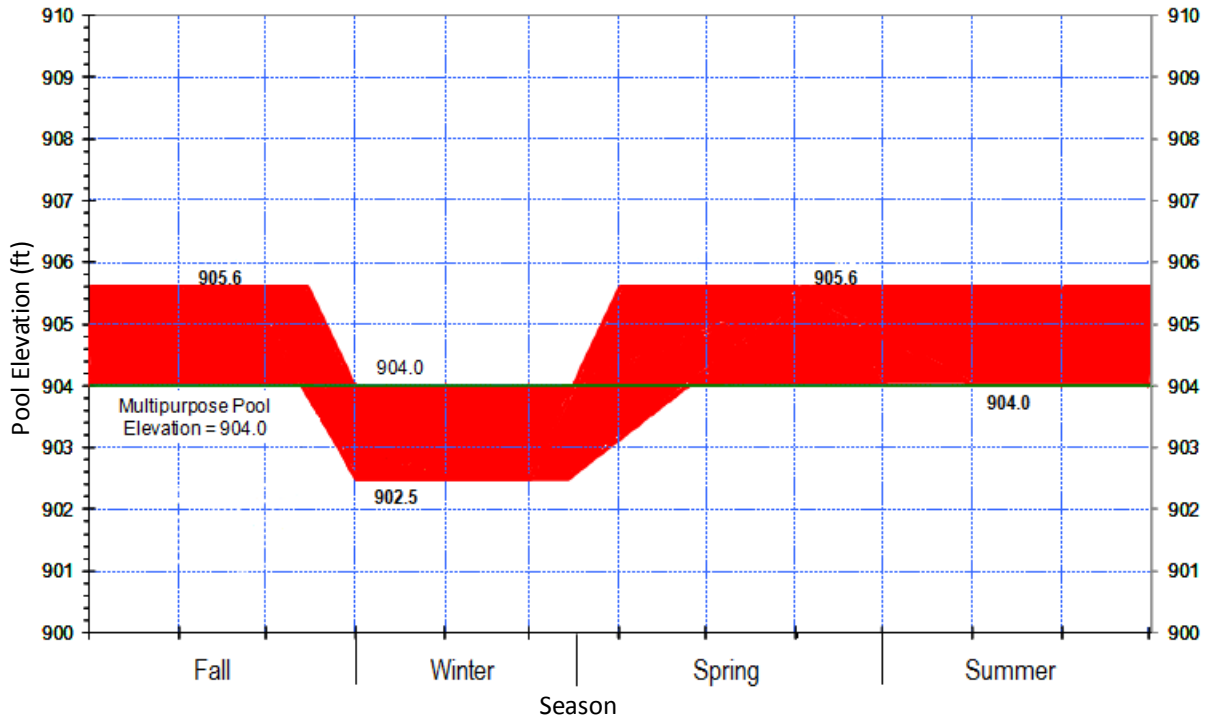
Period 4: Summer. The pool elevation may be maintained at a target elevation between 904.0 ft and 905.6 ft during this period as needed to improve recreational opportunities and improve the probability that storage will be available later in the year for fall needs. The target elevation may also be adjusted in response to hydrologic conditions. Releases above the normal minimum requirement should not cause the pool to fall below the MPP elevation of 904.0 ft.

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**Envelope of Permissible Water Level Management Plan**

**Authorized and Operating Project Purposes**

Each year USACE will utilize past year performance and upcoming year predictions to set the initial lake operation. Public comment and stakeholder input will be evaluated with respect to the authorized purposes and dam safety. Ultimately the new annual WLMP must seek to maximize project benefits while balancing the authorized purposes and maintaining dam safety. USACE will make the final decision on how the lake is operated each year. While agency and stakeholder input will influence the specific operation, USACE will determine the final operation considering agency and stakeholder input as well as factors for each of the authorized and operating purposes to ensure Rathbun Reservoir continues to balance all authorized purposes.

**1. Flood Control**

The flood control purpose includes management of the reservoir and its releases to minimize the risk of flooding both upstream and downstream of the dam embankment. A critical component to ensure the implementation of this purpose is dam safety. Modeling and field data collection allow for rapid and accurate forecasting of reservoir and channel water levels as well as reservoir evacuation rates and duration through the conduit. The use of precipitation gages in the upper Chariton River Basin will enable USACE Water Management to better manage releases at the onset of a precipitation

event. There will always be risk associated with precipitation extremes that may require dramatic deviations from the annual WLMP. The design of the dam and its integrity, such as features dependent on subsurface pore pressures, pressure relief wells, and seepage filter systems, can place limits on the implementation of the 2015 WCM and by extension the annual WLMP. In the event the need arises to replace or modify dam features or to account for features no longer performing as designed, the annual WLMP may be altered as needed to accommodate the limitation.

If high inflow is forecasted, or there were high inflows the previous year, the target pool elevation may be kept at the lower range of the flood control pool to reduce additional risk to the dam and upstream flooding. The yearly average pool elevation will also be considered and an effort will be made to balance release rates in order to not create an average increased pool elevation which could impact dam safety.

Future Risk Assessments may include hydrologic and hydraulic modeling of an Inflow Design Flood with antecedent conditions including an elevated pool. The results of future Risk Assessments may result in recommendations to change the flood control pool elevation based on identified risk,

**2. Navigation**

Historically Rathbun Reservoir's authorized support of navigation on the Missouri and/or the Mississippi Rivers has not been utilized. The normal Missouri River navigation season from Kansas City to the confluence is from March 28th through December 1st. MRBWM will be included with the annual WLMP meeting for awareness and input as to the navigation allocation within the conservation pool and for notification of changes in policy and likelihood of allocation use in the future.

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**3. Recreation**

Recreation is an important benefit of the lake for the local economy and for the regional quality of life. Access to boat ramps, camping areas, and day use sites are adversely influenced by relatively high and low reservoir levels. Managing the reservoir to improve populations of species in demand that draw hunters and nature observers is also a key component of the recreation purpose. The quality of the lake's fishery are key to those who enjoy fishing. Access to boat ramps and recreation areas should be relatively more reliable when managing the reservoir pool elevation according to the annual WLMP. There will be an effort made to restrict release rates, from approximately March 25 through approximately April 20, to a maximum release of 400 cfs to provide protection to walleye broodstock staging on and actively using the dam as a spawning site; as long as this does not disproportionately hinder another authorized purpose. Again, the unified input from Iowa Department of Natural Resources (IDNR) will be critical for balancing the conflicting needs for walleye populations on the reservoir and the needs of other hatchery species.

**4. Water Quality**

The water quality purpose is influenced by runoff and channel inflow as well as inclusion of wetland features and bank stabilization. This purpose is relatively less critical when developing the annual WLMP in near-normal runoff years. Minimum releases required to maintain downstream water quality (normally 11 cfs below the Fish Hatchery return channel) as the total can vary up to 33 cfs may result in large drawdowns in lake elevations during extreme droughts. Discharge rates and ramping rates, both up or down, will be considerations associated with the annual WLMP for downstream water quality. Other potential impacts to the annual WLMP may be associated with scheduled construction of features such as wetlands and bank stabilization. Although the water quality purpose is likely influenced relatively less by the annual WLMP; the other purposes such as recreation, water supply, and fish and wildlife rely heavily on the success of this purpose.

**5. Water Supply**

Rathbun Regional Water Association (RRWA) has constructed water intake systems both within the reservoir and downstream of the outlet structure within the Chariton River channel. The reservoir intake is the major source of RRWA water. The RRWA reservoir intake system is designed to be operational between reservoir pool elevations 898.8 and 940.0 ft. The downstream intake can be used when the reservoir intake is not fully functional or when needed to balance treatment plant needs .A minimum river release from Rathbun Reservoir of 13 cfs is required to supply sufficient channel depth for the downstream intake system to function properly. There are virtually no alternative supply sources if RRWA is unable to draw its water supply requirements from the reservoir or the downstream channel. The probabilities of falling below the reservoir operational level will be a significant consideration when developing the annual WLMP. Any forecast for drought or increased probabilities of falling below the water intake operational level will be a significant consideration with developing the yearly operation plan. For example, if drought is forecasted will consider not setting a target pool elevation below multipurpose in the winter and a higher target elevation may be set in the spring to help recharge the reservoir supply. Also, if a drought was experienced the prior year higher target pool elevations may be selected to recover the reservoir levels.

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**6. Fish and Wildlife**

The 2015 WCM implementation should improve the success of the fish and wildlife purpose. The diversity associated with this purpose risks having competing interests. The annual WLMP will rely heavily on interagency coordination and determination of annual fish and wildlife priorities. Reservoir levels associated with one species may not be favorable to another species. Discharges to improve the desired downstream channel or riparian habitat may result in an unacceptable loss of fish from the lake through the conduit. The need to flood reservoir shorelines for desired habitat may result in a deficiency of channel discharges downstream of the dam or a reservoir elevation at an unacceptable level for specific fish species. Discussions of a proposed

WLMP for the fish and wildlife purpose will benefit from the annual documentation of previous plans. The documentation can include fish populations, fish passing through the conduit for various reservoir levels and discharges, the species demands for creating specific habitat upstream and downstream, and the consequences if a specific condition is not implemented or if it is put off for a future year.

Since IDNR manages for many competing aspects of fish and wildlife as well as competing needs for various fisheries species, it will be imperative that their agency submit one unified proposal for the WLMP each year. Consideration will also be given to if a specific operation was included the previous year for one aspect of fish and wildlife, priority may be given to other aspects of this purpose the following year.

The operation for fish and wildlife will also include the consideration on if a fall pulse is needed:

As part of the annual stakeholder input process to the seasonal WLMP, IDNR and Missouri Department of Conservation (MDC), representing Sedan Bottoms Wildlife Management Area and Rebel's Cove Conservation Area respectively, may exercise the option to jointly request a fall pulse for downstream wetland recharge. A formal request for a fall pulse does not necessarily guarantee that said request can or will be accommodated. This joint request and interagency evaluation will include a 30-day comment period following a USACE press release describing the estimated magnitude and scheduled dates for the release. It is anticipated that the pulse will occur in late fall and last three to four days excluding ramp up and ramp down. The timing of the pulse release shall be coordinated with downstream farmers in an effort to allow ease of access to their lands for field work and harvesting and to limit any potential damage caused by the pulse. In addition to a public notice, the damtender will send notification within one week of implementation to known downstream stakeholders to ensure they are aware and ask for documentation of any impacts (negative or beneficial) from all impacted by the pulse.

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Water from the pulse can be beneficial in wetting and refilling public and private wetlands throughout the reach from the Dam down through Sedan Bottoms and Rebel's Cove, thereby increasing downstream fish, wildlife and recreation benefits. The pulse is discretionary and not mandated by any biological opinion. At the conclusion of each fall pulse, the requesting agencies will document all impacts and make them available during the following year's annual stakeholder coordination meeting.

Water for the pulse release may be taken from a combination of flood control and multipurpose storage, will not exceed a target flow of 2,700 cfs at the Moulton gage, will require normal ramp up and slower ramp down release changes to minimize bank sloughing concerns, and will be completed over a period not to exceed 8 consecutive calendar days. No deviation is required to implement the Fall Pulse. However, the

District will provide notification to the Chief of the Missouri River Basin Water Management Office prior to the start of the event. The requested fall pulse will take place only to the extent that water in storage is available and include a consideration of hydrologic conditions relative to flooding potential and drought impacts. The resulting reservoir elevation at the conclusion of the fall pulse will not be targeted to be lower than the planned winter drawdown elevation.

A test pulse of 2,500 cfs was conducted in 2013, resulting in a positive impact to downstream fish and wildlife and recreation resources. Hydrologic conditions were favorable, and consequently there were no observed or reported flooding impacts to private lands, public utilities or roads over the course of this release. The test demonstrated the value of a near steady-state pulse of water with sufficient magnitude to overtop most wetland control structures and sufficient duration to fill constructed ditches and wet the ponds.

The damtender will compile all feedback received from the state agencies and downstream stakeholders to document: downstream impacts, benefits to authorized purposes, lessons learned, and how implementation can be improved in future years.

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**EXHIBIT D**

**RATHBUN RESERVOIR AREA CAPACITY TABLES**

**Table D-1**

**Rathbun Reservoir 2000**

**Resurvey Area in Acres**

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RATHBUN LAKE JANUARY 2000 - AREA IN ACRES

| W.S. ELEV. | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 857 | 1 | 2 | 2 | 2 | 3 | 3 | 4 | 5 | 8 | 11 |
| 858 | 16 | 22 | 29 | 39 | 49 | 59 | 71 | 85 | 99 | 114 |
| 859 | 128 | 141 | 155 | 171 | 187 | 203 | 221 | 238 | 253 | 266 |
| 860 | 279 | 293 | 304 | 316 | 327 | 338 | 349 | 361 | 372 | 383 |
| 861 | 396 | 409 | 423 | 436 | 450 | 465 | 479 | 494 | 510 | 525 |
| 862 | 542 | 558 | 574 | 590 | 606 | 622 | 638 | 654 | 672 | 690 |
| 863 | 709 | 728 | 747 | 767 | 786 | 807 | 827 | 849 | 870 | 893 |
| 864 | 917 | 941 | 966 | 989 | 1009 | 1027 | 1047 | 1064 | 1079 | 1094 |
| 865 | 1109 | 1124 | 1141 | 1159 | 1179 | 1200 | 1223 | 1251 | 1283 | 1317 |
| 866 | 1349 | 1378 | 1406 | 1433 | 1461 | 1488 | 1516 | 1544 | 1570 | 1595 |
| 867 | 1618 | 1638 | 1658 | 1678 | 1699 | 1722 | 1744 | 1767 | 1788 | 1808 |
| 868 | 1828 | 1848 | 1867 | 1884 | 1901 | 1917 | 1934 | 1951 | 1970 | 1989 |
| 869 | 2010 | 2026 | 2042 | 2058 | 2074 | 2090 | 2106 | 2122 | 2138 | 2154 |
| 870 | 2168 | 2183 | 2199 | 2214 | 2231 | 2247 | 2263 | 2280 | 2298 | 2315 |
| 871 | 2332 | 2349 | 2368 | 2390 | 2413 | 2437 | 2462 | 2486 | 2510 | 2536 |
| 872 | 2562 | 2589 | 2614 | 2638 | 2663 | 2689 | 2714 | 2738 | 2761 | 2785 |
| 873 | 2809 | 2834 | 2860 | 2888 | 2914 | 2939 | 2963 | 2988 | 3012 | 3035 |
| 874 | 3058 | 3082 | 3105 | 3128 | 3152 | 3175 | 3199 | 3222 | 3243 | 3263 |
| 875 | 3282 | 3302 | 3327 | 3352 | 3378 | 3408 | 3434 | 3463 | 3497 | 3526 |
| 876 | 3558 | 3592 | 3625 | 3653 | 3680 | 3705 | 3728 | 3750 | 3772 | 3792 |
| 877 | 3813 | 3834 | 3854 | 3875 | 3899 | 3926 | 3950 | 3972 | 3994 | 4017 |
| 878 | 4041 | 4063 | 4086 | 4110 | 4133 | 4157 | 4179 | 4201 | 4222 | 4241 |
| 879 | 4260 | 4280 | 4301 | 4323 | 4344 | 4366 | 4388 | 4410 | 4433 | 4456 |
| 880 | 4482 | 4512 | 4542 | 4567 | 4595 | 4625 | 4650 | 4674 | 4699 | 4723 |
| 881 | 4747 | 4772 | 4798 | 4828 | 4864 | 4895 | 4927 | 4957 | 4985 | 5013 |
| 882 | 5040 | 5068 | 5096 | 5122 | 5147 | 5174 | 5201 | 5227 | 5255 | 5281 |
| 883 | 5306 | 5331 | 5353 | 5374 | 5395 | 5415 | 5436 | 5457 | 5476 | 5494 |
| 884 | 5512 | 5529 | 5547 | 5564 | 5582 | 5599 | 5617 | 5634 | 5651 | 5668 |
| 885 | 5685 | 5703 | 5723 | 5743 | 5765 | 5787 | 5810 | 5835 | 5860 | 5884 |
| 886 | 5908 | 5933 | 5956 | 5978 | 6000 | 6022 | 6043 | 6064 | 6088 | 6110 |
| 887 | 6132 | 6154 | 6175 | 6196 | 6218 | 6240 | 6263 | 6287 | 6312 | 6338 |
| 888 | 6364 | 6391 | 6417 | 6445 | 6472 | 6498 | 6524 | 6551 | 6576 | 6602 |
| 889 | 6626 | 6651 | 6675 | 6699 | 6722 | 6745 | 6768 | 6792 | 6816 | 6838 |

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NOTE: Revised area-capacity tables are based on a June-August 1999 total lak ake hydrologic survey. In addition land portions of the lake ranges were also surveyed. The areas & volumes shown are larger than the orginal tables. The new tables have been reviewed & verified by historic lake data & hand measured areas on 7.5 minute series USGS topographic quad sheets dated 1982, using a planimeter.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 890 | 6859 | 6881 | 6901 | 6923 | 6944 | 6965 | 6987 | 7010 | 7033 | 7055 |
| 891 | 7076 | 7098 | 7119 | 7140 | 7161 | 7183 | 7205 | 7227 | 7249 | 7272 |
| 892 | 7294 | 7317 | 7340 | 7364 | 7388 | 7414 | 7439 | 7464 | 7488 | 7511 |
| 893 | 7534 | 7558 | 7582 | 7606 | 7629 | 7652 | 7675 | 7698 | 7722 | 7745 |
| 894 | 7770 | 7794 | 7818 | 7842 | 7865 | 7889 | 7913 | 7939 | 7964 | 7989 |
| 895 | 8013 | 8039 | 8064 | 8090 | 8115 | 8141 | 8169 | 8196 | 8222 | 8247 |
| 896 | 8271 | 8294 | 8317 | 8340 | 8364 | 8387 | 8410 | 8433 | 8457 | 8481 |
| 897 | 8506 | 8534 | 8559 | 8587 | 8615 | 8641 | 8665 | 8691 | 8717 | 8745 |
| 898 | 8773 | 8801 | 8829 | 8857 | 8883 | 8909 | 8935 | 8960 | 8985 | 9009 |
| 899 | 9033 | 9057 | 9080 | 9104 | 9128 | 9151 | 9174 | 9197 | 9220 | 9242 |
| 900 | 9265 | 9288 | 9311 | 9334 | 9357 | 9380 | 9403 | 9427 | 9450 | 9473 |
| 901 | 9496 | 9520 | 9544 | 9567 | 9591 | 9615 | 9640 | 9664 | 9689 | 9714 |
| 902 | 9739 | 9764 | 9790 | 9816 | 9842 | 9869 | 9896 | 9923 | 9951 | 9979 |
| 903 | 10008 | 10037 | 10067 | 10098 | 10130 | 10162 | 10194 | 10227 | 10261 | 10295 |
| 904 | 10329 (A) | 10364 | 10400 | 10437 | 10474 | 10513 | 10552 | 10592 | 10633 | 10675 |
| 905 | 10718 | 10761 | 10807 | 10853 | 10901 | 10951 | 11003 | 11056 | 11111 | 11166 |
| 906 | 11222 | 11280 | 11339 | 11399 | 11461 | 11526 | 11592 | 11657 | 11723 | 11790 |
| 907 | 11859 | 11932 | 12004 | 12075 | 12148 | 12222 | 12295 | 12367 | 12439 | 12509 |
| 908 | 12574 | 12637 | 12699 | 12760 | 12820 | 12880 | 12940 | 13000 | 13057 | 13112 |
| 909 | 13169 | 13222 | 13274 | 13322 | 13367 | 13408 | 13450 | 13488 | 13525 | 13566 |
| 910 | 13597 | 13627 | 13657 | 13687 | 13717 | 13747 | 13777 | 13807 | 13837 | 13867 |
| 911 | 13897 | 13927 | 13957 | 13987 | 14017 | 14047 | 14077 | 14107 | 14137 | 14167 |
| 912 | 14198 | 14228 | 14258 | 14289 | 14319 | 14350 | 14381 | 14412 | 14443 | 14474 |
| 913 | 14505 | 14536 | 14567 | 14598 | 14629 | 14659 | 14690 | 14721 | 14752 | 14783 |
| 914 | 14814 | 14844 | 14875 | 14907 | 14938 | 14969 | 15000 | 15032 | 15064 | 15095 |
| 915 | 16683 | 16917 | 16751 | 16784 | 16817 | 16850 | 16883 | 16917 | 16950 | 16983 |
| 916 | 17016 | 17049 | 17082 | 17115 | 17148 | 17181 | 17214 | 17247 | 17280 | 17313 |
| 917 | 17346 | 17379 | 17412 | 17446 | 17479 | 17512 | 17545 | 17578 | 17611 | 17644 |
| 918 | 17677 | 17710 | 17743 | 17776 | 17810 | 17843 | 17876 | 17909 | 17943 | 17976 |
| 919 | 18009 | 18043 | 18076 | 18110 | 18144 | 18178 | 18212 | 18246 | 18280 | 18314 |
| 920 | 18348 | 18382 | 18416 | 18450 | 18485 | 18519 | 18553 | 18587 | 18622 | 18656 |
| 921 | 18691 | 18725 | 18760 | 18794 | 18829 | 18864 | 18898 | 18933 | 18968 | 19003 |
| 922 | 19038 | 19073 | 19108 | 19143 | 19178 | 19213 | 19248 | 19283 | 19319 | 19354 |
| 923 | 19390 | 19425 | 19461 | 19496 | 19532 | 19568 | 19604 | 19640 | 19677 | 19714 |
| 924 | 19752 | 19790 | 19828 | 19866 | 19903 | 19941 | 19979 | 20016 | 20054 | 20091 |

(A) TOP OF CONSERVATION POOL

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 925 | 22007 | 22052 | 22096 | 22141 | 22186 | 22230 | 22275 | 22319 | 22363 | 22407 |
| 926 | 22452 (B) | 22496 | 22540 | 22585 | 22629 | 22673 | 22718 | 22762 | 22806 | 22851 |
| 927 | 22895 | 22939 | 22984 | 23028 | 23073 | 23117 | 23162 | 23206 | 23250 | 23295 |
| 928 | 23339 | 23384 | 23429 | 23473 | 23518 | 23562 | 23607 | 23651 | 23696 | 23741 |
| 929 | 23785 | 23830 | 23875 | 23920 | 23964 | 24009 | 24054 | 24099 | 24144 | 24188 |
| 930 | 24233 | 24278 | 24323 | 24368 | 24413 | 24458 | 24503 | 24548 | 24593 | 24638 |
| 931 | 24683 | 24728 | 24773 | 24819 | 24864 | 24909 | 24954 | 24999 | 25045 | 25090 |
| 932 | 25135 | 25181 | 25226 | 25271 | 25317 | 25362 | 25408 | 25453 | 25498 | 25544 |
| 933 | 25589 | 25635 | 25681 | 25726 | 25772 | 25817 | 25863 | 25909 | 25954 | 26000 |
| 934 | 26046 | 26092 | 26137 | 26183 | 26229 | 26275 | 26321 | 26367 | 26413 | 26459 |
| 935 | 28393 | 28445 | 28497 | 28549 | 28601 | 28653 | 28705 | 28757 | 28810 | 28862 |
| 936 | 28915 | 28968 | 29021 | 29074 | 29127 | 29181 | 29234 | 29288 | 29342 | 29396 |
| 937 | 29450 | 29504 | 29558 | 29613 | 29667 | 29722 | 29777 | 29832 | 29887 | 29942 |
| 938 | 29998 | 30053 | 30109 | 30165 | 30221 | 30277 | 30333 | 30390 | 30446 | 30503 |
| 939 | 30560 | 30617 | 30674 | 30731 | 30788 | 30846 | 30903 | 30961 | 31019 | 31077 |
| 940 | 31135 | 31193 | 31252 | 31310 | 31369 | 31428 | 31487 | 31546 | 31605 | 31665 |
| 941 | 31724 | 31784 | 31844 | 31904 | 31964 | 32024 | 32084 | 32145 | 32205 | 32266 |
| 942 | 32327 | 32388 | 32449 | 32511 | 32572 | 32634 | 32695 | 32757 | 32819 | 32881 |
| 943 | 32944 | 33006 | 33069 | 33131 | 33194 | 33257 | 33320 | 33384 | 33447 | 33510 |
| 944 | 33574 | 33638 | 33702 | 33766 | 33830 | 33895 | 33959 | 34024 | 34088 | 34153 |
| 945 | 36484 | 36561 | 36639 | 36717 | 36795 | 36873 | 36951 | 37030 | 37108 | 37187 |
| 946 | 37266 (C) | 37345 | 37424 | 37503 | 37583 | 37662 | 37742 | 37822 | 37902 | 37982 |
| 947 | 38062 | 38143 | 38223 | 38304 | 38385 | 38466 | 38547 | 38628 | 38710 | 38791 |
| 948 | 38873 | 38955 | 39037 | 39119 | 39202 | 39284 | 39367 | 39449 | 39532 | 39615 |
| 949 | 39698 | 39782 | 39865 | 39949 | 40033 | 40117 | 40201 | 40285 | 40369 | 40454 |
| 950 | 40454 | | | | | | | | | |

(B) TOP OF FLOOD POOL AND SPILLWAY CREST
(C) TOP OF DAM

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**Table D-2**

**Rathbun Reservoir 2000 Resurvey**

**Capacity in Acre-Feet**

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RATHBUN LAKE JANUARY 2000 - CAPACITY IN ACRE FEET

| W.S. ELEV. | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 857 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 4 |
| 858 | 5 | 7 | 10 | 13 | 18 | 23 | 29 | 37 | 46 | 57 |
| 859 | 69 | 83 | 97 | 114 | 132 | 151 | 172 | 195 | 220 | 246 |
| 860 | 273 | 302 | 331 | 362 | 395 | 428 | 462 | 497 | 534 | 572 |
| 861 | 611 | 651 | 693 | 736 | 780 | 826 | 873 | 922 | 972 | 1023 |
| 862 | 1077 | 1132 | 1188 | 1247 | 1307 | 1368 | 1431 | 1496 | 1562 | 1630 |
| 863 | 1700 | 1772 | 1846 | 1921 | 1999 | 2078 | 2160 | 2244 | 2330 | 2418 |
| 864 | 2509 | 2602 | 2697 | 2795 | 2895 | 2996 | 3100 | 3206 | 3313 | 3421 |
| 865 | 3532 | 3643 | 3756 | 3871 | 3988 | 4107 | 4228 | 4352 | 4479 | 4609 |
| 866 | 4742 | 4878 | 5018 | 5159 | 5304 | 5452 | 5602 | 5755 | 5911 | 6069 |
| 867 | 6229 | 6392 | 6557 | 6724 | 6893 | 7064 | 7237 | 7412 | 7590 | 7770 |
| 868 | 7952 | 8136 | 8321 | 8509 | 8698 | 8889 | 9082 | 9276 | 9472 | 9670 |
| 869 | 9870 | 10072 | 10275 | 10480 | 10687 | 10895 | 11105 | 11316 | 11529 | 11744 |
| 870 | 11960 | 12178 | 12397 | 12617 | 12839 | 13063 | 13289 | 13516 | 13745 | 13976 |
| 871 | 14208 | 14442 | 14678 | 14916 | 15156 | 15398 | 15643 | 15891 | 16141 | 16393 |
| 872 | 16648 | 16905 | 17165 | 17428 | 17693 | 17961 | 18231 | 18504 | 18779 | 19056 |
| 873 | 19335 | 19618 | 19902 | 20190 | 20480 | 20772 | 21068 | 21365 | 21665 | 21967 |
| 874 | 22272 | 22579 | 22888 | 23200 | 23514 | 23830 | 24149 | 24470 | 24793 | 25119 |
| 875 | 25446 | 25775 | 26106 | 26440 | 26777 | 27116 | 27458 | 27803 | 28151 | 28502 |
| 876 | 28856 | 29214 | 29575 | 29939 | 30305 | 30674 | 31046 | 31420 | 31796 | 32174 |
| 877 | 32174 | 32937 | 33321 | 33707 | 34096 | 34488 | 34881 | 35277 | 35676 | 36076 |
| 878 | 36479 | 36884 | 37292 | 37702 | 38114 | 38529 | 38945 | 39364 | 39785 | 40209 |
| 879 | 40633 | 41060 | 41490 | 41921 | 42354 | 42790 | 43227 | 43667 | 44109 | 44554 |
| 880 | 45001 | 45450 | 45903 | 46358 | 46816 | 47278 | 47741 | 48207 | 48676 | 49147 |
| 881 | 49621 | 50096 | 50575 | 51056 | 51541 | 52029 | 52520 | 53014 | 53511 | 54011 |
| 882 | 54513 | 55019 | 55527 | 56038 | 56551 | 57068 | 57586 | 58108 | 58632 | 59158 |
| 883 | 59688 | 60220 | 60754 | 61290 | 61829 | 62369 | 62912 | 63456 | 64003 | 64552 |
| 884 | 65102 | 65654 | 66208 | 66763 | 67321 | 67880 | 68440 | 69003 | 69567 | 70133 |
| 885 | 70700 | 71270 | 71841 | 72415 | 72990 | 73568 | 74147 | 74730 | 75315 | 75901 |
| 886 | 76491 | 77083 | 77678 | 78274 | 78873 | 79474 | 80078 | 80683 | 81290 | 81900 |
| 887 | 82513 | 83127 | 83743 | 84362 | 84982 | 85606 | 86230 | 86858 | 87488 | 88121 |
| 888 | 88756 | 89393 | 90034 | 90677 | 91323 | 91971 | 92622 | 93276 | 93932 | 94591 |
| 889 | 95252 | 95916 | 96583 | 97252 | 97922 | 98596 | 99272 | 99950 | 100630 | 101312 |

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NOTE: Revised area-capacity tables are based on a June-August 1999 total lake hydrologic survey. In addition land portions of the lake ranges were also surveyed. The areas & volumes shown are larger than the orginal tables. The new tables have been reviewed & verified by historic lake data & hand measured areas on 7.5 minute series USGS topographic quad sheets dated 1982 using a planimeter.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 890 | 101997 | 102685 | 103373 | 104065 | 104758 | 105454 | 106151 | 106851 | 107553 | 108257 |
| 891 | 108964 | 109672 | 110383 | 111096 | 111812 | 112528 | 113248 | 113969 | 114693 | 115420 |
| 892 | 116147 | 116878 | 117611 | 118346 | 119083 | 119824 | 120567 | 121312 | 122059 | 122809 |
| 893 | 123561 | 124316 | 125073 | 125832 | 126594 | 127358 | 128125 | 128893 | 129664 | 130437 |
| 894 | 131213 | 131991 | 132772 | 133555 | 134341 | 135128 | 135918 | 136711 | 137506 | 138304 |
| 895 | 139103 | 139906 | 140711 | 141519 | 142329 | 143142 | 143957 | 144776 | 145596 | 146420 |
| 896 | 147246 | 148074 | 148905 | 149737 | 150573 | 151410 | 152250 | 153092 | 153936 | 154784 |
| 897 | 155633 | 156484 | 157339 | 158197 | 159057 | 159920 | 160785 | 161653 | 162523 | 163396 |
| 898 | 164272 | 165151 | 166032 | 166917 | 167803 | 168693 | 169585 | 170480 | 171378 | 172277 |
| 899 | 173179 | 174084 | 174991 | 175899 | 176811 | 177725 | 178642 | 179559 | 180480 | 181404 |
| 900 | 182329 | 183257 | 184186 | 185119 | 186054 | 186991 | 187929 | 188871 | 189815 | 190761 |
| 901 | 191709 | 192660 | 193613 | 194569 | 195527 | 196487 | 197450 | 198415 | 199383 | 200352 |
| 902 | 201325 | 202301 | 203279 | 204258 | 205241 | 206227 | 207215 | 208206 | 209199 | 210196 |
| 903 | 211196 | 212198 | 213202 | 214211 | 215223 | 216237 | 217254 | 218276 | 219300 | 220328 |
| 904 | 221360 (A) | 222393 | 223432 | 224474 | 225520 | 226568 | 227622 | 228679 | 229741 | 230805 |
| 905 | 231875 | 232949 | 234028 | 235110 | 236198 | 237291 | 238389 | 239492 | 240599 | 241713 |
| 906 | 242833 | 243958 | 245088 | 246225 | 247369 | 248518 | 249673 | 250836 | 252005 | 253181 |
| 907 | 254364 | 255552 | 256750 | 257954 | 259165 | 260383 | 261609 | 262842 | 264083 | 265329 |
| 908 | 266584 | 267845 | 269112 | 270385 | 271663 | 272948 | 274240 | 275537 | 276839 | 278148 |
| 909 | 279462 | 280782 | 282106 | 283436 | 284770 | 286109 | 287453 | 288799 | 290150 | 291504 |
| 910 | 292863 | 294223 | 295587 | 296955 | 298325 | 299698 | 301074 | 302454 | 303836 | 305222 |
| 911 | 306609 | 308000 | 309395 | 310792 | 312192 | 313595 | 315002 | 316411 | 317822 | 319238 |
| 912 | 320656 | 322078 | 323503 | 324929 | 326360 | 327793 | 329230 | 330669 | 332112 | 333558 |
| 913 | 335007 | 336458 | 337913 | 339372 | 340834 | 342298 | 343765 | 345236 | 346710 | 348187 |
| 914 | 349665 | 351149 | 352635 | 354124 | 355615 | 357111 | 358610 | 360112 | 361617 | 363124 |
| 915 | 364635 | 366305 | 367979 | 369655 | 371335 | 373019 | 374706 | 376394 | 378088 | 379785 |
| 916 | 381485 | 383189 | 384894 | 386605 | 388318 | 390035 | 391753 | 393477 | 395204 | 396934 |
| 917 | 398665 | 400402 | 402142 | 403885 | 405632 | 407380 | 409133 | 410890 | 412649 | 414411 |
| 918 | 416177 | 417947 | 419720 | 421495 | 423274 | 425057 | 426844 | 428632 | 430425 | 432221 |
| 919 | 434021 | 435824 | 437628 | 439438 | 441251 | 443067 | 444886 | 446709 | 448535 | 450366 |
| 920 | 452197 | 454034 | 455874 | 457718 | 459565 | 461414 | 463268 | 465125 | 466986 | 468849 |
| 921 | 470716 | 472588 | 474462 | 476339 | 478220 | 480105 | 481994 | 483886 | 485779 | 487678 |
| 922 | 489581 | 491487 | 493394 | 495307 | 497224 | 499144 | 501065 | 502992 | 504923 | 506857 |
| 923 | 508794 | 510734 | 512678 | 514627 | 516578 | 518532 | 520491 | 522454 | 524420 | 526388 |
| 924 | 528362 | 530339 | 532320 | 534306 | 536293 | 538285 | 540282 | 542282 | 544284 | 546291 |

(A) TOP OF CONSERVATION POOL

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 925 | 548303 | 550506 | 552712 | 554924 | 557141 | 559362 | 561588 | 563816 | 566051 | 568290 |
| 926 | 570533 (B) | 572779 | 575031 | 577288 | 579549 | 581812 | 584082 | 586357 | 588636 | 590919 |
| 927 | 593205 | 595497 | 597793 | 600095 | 602398 | 604708 | 607022 | 609341 | 611662 | 613990 |
| 928 | 616322 | 618659 | 621000 | 623343 | 625693 | 628048 | 630407 | 632768 | 635136 | 637508 |
| 929 | 639885 | 642264 | 644650 | 647040 | 649435 | 651834 | 654235 | 656643 | 659056 | 661473 |
| 930 | 663892 | 666318 | 668749 | 671184 | 673621 | 676065 | 678514 | 680967 | 683424 | 685884 |
| 931 | 688351 | 690822 | 693297 | 695775 | 698260 | 700749 | 703243 | 705738 | 708241 | 710748 |
| 932 | 713260 | 715774 | 718295 | 720820 | 723350 | 725885 | 728421 | 730965 | 733513 | 736066 |
| 933 | 738620 | 741182 | 743748 | 746319 | 748892 | 751472 | 754057 | 756646 | 759240 | 761835 |
| 934 | 764438 | 767046 | 769658 | 772272 | 774893 | 777519 | 780149 | 782781 | 785421 | 788065 |
| 935 | 790714 | 793556 | 796401 | 799254 | 802112 | 804975 | 807841 | 810715 | 813594 | 816478 |
| 936 | 819365 | 822259 | 825159 | 828065 | 830976 | 833889 | 836810 | 839737 | 842669 | 845604 |
| 937 | 848546 | 851495 | 854449 | 857405 | 860369 | 863340 | 866315 | 869296 | 872280 | 875272 |
| 938 | 878270 | 881273 | 884279 | 887293 | 890313 | 893339 | 896367 | 899403 | 902446 | 905494 |
| 939 | 908548 | 911604 | 914669 | 917740 | 920817 | 923896 | 926984 | 930078 | 933178 | 936280 |
| 940 | 939392 | 942509 | 945632 | 948760 | 951892 | 955032 | 958179 | 961331 | 964486 | 967651 |
| 941 | 970821 | 973997 | 977176 | 980364 | 983558 | 986758 | 989964 | 993173 | 996391 | 999615 |
| 942 | 1002846 | 1006079 | 1009322 | 1012570 | 1015825 | 1019083 | 1022350 | 1025623 | 1028903 | 1032189 |
| 943 | 1035477 | 1038776 | 1042080 | 1045391 | 1048704 | 1052028 | 1055357 | 1058693 | 1062032 | 1065381 |
| 944 | 1068736 | 1072097 | 1075461 | 1078836 | 1082216 | 1085603 | 1088997 | 1092393 | 1095799 | 1099212 |
| 945 | 1102632 | 1106281 | 1109942 | 1113610 | 1117287 | 1120967 | 1120967 | 1128359 | 1132067 | 1135783 |
| 946 | 1139502 (C) | 1143234 | 1146973 | 1150720 | 1154471 | 1158235 | 1162006 | 1165785 | 1169568 | 1173363 |
| 947 | 1177166 | 1180977 | 1184796 | 1188619 | 1192455 | 1196298 | 1200150 | 1204005 | 1207873 | 1211749 |
| 948 | 1215633 | 1219521 | 1223422 | 1227331 | 1231247 | 1235173 | 1239102 | 1243044 | 1246994 | 1250952 |
| 949 | 1254914 | 1258889 | 1262873 | 1266864 | 1270860 | 1274868 | 1278885 | 1282910 | 1286944 | 1290982 |
| 950 | 1290982 | | | | | | | | | |

(B) TOP OF FLOOD POOL AND SPILWAY CREST
(C) TOP OF DAM

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**EXHIBIT E**

**WRDA 2007 Implementation Guidance for RRWA Right of First Refusal**

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**DEPARTMENT OF THE ARMY**
**U.S. ARMY CORPS OF ENGINEERS**
**WASHINGTON, D.C. 20314-1000**

REPLY TO
ATTENTION OF

**DEC 12 2008**

CECW-NWD

MEMORANDUM FOR Commander, Northwestern Division (CENWD-PDD)

SUBJECT: Implementation Guidance for Section 3070 of the Water Resources Development Act of 2007 (WRDA 2007), Rathbun Lake, Iowa

1. Section 3070 of WRDA 2007 directs the Secretary, in accordance with the recommendations in the July 22, 1985, Rathbun Lake Reallocation Report, to provide the Rathbun Regional Water Association (RRWA) with the right of first refusal to contract for or purchase any increment of the remaining allocation of 8,320 acre-feet of water supply storage at Rathbun Lake, Iowa. The RRWA shall pay the cost of any water supply storage allocation for which they contract. A copy of Section 3070 is attached for information.

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2. Water supply storage, in the amount of 15,000 acre-feet was made available as a result of the Rathbun Lake Reallocation Report. Currently, the RRWA has contracted for a total of 6,680 acre-feet of the storage under contracts DACW41-86-C-0114 and DACW41-89-C-0092 (3,340 AF under each contract), leaving 8,320 acre-feet available for contracting. Purchase of water supply storage must be accomplished in accordance with the requirements of the Water Supply Act of 1958, as amended (43 U.S.C. 390b), through a water supply contract approved by the Assistant Secretary of the Army for Civil Works, or by the Chief of Engineers if so delegated.

3. The Corps of Engineers shall provide the RRWA the right of first refusal to contract for or purchase any portion of the remaining 8,320 acre feet of water supply storage. In the event that another entity expresses a desire to contract for the storage space and but for section 3070 of WRDA 2000 such contract would be approved, such contract will not be approved or awarded until RRWA has had an opportunity for right of first refusal on the storage space in question as follows. Kansas City District, Corps of Engineers, shall provide written notice to RRWA. RRWA shall then have 120 days to respond, in writing, as to whether it intends to exercise its refusal right and initiate a water supply contract action or decline to contract for the storage space. If RRWA either doesn't respond within the 120 days, or responds that it does not intend to contract for the remaining storage space, the Corps of Engineers may move forward with contracting for storage by the other entity. If RRWA elects to contract for the remaining storage

or the designated portion thereof, it shall initiate the formal process of development of a water supply contract. The Kansas City District shall respond accordingly in writing to the other requesting entity.

FOR THE COMMANDER:

Encl

EDWARD J. HECKER
Chief, NWD Regional Integration Team
Directorate of Civil Works

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121 STAT. 1124 PUBLIC LAW 110–114—NOV. 8, 2007

SEC. 3070. RATHBUN LAKE, IOWA.
(a) RIGHT OF FIRST REFUSAL.—The Secretary shall provide, in accordance with the recommendations in the Rathbun Lake Reallocation Report approved by the Chief of Engineers on July 22, 1985, the Rathbun Regional Water Association with the right of first refusal to contract for or purchase any increment of the remaining allocation of 8,320 acre-feet of water supply storage in Rathbun Lake, Iowa.
(b) PAYMENT OF COST.—The Rathbun Regional Water Association shall pay the cost of any water supply storage allocation provided under subsection (a).

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**Rathbun Regional Water Association**
**Water Supply Contract**

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Contr..-t No: DACW41-89-C-0092

WATER STORAGE CONTRACT

BETWEEN THE UNITED STATES OF AMERICA

AND

RATHBUN REGIONAL WATER ASSOCIATION, INC.

FOR

WATER STORAGE SPACE IN RATHBUN LAKE, IOWA

THIS CONTRA , entered into this 1st day of May, 1989, by and between THE UNITED STATES OF AMERICA (hereinafter called the "Government") represented by the Contracting Officer executing this contract, and the Rathbun Regional Water Association, Inc. (hereinafter called the User"*);

WITNESSETH THAT:

WHEREAS, the Flood Control Act of 1954 (Public Law 780, 83rd Congress 2d Session), authorized the construction, operation, and maintenance of Rathbun Lake on the Chariton River, Iowa, (hereinafter called the "Project"); and

WHEREAS, the User desires to contract with the Government for the use of storage added to the Project by reallocation of storage space approved by the Chief of Engineers on July 22, 1985 for municipal and industrial water supply, and for payment of the cost thereof in accordance with the provisions of the Water Supply Act of 1958, as amended (43 U.S.C. 390b-f); and

WHEREAS, the User is empowered to contract with the Government and is vested with all necessary powers of accomplishment of the purposes of this contract, including those required by Section 221 of the Flood Control Act of 1970 (42 U.S.C. 1962d-5d) (as amended);

NOW THEREFORE, the Government and the User agree as follows:

ARTICLE 1 - Water Storage Space.

a. Project Construction. The Government, subject to the directions of Federal law and any limitations imposed thereby, has modified the Project so as to include therein space for the storage of water by the User.

b. Rights of User.

(1) The User shall have the right to utilize an undivided 1.77 percent (estimated to contain 3,340 acre-feet after adjustment for sediment deposits) of the usable storage space in the Project between elevations 860 feet above mean sea level and 904 feet above mean sea level, which usable



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conservation storage space is estimated to contain 189,000 acre-feet after adjustment for sediment deposits. This storage space is to be used to impound water for present demand or need for municipal and industrial water supply. This storage space is in addition to storage space already under contract to the User under the terms and conditions of contract DACW41-86-C-0114.

(2) The User shall have the right to withdraw water from the lake, or to order releases to be made by the Government through the outlet works in the Dam, subject to the provisions of Article 1c and to the extent the aforesaid storage space will provide; and shall have the right to construct all such works, plants, pipelines, and appurtenances as may be necessary and convenient for the purpose of diversion or withdrawals, subject to the approval of the Contracting Officer as to design and location. The grant of an easement for right-of-way, across, in and upon land of the Government at the Project shall be by a separate instrument in a form satisfactory to the Secretary of the Army, without additional cost to the User, under the authority of and in accordance with the provisions of 10 U.S.C. 2669 and such other authorities as may be necessary. Subject to the conditions of such easement, the User shall have the right to use so much of the Project land as may reasonably be required in the exercise of the rights and privileges granted under this contract.

c. Rights Reserved. The Government reserves the right to maintain at all times a minimum downstream release of up to 33 cubic feet per second through the gates or spillway of the dam. The Government further reserves the right to take such measures as may be necessary in the operation of the Project to preserve life and/or property, including the right not to make downstream releases during such periods of time as are deemed necessary, in its sole discretion, to inspect, maintain, or repair the Project.

d. Quality or Availability of Water. The User recognizes that this contract provides storage space for raw water only. The Government makes no representations with respect to the quality or availability of water and assumes no responsibility therefor, or for the treatment of the water.

e. Sedimentation Surveys.

(1) Sedimentation surveys will be made by the Contracting Officer during the term of this contract at intervals not to exceed fifteen (15) years unless otherwise agreed to in writing by both parties. When, in the opinion of the Contracting Officer, the findings of such survey indicate any Project purpose will be affected by unanticipated sedimentation distribution, there shall be an equitable redistribution of the sediment reserve storage space among the purposes served by the Project including municipal and industrial water supply. The total available remaining storage space in the Project will then be divided among the various Project features in the same ratio as was initially utilized. Adjusted pool elevations will be rounded to the nearest one-half foot. Such findings and the storage space allocated to municipal and industrial water supply shall be defined and described as an exhibit which will be made a part of this contract and the reservoir regulation manual will be modified accordingly.



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(2) The Government assumes no responsibility for deviations from estimated rates of sedimentation, or the distribution thereof. Such deviations may cause unequal distribution of sediment reserve storage greater than estimated, and/or encroachment on the total storage at the Project.

ARTICLE 2 - Regulation of and Right to Use of Water. The regulation of the use of water withdrawn or released from the aforesaid storage space shall be the sole responsibility of the User. The User has the full responsibility to acquire in accordance with State laws and regulations, and, if necessary, to establish or defend, any and all water rights needed for utilization of the storage provided under this contract. The Government shall not be responsible for diversions by others, nor will it become a party to any controversies involving the use of the storage space by the User except as such controversies may affect the operations of the Government.

ARTICLE 3 - Operation and Maintenance. The Government shall operate and maintain the Project and the User shall pay to the Government a share of the costs of such operation and maintenance as provided in Article 5. The User shall be responsible for operation and maintenance of all installations and facilities which it may construct for the diversion or withdrawal of water, and shall bear all costs of construction, operation and maintenance of such installations and facilities.

ARTICLE 4 - Measurement of Withdrawals and Releases. The user agrees to furnish and install, without cost to the Government, suitable meters or measuring devices satisfactory to the Contracting Officer for the measurement of water which is withdrawn from the Project by any means other than through the Project outlet works. The User shall furnish to the Government monthly statements of all such withdrawals. Prior to the construction of any facilities for withdrawal of water from the Project, the User will obtain the Contracting Officer's approval of the design, location and installation of the facilities including the meters or measuring devices. Such devices shall be available for inspection by Government representatives at all reasonable times. Releases from the water supply storage space through the Project outlet works shall be made in accordance with written schedules furnished by the User and approved by the Contracting Officer and shall be subject to Article 1 (c). The measure of all such releases shall be by means of a rating curve of the outlet works, or by such other suitable means as may be agreed upon prior to use of the water supply storage space.

ARTICLE 5 - Payments. In consideration of the right to utilize the aforesaid storage space in the Project for municipal and industrial water supply purposes, the User shall pay the following sums to the Government:

a. Project Investment Costs.

(1) The User shall repay to the Government, at the times and with interest on the unpaid balance as hereinafter specified, the amounts stated below which, as shown in Exhibit "C" attached to and made a part of this contract, constitute the entire actual amount of costs allocated to



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the water storage right acquired by the User under this contract. The amount of costs is based on updated cost of storage. The interest rate to be used for purposes of computing interest on the unpaid balance will be the yield rate adjusted at five-year intervals as determined by the Secretary of the Treasury on the basis set forth in Section 932 of the 1986 Water Resources Development Act. For this contract, the starting interest rate shall be that rate in effect at the time the contract is approved. For FY 89, such rate is 9.25 percent. Should the contract not be signed in FY 89, the amounts due herein will be adjusted to reflect the application of the appropriate rate.

(2) The cost allocated to the storage space indicated in Article 1b(1) is currently estimated at $498,916 on the basis of the costs presented in Exhibit "C". These costs shall be repaid within the life of the Project in not to exceed 30 years from the date of approval of this contract by the Secretary of the Army. The payments shall be in equal consecutive annual installments, the first of which shall be due and payable within 30 days after the User is notified by the Contracting Officer of approval of this contract by the Secretary of the Army. Annual installments thereafter will be due and payable on the anniversary date of the date of notification. Except for the first payment which will be applied solely to the retirement of principal all installments shall include accrued interest on the unpaid balance at the rate provided above. The last annual installment shall be adjusted upward or downward when due to assure repayment of all of the investment costs allocated to the storage within 30 years from the above date.

b. Major Replacement Cost.

(1) Present Use Storage. The User will be required to pay 0.633 percent of the cost of joint-use major replacement items.

(2) Payment. Payment of costs, including interest during construction, shall be made either during construction or in lump sum upon completion of construction.

c. Annual Operation and Maintenance (O&M Expense).

(1) Present Use Storage. The User will be required to pay 0.633 percent of the annual experienced joint-use O&M expense of the Project.

(2) Payment. Payments for O&M expense are due and payable in advance on the date for payment of Project investment costs as set forth in Article 5a(2) and shall be based on O&M expense for the Project in the Government fiscal year most recently ended. The amount of each annual payment will be the actual experienced O&M expense (allocated joint-use) for the preceding fiscal year or an estimate thereof when actual expense information is not available.

d. Major Rehabilitation Program Costs. For costs associated with the major rehabilitation program, the percentages of joint use costs which the User will be required to pay will be in accordance with Article 5c for

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present use storage. Payments for the costs associated with the program shall be in accordance with Article 5b(2).

e. The User shall have the right at any time he so elects to prepay the indebtedness under this Article, subject to redetermination of costs as provided for in Article 6, in whole or in part, with accrued interest thereon to the date of such prepayment.

f. Delinquent Payments. If the User shall fail to make any of the aforesaid payments when due, then the overdue payments shall bear interest compounded annually until paid. The interest rate to be used for overdue payments due under the provisions of Articles 5a, 5b, 5c and 5d above shall be that determined by the Department of Treasury's Treasury Fiscal Requirements Manual (1 TFRM 6-8000, "Cash Management"). The amount charged on payments overdue for a period of less than one year shall be figured on a monthly basis. For example, if the payment is made within the first month after being overdue after a 15-day grace period from the anniversary date of the date of notification, one month's interest shall be charged. Thereafter a month's interest will be charged for any portion of each succeeding month that the payment is delinquent. This provision shall not be construed as giving the User a choice of either making payments when due or paying interest, nor shall it be construed as waiving any other rights of the Government, at law or in equity, which might result from any default by the User.

ARTICLE 6 - Adjustment to Project Investment Cost. The investment cost shown in this contract and the exhibits are based on actual final construction costs of the Project. Any further investment cost accruing to the Users water storage right shall be repaid under major replacement costs if capitalized or under Operation and Maintenance expense if not capitalized. For this contract which involves reallocation of storage, there will be no adjustment to the investment cost.

ARTICLE 7 - Duration of Contract. This contract shall become effective when approved by the Secretary of the Army or his duly authorized representative and shall continue in full force and effect for the life of the Project.

ARTICLE 8 Permanent Rights to Storage. Upon completion of payments by the User, as provided in Article 5a herein, the User shall have a permanent right under the provisions of the Act of 16 October 1963 (Public Law 88-140, 43 U.S.C. 390e), to the use of the water supply storage space in the Project as provided in Article 1, subject to the following:

a. The User shall continue payment of annual operation and maintenance costs allocated to water supply.

b. The User shall bear the costs allocated to water supply of any necessary reconstruction, rehabilitation, or replacement of Project features which may be required to continue satisfactory operation of the Project. Such costs will be established by the contracting Officer and repayment arrangements shall be in writing in accordance with the terms and



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conditions set forth in Article 5b for Major Replacement Costs, and be made a part of this contract.

c. Upon completion of payments by the User as provided in Article 5a, the Contracting Officer shall redetermine the storage space for municipal and industrial water supply in accordance with the provisions of Article 1e. Such redetermination of reservoir storage capacity may be further adjusted from time to time as the result of sedimentation resurveys to reflect actual rates of sedimentation and the exhibit revised to show the revised storage space allocated to municipal and industrial water supply.

d. The permanent rights of the User under this contract shall be continued so long as the Government continues to operate the Project. In the event the Government no longer operates the Project, such rights may be continued subject to the execution of a separate contract, or additional supplemental agreement providing for:

(1) Continued operation by the User of such part of the facility as is necessary for utilization of the water supply storage space allocated to it;

(2) Terms which will protect the public interest; and

(3) Effective absolvement of the Government by the User from all liability in connection with such continued operation.

ARTICLE 9 - Release of Claims. The user shall hold and save the Government, including its officers, agents and employees harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the storage in the Project, or withdrawal or release of water from the Project, made or ordered by the User or as a result of the construction, operation, or maintenance of the water supply facilities and appurtenances thereto owned and operated by the User except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE 10 - Assignment. The User shall not transfer or assign this contract nor any rights acquired thereunder, nor suballot said water supply storage space or any part thereof, nor grant any interest, privilege or license whatsoever in connection with this contract, without the approval of the Secretary of the Army, or his duly authorized representative provided that, unless contrary to the public interest, this restriction shall not be construed to apply to any water that may be obtained from the water supply storage space by the User and furnished to any third party or parties, nor any method of allocation thereof.

ARTICLE 11 - Officials Not to Benefit. No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this contract, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

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ARTICLE 12 - Covenant Against Contingent Fees. The User warrants that no person or selling agency has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the User for the purpose of securing business. For breach or violation of this warrant, the Government shall have the right to annul this contract without liability or in its discretion to add to the contract price or consideration, or otherwise recover the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 13 - Environmental Quality. During any construction, operation, and maintenance by User of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State, and local laws and regulations concerning environmental pollution. Particular attention should be given to: (1) reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters; (2) reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion; (3) minimization of noise levels; (4) onsite and offsite disposal of waste and spoil; and (5) prevention of landscape defacement and damage.

ARTICLE 14 - Federal and State Laws.

a. In acting under its rights and obligations hereunder, the User agrees to comply with all applicable Federal and State laws and regulations, including but not limited to the provisions of the Davis-Bacon Act (40 U.S.C. 276a et seq.); the Contract Work Hours and Safety Standards Act (40 U.S.C. 327-333); Title 29, Code of Federal Regulations, Part 3; and Sections 210 and 305 of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (PL 91-646).

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b. The User furnishes, as part of this contract, an assurance Exhibit "E" that it will comply with Title VI of the Civil Rights Act of 1964 (78 Stat. 241, 42 U.S.C. 2000d, et seq.) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations.

c. Any discharges of water or pollutants into a navigable stream or tributary thereof resulting from the User's facilities and operations undertaken under this contract shall be performed only in accordance with applicable Federal, State, and local laws and regulations.

ARTICLE 15 - Definitions.

a. Project investment costs - The initial cost of the Project, including: land acquisition; construction; interest during construction on the value of land, labor, and materials used for planning and construction of the Project.

b. Interest during construction - An amount of interest which accrues on expenditures for the establishment of Project services during the period between the actual outlay and the time the Project is first made available for water storage.

c. Specific costs - The costs of Project features normally serving only one particular Project purpose.

d. Joint-use costs - The costs of features used for any two or more Project purposes.

e. Plant-in-service date - This date is the date that the Project is physically available to initiate deliberate impoundment for water supply purposes.

f. Annual operation and maintenance (O&M) expense - Annual expenses funded under the O&M, General account. These expenses include the daily Project O&M costs as well as those O&M costs which are capitalized.

g. Major replacement cost - Costs funded under the Operation and Maintenance, General, or Construction, General accounts but not associated with initial Project investment costs.

h. Fiscal Year - Refers to the Government's fiscal year. This year begins on 1 October and ends on 30 September. The September calendar year corresponds to the fiscal year.

i. Life of the Project- This is the physical life of the Project.

j. Major Rehabilitation - This program is to facilitate accomplishment of significant, costly infrequent rehabilitation work at the Project without unduly distorting the Operation and Maintenance General budget.

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ARTICLE 16 - Approval of Contract. This contract shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties have executed this contract as of the day and year first above written.

APPROVED: Patricia Kelly
Assistant Secretary of the Army
(Civil Works)
Director of Civil Works

DATE: 30 May 1989

THE UNITED STATES OF AMERICA
By John H. Atkinson
John H. Atkinson
Colonel, CE
Contracting Officer

THE RATHBUN REGIONAL WATER ASSOCIATION, INC.
By Ralph Goode
Ralph Goode
Chairman, Board of Directors

EXHIBIT B

LAKE STORAGE

| Feature | Elevation (ft., m.l.s.) | * Usable Storage (ac. ft.) | Percent of Conservation Storage | Percent of Water Supply Storage |
|---|---|---|---|---|
| Flood Control | 904.0 - 926.0 | 339,000 | NA | NA |
| Conservation | 860.0 - 904.0 | | | |
| Water Supply ** | | 3,340 | 1.77 | 50 |
| Water Supply | | 3,340 | 1.77 | 50 |
| Water Supply Subtotal | | 6,680 | 3.54 | 100 |
| Water Quality | | 68,000 | 35.98 | NA |
| Navigation | | 74,000 | 39.15 | NA |
| Recreation *** | | 40,320 | 21.33 | NA |
| Conservation Subtotal | | 189,000 | 100.00 | NA |
| TOTAL | | 528,000 | | |

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*Storage remaining after 100 years of sedimentation from the date the project is operational.

**Water Supply storage purchased by Rathbun Regional Water Association, Inc. under Contract No: DACW41-86-C-0114

***Reallocation report approved for reallocation of 15,000 acre-feet from recreation to M&I water supply. This 40,320 acre-feet includes 8,320 acre-feet (15,000 - 6,680) available for reallocation to water supply.

**DEPARTMENT OF THE ARMY**
**U.S. ARMY CORPS OF ENGINEERS**
**WASHINGTON, D.C. 20314-1000**

REPLY TO
ATTENTION OF

**DEC 12 2008**

CECW-NWD

MEMORANDUM FOR Commander, Northwestern Division (CENWD-PDD)

SUBJECT: Implementation Guidance for Section 3070 of the Water Resources Development Act of 2007 (WRDA 2007), Rathbun Lake, Iowa

1. Section 3070 of WRDA 2007 directs the Secretary, in accordance with the recommendations in the July 22, 1985, Rathbun Lake Reallocation Report, to provide the Rathbun Regional Water Association (RRWA) with the right of first refusal to contract for or purchase any increment of the remaining allocation of 8,320 acre-feet of water supply storage at Rathbun Lake, Iowa. The RRWA shall pay the cost of any water supply storage allocation for which they contract. A copy of Section 3070 is attached for information.

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2. Water supply storage, in the amount of 15,000 acre-feet was made available as a result of the Rathbun Lake Reallocation Report. Currently, the RRWA has contracted for a total of 6,680 acre-feet of the storage under contracts DACW41-86-C-0114 and DACW41-89-C-0092 (3,340 AF under each contract), leaving 8,320 acre-feet available for contracting. Purchase of water supply storage must be accomplished in accordance with the requirements of the Water Supply Act of 1958, as amended (43 U.S.C. 390b), through a water supply contract approved by the Assistant Secretary of the Army for Civil Works, or by the Chief of Engineers if so delegated.

3. The Corps of Engineers shall provide the RRWA the right of first refusal to contract for or purchase any portion of the remaining 8,320 acre feet of water supply storage. In the event that another entity expresses a desire to contract for the storage space and but for section 3070 of WRDA 2000 such contract would be approved, such contract will not be approved or awarded until RRWA has had an opportunity for right of first refusal on the storage space in question as follows. Kansas City District, Corps of Engineers, shall provide written notice to RRWA. RRWA shall then have 120 days to respond, in writing, as to whether it intends to exercise its refusal right and initiate a water supply contract action or decline to contract for the storage space. If RRWA either doesn't respond within the 120 days, or responds that it does not intend to contract for the remaining storage space, the Corps of Engineers may move forward with contracting for storage by the other entity. If RRWA elects to contract for the remaining storage

or the designated portion thereof, it shall initiate the formal process of development of a water supply contract. The Kansas City District shall respond accordingly in writing to the other requesting entity.

FOR THE COMMANDER:

Encl

EDWARD J. HECKER
Chief, NWD Regional Integration Team
Directorate of Civil Works

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CECW-NWD
SUBJECT: Implementation Guidance for Section 3070 of the Water Resources Development Act of 2007 (WRDA 2007), Rathbun Lake, Iowa

121 STAT. 1124 PUBLIC LAW 110–114—NOV. 8, 2007

SEC. 3070. RATHBUN LAKE, IOWA.
(a) RIGHT OF FIRST REFUSAL.—The Secretary shall provide, in accordance with the recommendations in the Rathbun Lake Reallocation Report approved by the Chief of Engineers on July 22, 1985, the Rathbun Regional Water Association with the right of first refusal to contract for or purchase any increment of the remaining allocation of 8,320 acre-feet of water supply storage in Rathbun Lake, Iowa.
(b) PAYMENT OF COST.—The Rathbun Regional Water Association shall pay the cost of any water supply storage allocation provided under subsection (a).

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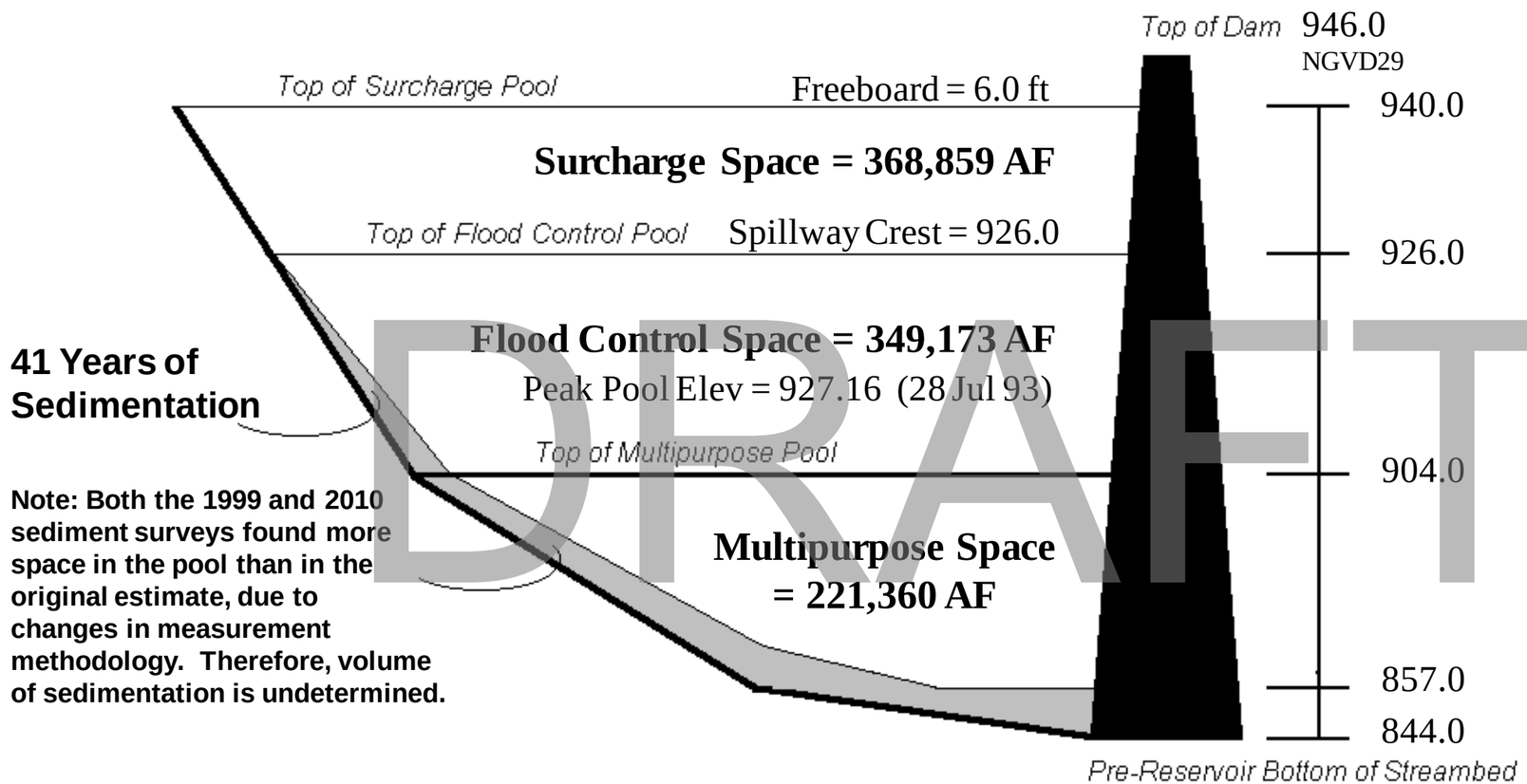
# Rathbun Lake Storage Allocations

## Operational Tables 1999 Last Sediment Survey May 2010

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**Note: Both the 1999 and 2010 sediment surveys found more space in the pool than in the original estimate, due to changes in measurement methodology. Therefore, volume of sedimentation is undetermined.**

| Storage Allocations (AF) | 1969 (initial) | 1999 | 2010 | 2069 (est) |
|---|---|---|---|---|
| Flood Control | 346,297 | 349,173 | Not Measured | 339,000 |
| Multipurpose | 205,359 | 221,360 | 210,700 | 189,000 |
| Water Supply | 0 | 17,568 | 16,722 | 15,000 |
| Recreation | 51,068 | 37,479 | 35,674 | 32,000 |
| Water Quality | 73,886 | 79,643 | 75,807 | 68,000 |
| Navigation | 80,405 | 86,670 | 82,496 | 74,000 |

**Water Supply space added with 1985 Reallocation. As of 2015, Rathbun Rural Water District has contracted for 6,680 AF of nominal 15,000 AF of available space. WRDA 2007 gave RRWA rights of first refusal for future contracts.**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Rathbun Lake Storage Allocations
July 2015
**Plate NO. 1-1**

**Plate 2-1: General Map**

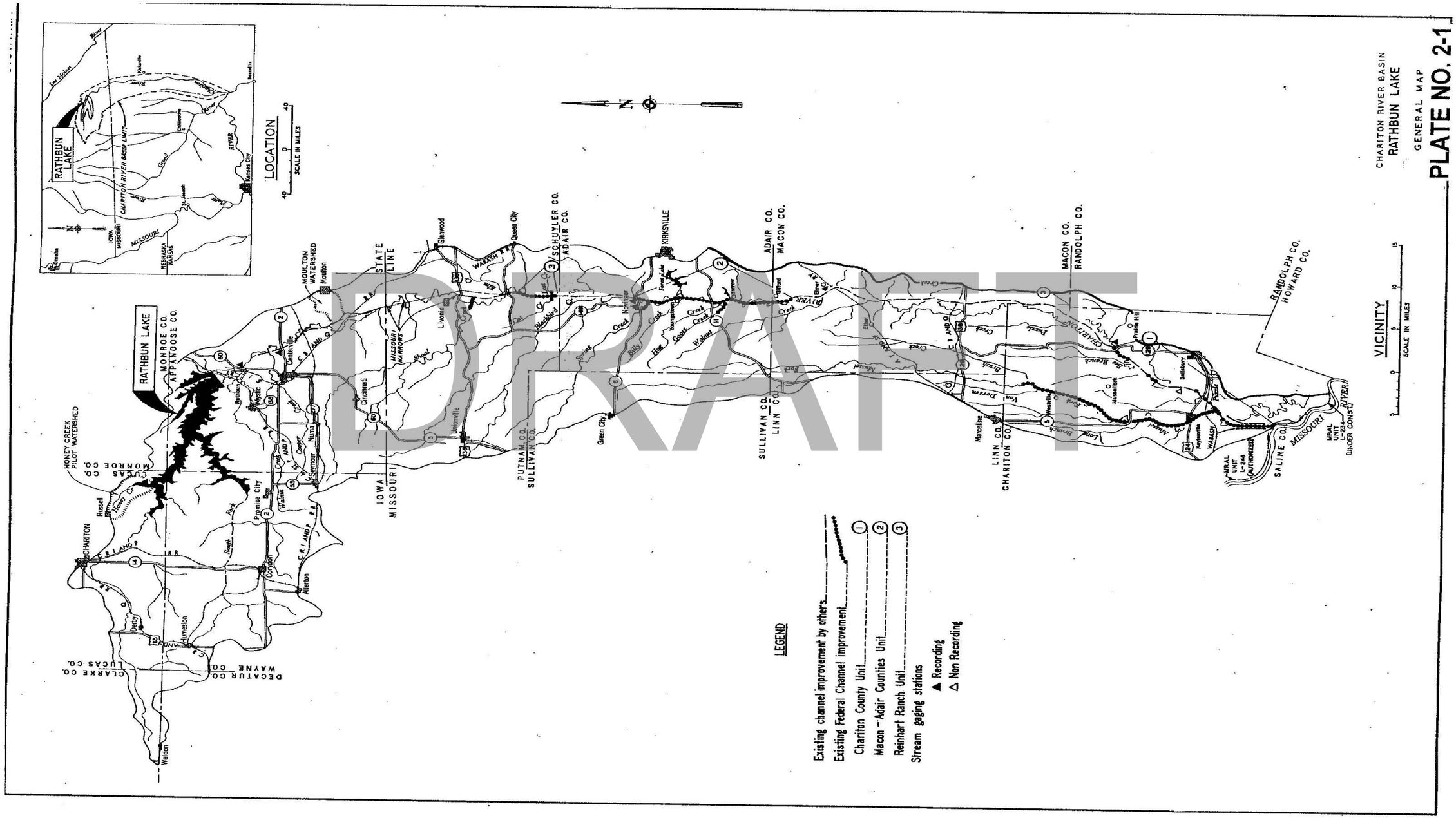


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**Plate 2-2: Embankment**

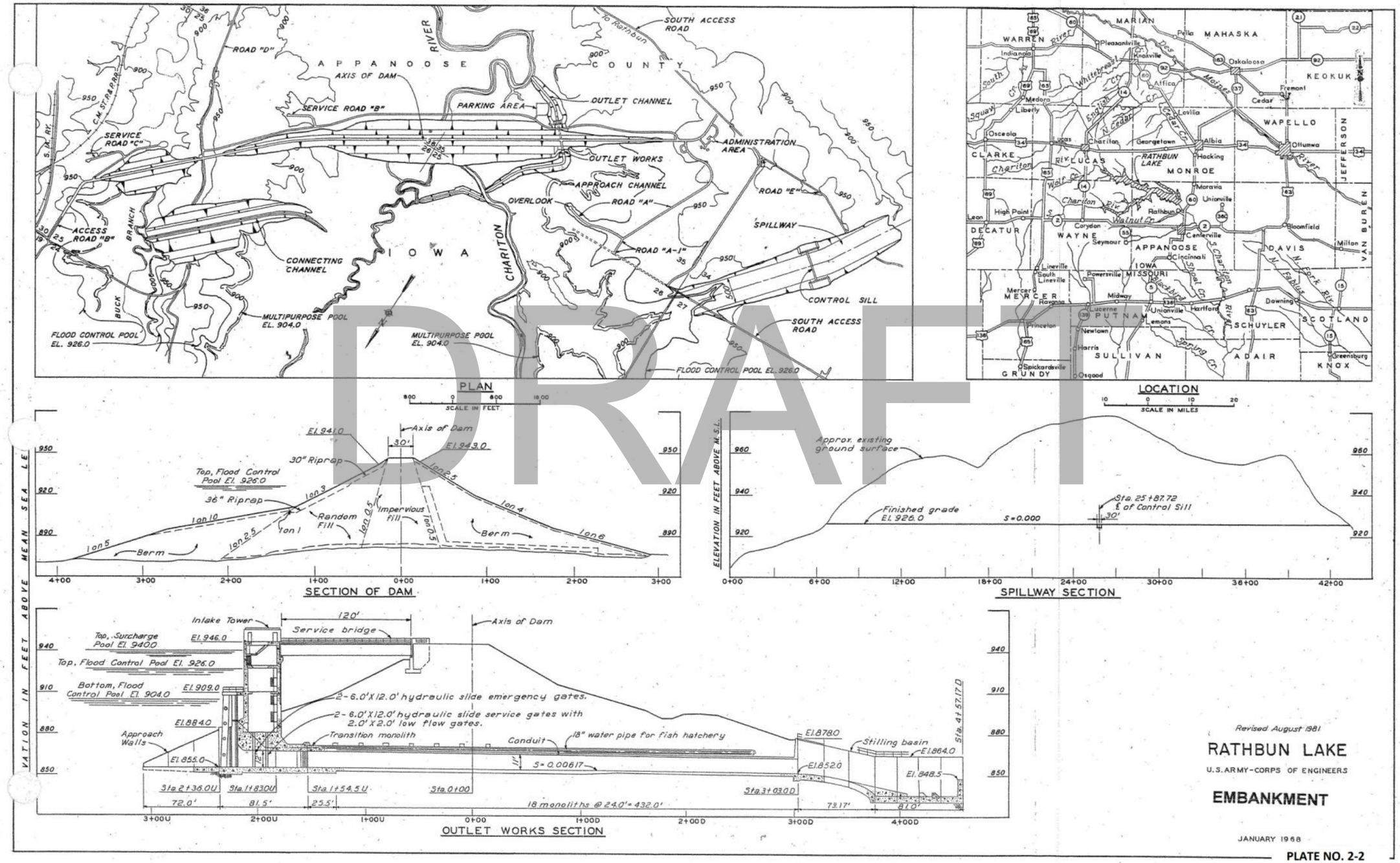


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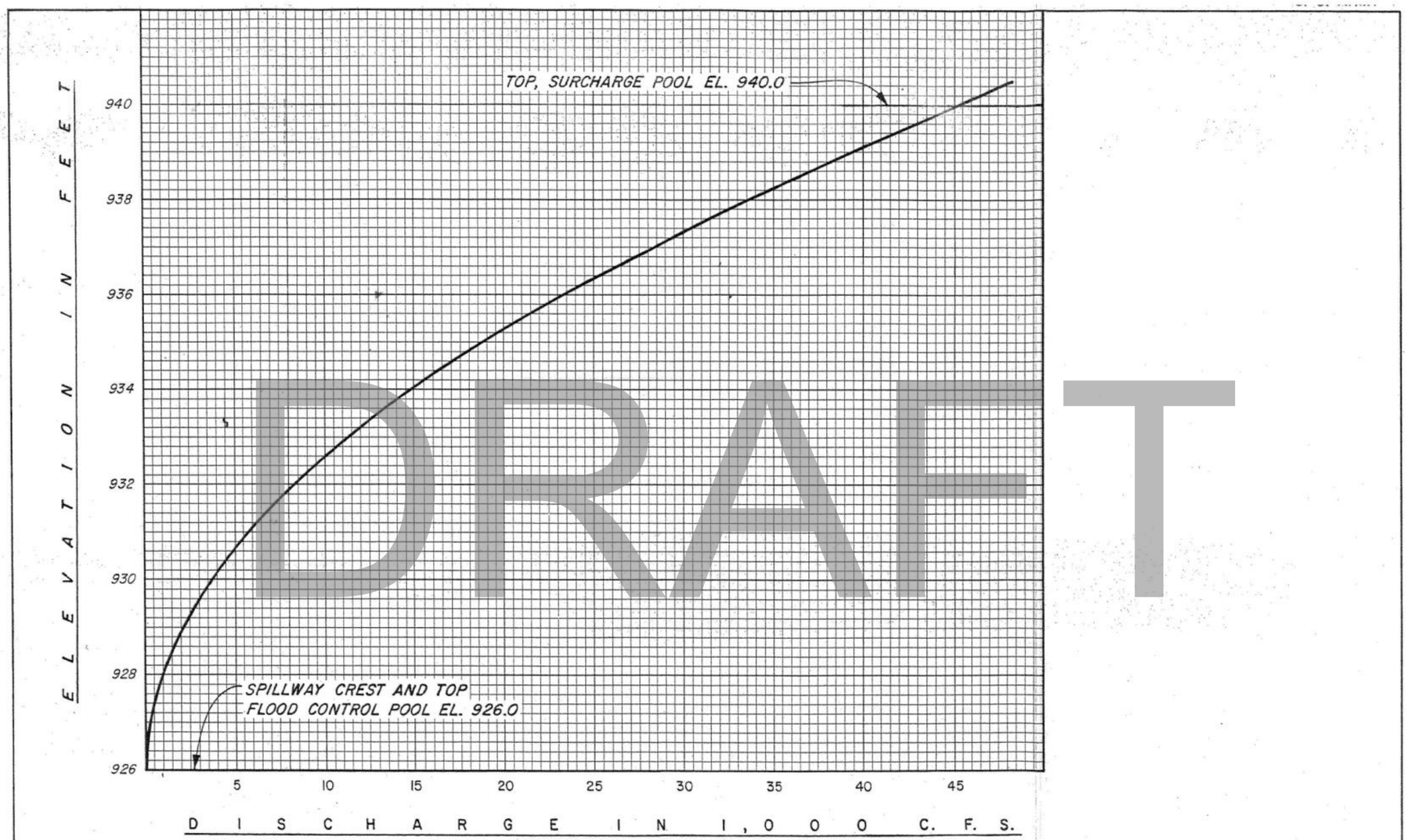
**Plate 2-3: Spillway Rating**

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RATHBUN LAKE

SPILLWAY
RATING CURVE

KANSAS CITY DISTRICT

OCTOBER 1968

**PLATE NO. 2-3**

**Plate2-4: Outlet Works Rating Curve**

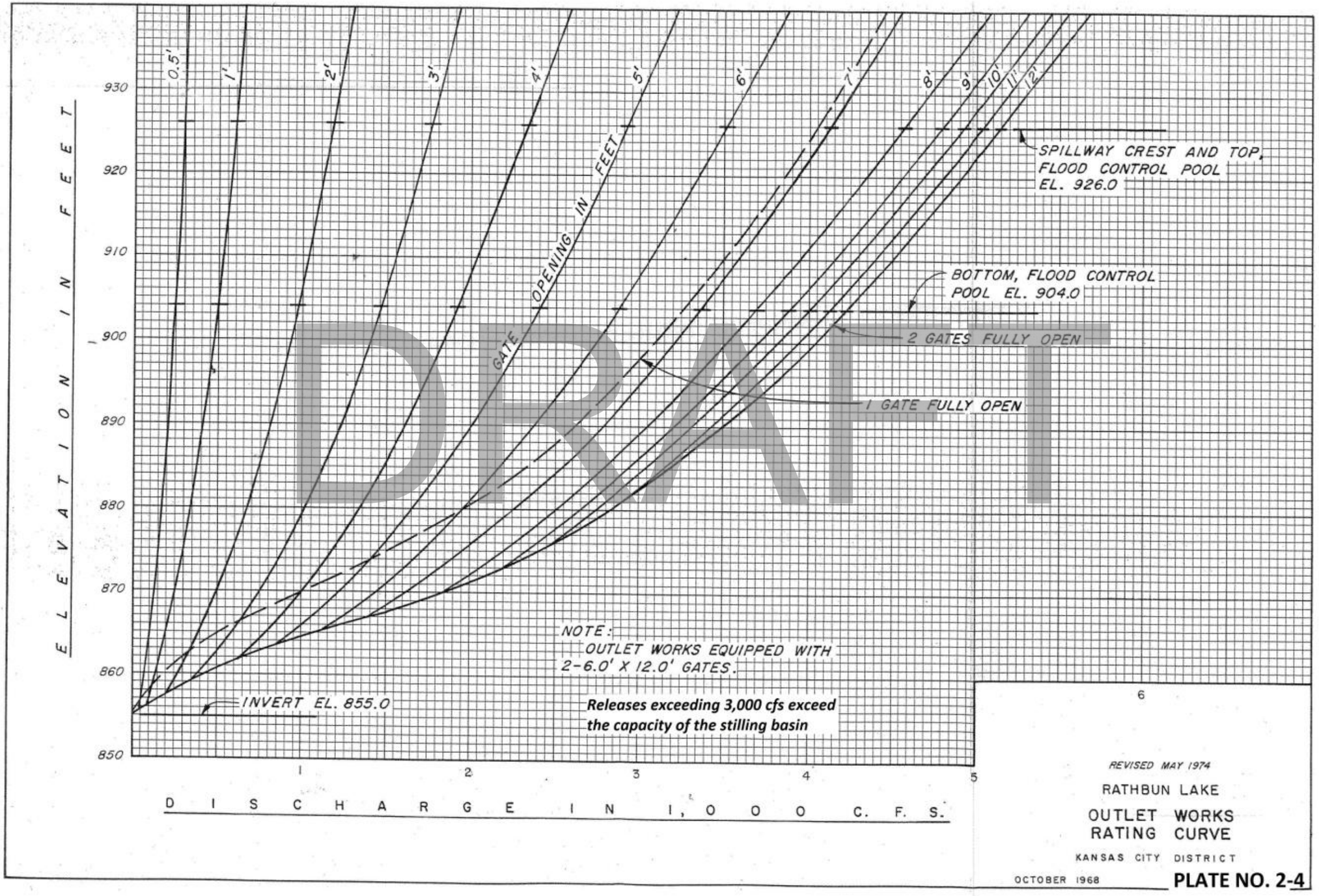

**Plate 2-5: Rathbun Dam Outlet Works and Intake Tower**

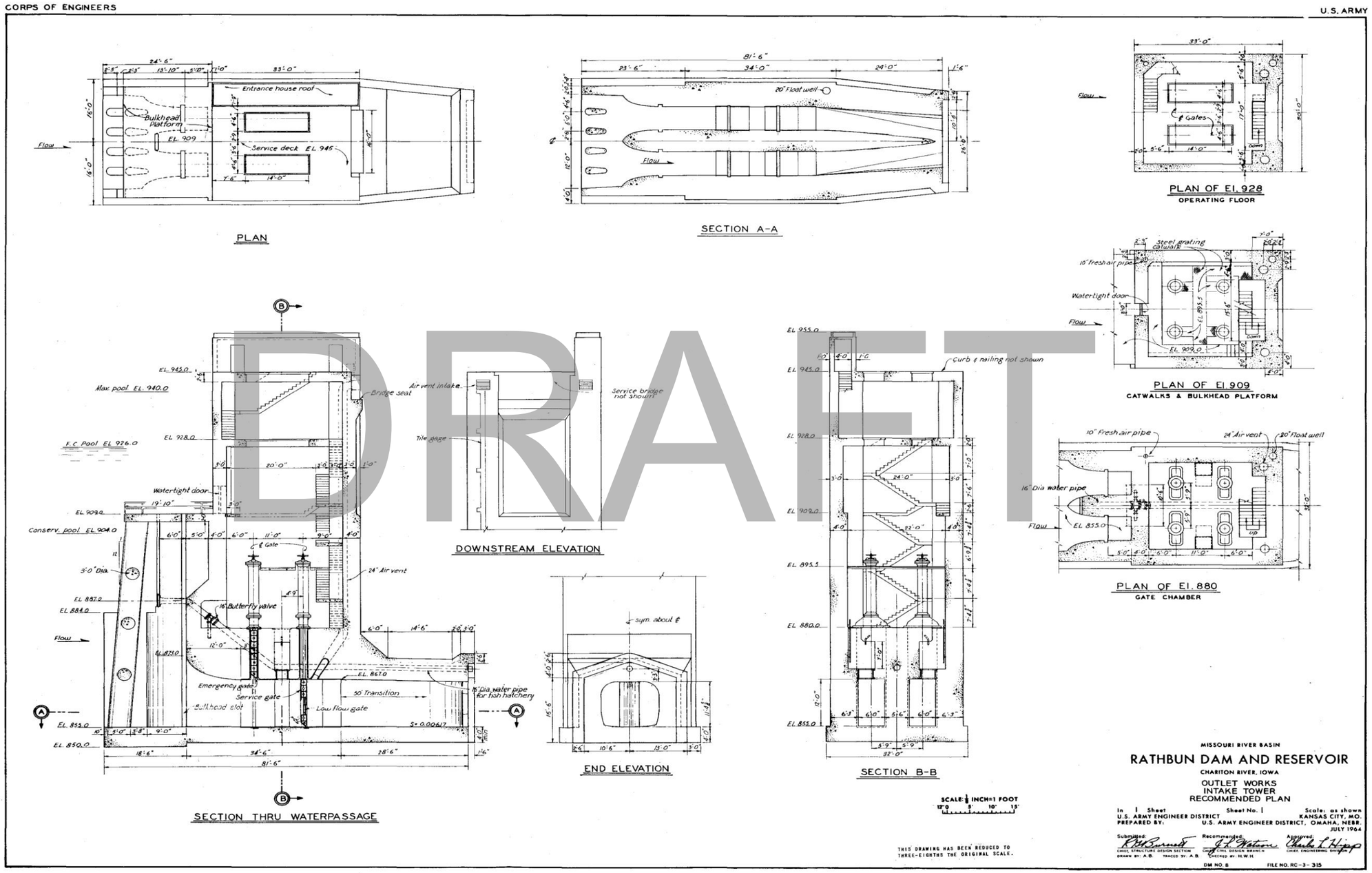


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**Plate 2-6: Stilling Basin Modifications**

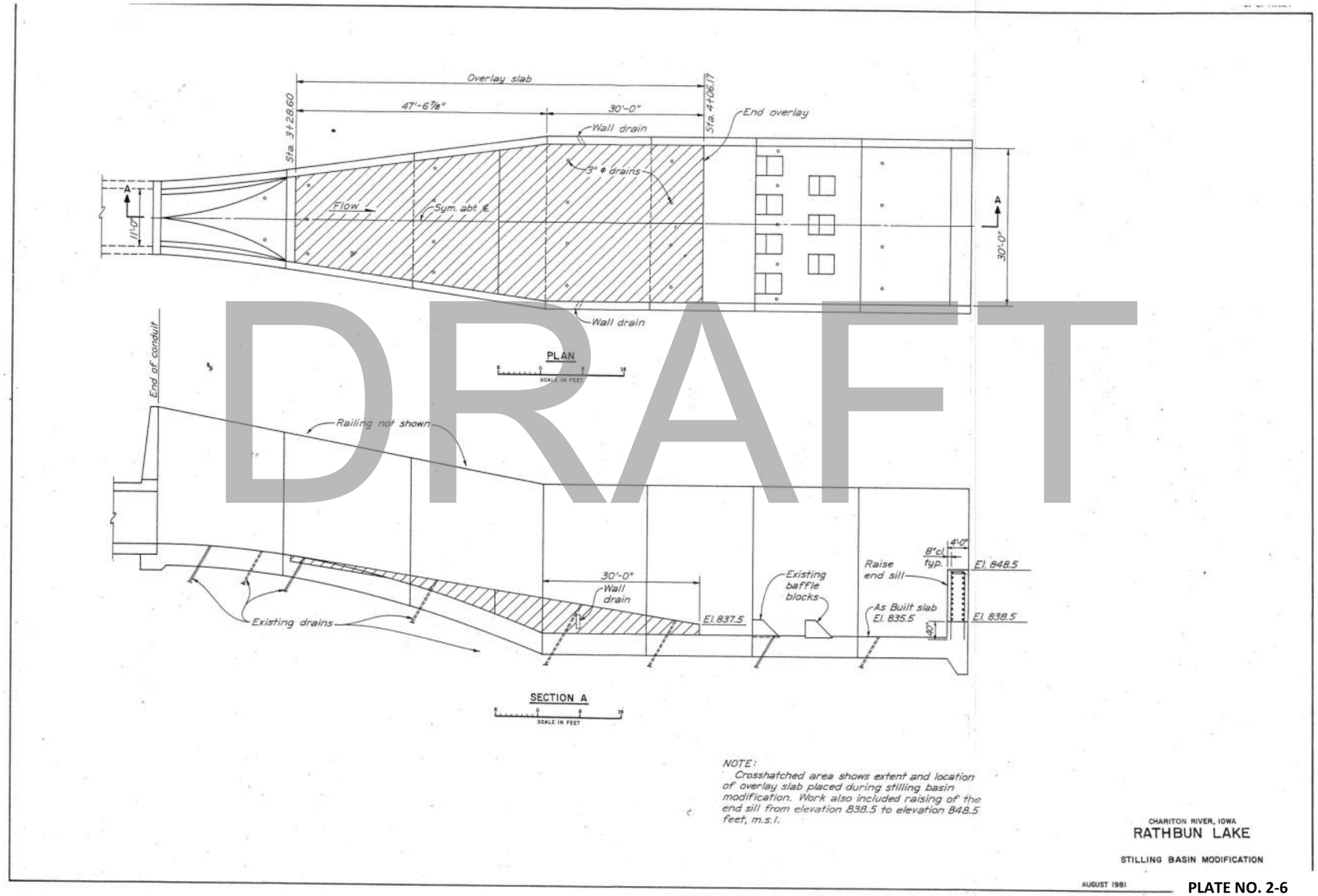
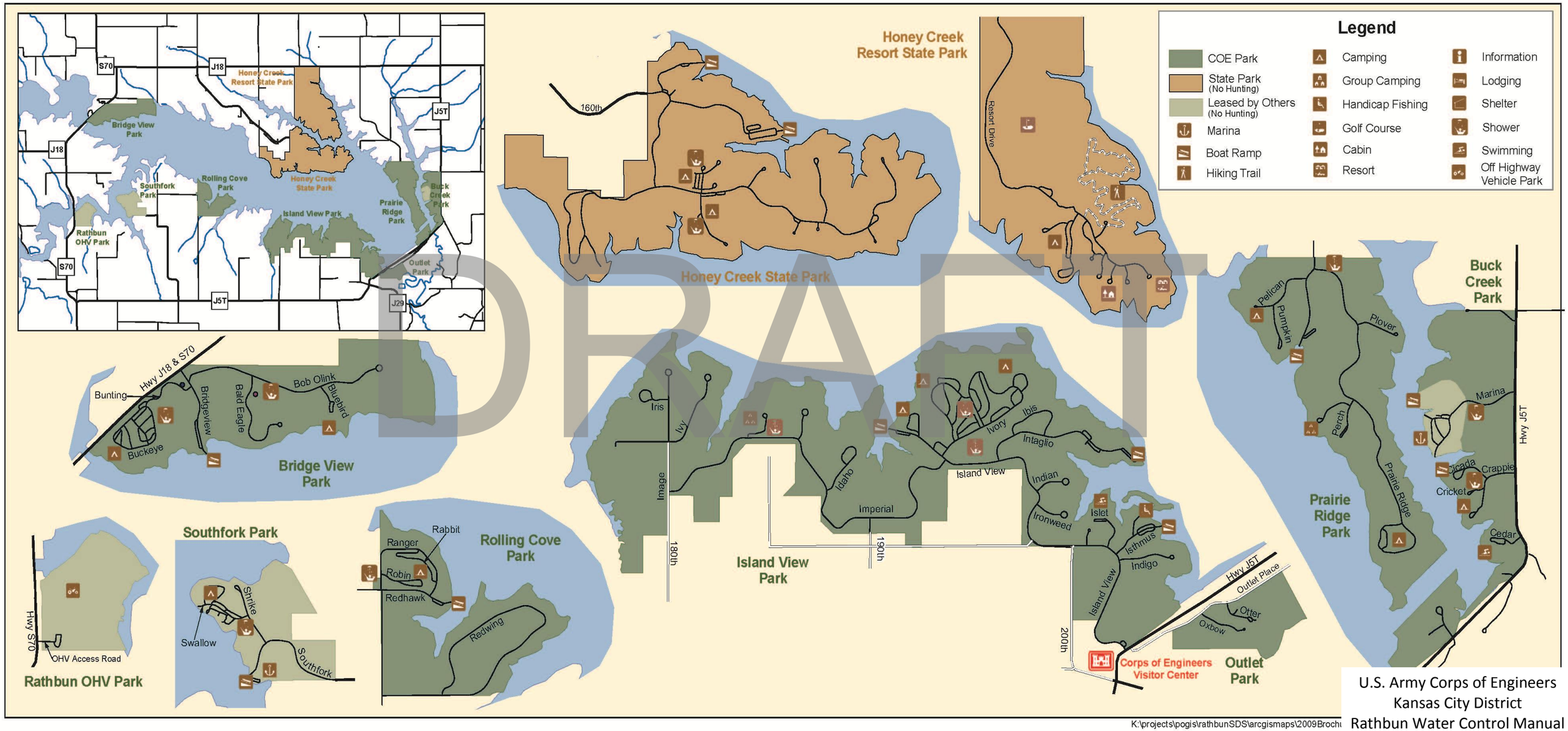



PLATE NO. 2-6

**Plate 2-7: Rathbun Recreation**

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U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Rathbun Recreation
July 2015
**Plate NO. 2-7**

**Plate 4-1: Chariton River Profile Elevations**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Chariton River Profile Elevations
July 2015
**Plate NO.4-1**

| Chariton River Profile Elevations | | Approximate River Profile Elevations Measured 2010 - 2013 | | | | | |
|---|---|---|---|---|---|---|---|
| **Location** | **River Mile** | **River Bottom** | **Low Flow Profile** | **2000 cfs Profile** | **2500 cfs Profile** | **3000 cfs Profile** | **Notes** |
| nr Chariton USGS Gage (06903400) | 173.7 | 921.9 | 922.0 | 934.1 | 934.9 | 935.5 | S43 Bridge, NWS Flood Stage = 19.5 ft (ele |
| Highway S56 Bridge | 163.7 | 899.0 | 904.0 | | Not applicable | | |
| Highway S70 Bridge | 151.7 | 875.0 | 904.0 | | Not applicable | | |
| S. Fk Chariton River Confluence | 149.6 | 872.0 | 904.0 | | Not applicable | | |
| Rathbun Dam Axis | 142.3 | 844.0 | 904.0 | | Not applicable | | Multipurpose Pool 904.0 |
| nr Rathbun USGS Gage (06903900) | 142.1 | 848.7 | 850.2 | 860.4 | 862.0 | 863.6 | Located at lower end of north parking lot bel |
| RRWA River Intake | 142.1 | 848.7 | 850.2 | 860.4 | 862.0 | 863.6 | Left low bank = 865.0 (parking lot) |
| Degradation Range A | 141.86 | 847.0 | 848.2 | 860.1 | 861.7 | 863.3 | Right low bank = 861.3 (riparian woodland), |
| Fish Hatchery Outfall Confluence | 141.65 | 846.6 | 847.7 | 859.9 | 861.5 | 863.1 | Right low bank = 861.8 (riparian woodland) |
| 461st St Bridge (Darby Bridge) | 139.2 | 844.4 | 843.9 | 856.9 | 858.5 | 860.1 | Low girder elevation about 865 |
| Degradation Range B | 139.1 | 842.1 | 843.8 | 856.7 | 858.4 | 860.0 | Left low bank = 860.1 (trees), then 861.5 (pa |
| Railroad Bridge | 138.9 | 842.1 | 843.6 | 856.5 | 858.2 | 859.8 | Low steel elevation about 868 |
| Walnut Creek Confluence | 137.9 | 840.6 | 842.2 | 855.0 | 856.6 | 858.2 | Right low bank = 859.0 (riparian woodland) |
| State Highway 5 Bridge | 135.6 | 837.0 | 838.0 | 851.8 | 853.4 | 854.9 | Low girder elevation about 870 |
| Degradation Range D | 135.59 | 837.7 | 838.0 | 851.7 | 853.3 | 854.8 | Left low bank = 854.0 (riparian woodland), tl |
| Degradation Range E | 133.72 | 835.0 | 835.7 | 849.8 | 851.4 | 852.9 | Both low banks = 852 (woodland) rising stea |
| 493rd St Bridge (Clayworth Bridge) | 131.8 | 831.6 | 833.6 | 846.4 | 848.2 | 849.9 | Low girder elevation about 856.0 |
| Degradation Range F | 131.74 | 832.0 | 833.5 | 846.2 | 848.0 | 849.7 | Right low bank = 853.5 (tilled farmland) |
| Cooper Creek Confluence | 129.2 | 828.5 | 828.7 | 841.4 | 843.1 | 844.8 | Left low bank = 846.6 (woodland) |
| State Highway 2 Bridge | 125.2 | 823.8 | 824.2 | 835.2 | 836.8 | 838.3 | Low girder 852.8, old Centerville Gage (069 |
| Degradation Range G | 125.18 | 823.7 | 824.0 | 835.1 | 836.7 | 838.2 | Right low bank = 840 (woodland) then fields |
| Sharon Bluffs State Park Boat Ramp (520th St) | 123.8 | 820.9 | 822.4 | 832.9 | 834.5 | 836.0 | Left low bank = 841.8 (woodland) then fields |
| Railroad Bridge | 121.0 | 818.0 | 818.3 | 828.2 | 829.7 | 831.2 | Low steel elevation about 860 |
| nr Moulton USGS Gage (06904010) | 120.0 | 817.0 | 817.5 | 827.3 | 828.8 | 830.3 | 543rd St Bridge, low girder elevation about 8 |
| Degradation Range H | 119.99 | 816.6 | 816.8 | 827.2 | 828.7 | 830.2 | Right low bank = 834.8 (tilled farmland) |
| Upstream Bounds Sedan Bottoms WPA | 119.8 | 816.5 | 816.7 | 827.2 | 828.7 | 830.1 | Left low bank = 834.6 (tilled farmland) |
| 285th Ave Bridge (Sedan Bottoms Bridge) | 118.0 | 814.9 | 815.0 | 825.1 | 826.5 | 827.9 | Low girder elevation about 832.7 |
| Downstream Bounds Sedan Bottoms WPA | 114.3 | 807.1 | 809.6 | 820.3 | 821.6 | 822.9 | Banks about 822.5, but wetlands beyond lov |
| Degradation Range J near 590th Street | 114.2 | 808.5 | 809.4 | 820.1 | 821.4 | 822.7 | Banks abouit 824, but wetlands, fields beyor |
| 611th St Bridge (Coal City Bridge) | 111.9 | 801.6 | 806.2 | 817.0 | 818.1 | 819.2 | Low girder elevation about 828.7 |
| Degradation Range K | 111.89 | 804.5 | 806.0 | 816.8 | 818.0 | 819.1 | Low right bank about 820, but wetlands beyo |
| Missouri - Iowa State Line | 111.52 | 803.9 | 805.4 | 816.3 | 817.5 | 818.6 | Low right bank = 818.0 (riparian woodlands) |
| Blackberry Trail Boat Ramp, Rebels Cove CA | 104.0 | 791.7 | 794.1 | 804.8 | 806.0 | 807.1 | Low left bank = 810.2 (woodlands, wetlands) |
| Beech Trail River Crossing, Rebels Cove CA | 103.1 | 792.5 | 792.6 | 803.4 | 804.6 | 805.7 | Low right bank = 808.0 (woodlands, wetland |
| 135th Street Boat Ramp, Rebels Cove CA | 99.7 | 781.4 | 787.3 | 797.5 | 798.7 | 799.8 | Low left bank = 804.0 (tilled farmland left, wo |
| at Livonia USGS Gage (06904050) | 91.8 | 772.5 | 773.4 | 781.2 | 782.4 | 783.4 | US Highway 136 Bridge, no NWS Flood Sta |
| State Highway W Bridge | 86.8 | 762.8 | 764.1 | 771.0 | 772.1 | 773.2 | Bank elev not determined D/S of Rebels Cov |
| at Novinger USGS Gage (06904500) | 73.1 | 736.2 | 737.5 | 742.8 | 743.6 | 744.4 | State Highway 6 Bridge, NWS Flood Stage |
| State Highway J Bridge | 53.1 | 695.0 | 696.8 | 700.4 | 701.2 | 702.0 | Old Elmer USGS Gage (06905000) |
| US Highway 36 Bridge | 37.7 | 666.1 | 667.7 | 671.5 | 672.3 | 673.0 | |
| at Prairie Hill USGS Gage (06905500) | 19.6 | 632.1 | 633.5 | 637.0 | 638.0 | 638.8 | State Highway 129 Bridge, NWS Flood Stag |
| US Highway 24 Bridge | 8.8 | | 617.0 | | | | |
| Mussell Fork Creek Confluence w/Chariton R | 7.06 | | 613.0 | | | | |
| Confluence with Missouri River, RM 238.8 | 0.0 | | 608.0 | | | | Missouri River Flow = 40,000 cfs |

Notes: River Mileages are based on a GIS river centerline analysis using 2013 aerial imagery of the Chariton River. The point file of river mileage points was adjusted along the centerline to approximately retain the historical river mileages of key locations such as t Dam (RM 142.3) and the Prairie Hill streamgage (RM 19.6). River mileages will vary over time with channel improvements and as meanders lengthen or get cut off.

The river bottom, 2000 cfs, and 3000 cfs river profiles were measured during profile surveys in 2010 conducted from Rathbun Dam down to about RM 99.7 at the lower end of the Rebels Cove Conservation Area. The low flow profile for this table is estimated based o measured at the river gages and degradation ranges added to the river bottom profile. The 2500 cfs profile is approximated based on 2013 measurements obtained at river gages and degradation range monuments. Since river channel depths change continuously v deposition, the flow profiles are probably accurate to 1-2 feet. The river bottom profile is more variable. The profiles downstream of RM 99.7 and upstream of the Dam are estimated based on known gage information and the profiles shown on Plate 4 of the Water C dated 1980. River elevations at USGS gages for given flows are those indicated by the rating curves in effect 2010-2013.

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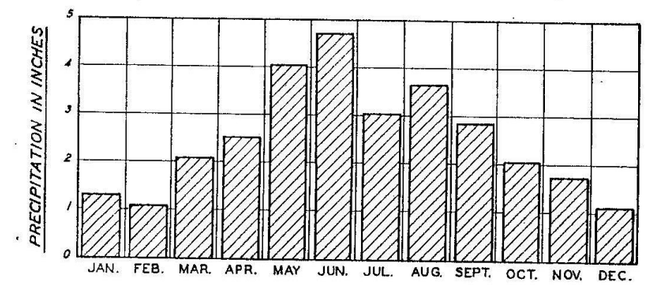
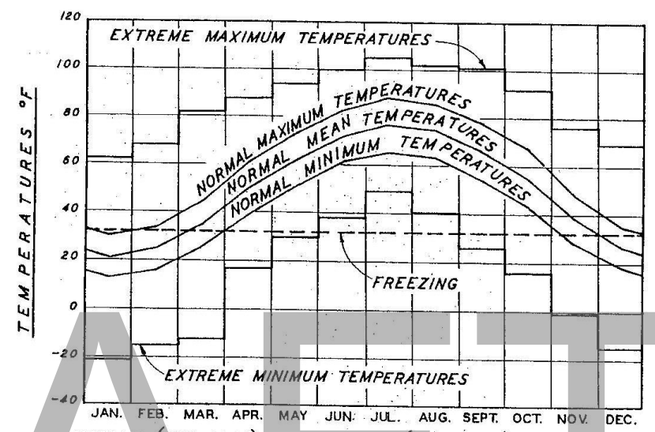
**Plate 4-2: Des Moines, IA Climate**

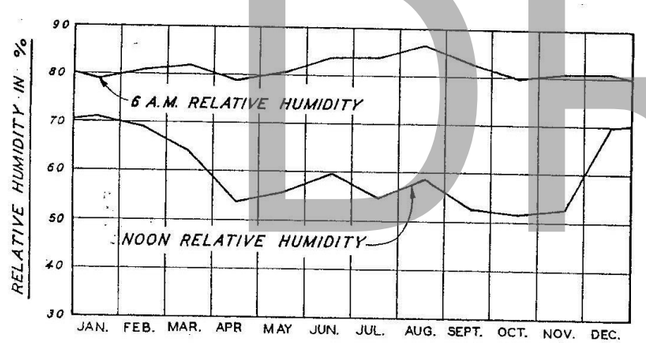
U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Des Moines, IA Climate
July 2015
**Plate NO. 4-2**



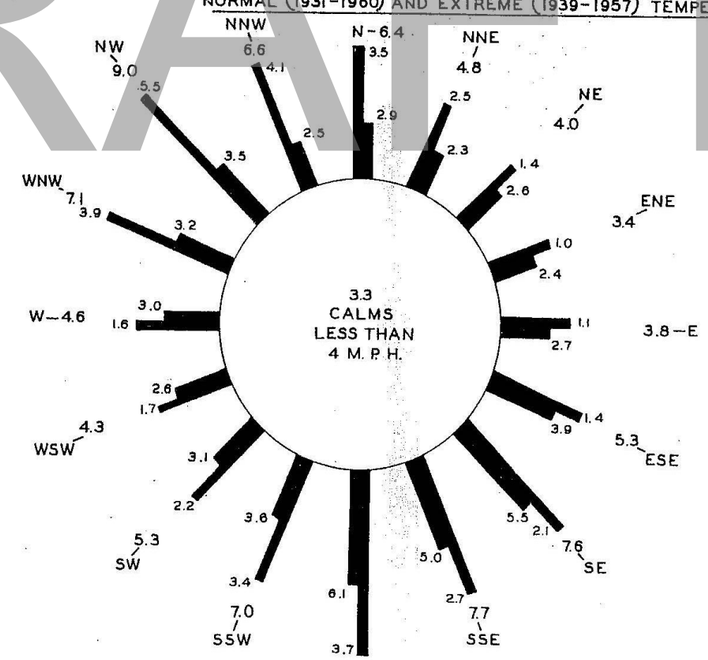

MEAN MONTHLY PRECIPITATION
(1931-1960)




NORMAL (1931-1960) AND EXTREME (1939-1957) TEMPERATURE



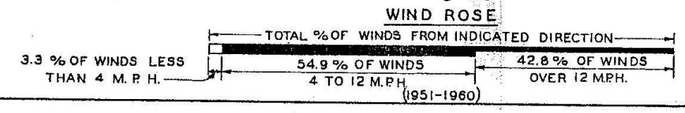

MEAN MONTHLY HUMIDITIES
(1939-1957)




WIND ROSE




AVERAGE PERCENT OF POSSIBLE SUNSHINE
(1895-1948)




CLIMATOLOGICAL DATA SUMMARY
FOR DES MOINES, IOWA

FILE NO. RC-3-853

PLATE NO. 4-2

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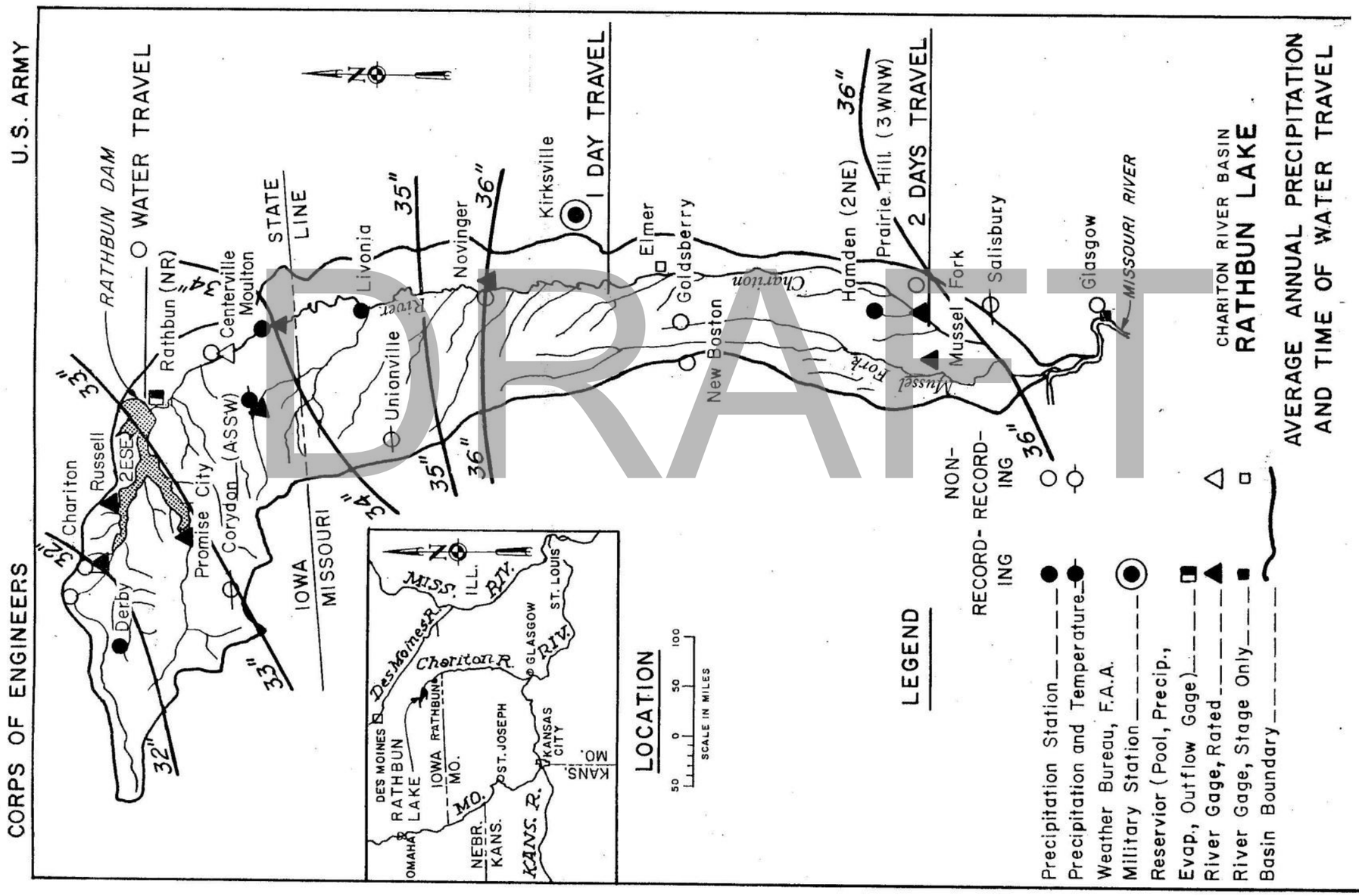
**Plate 4-3: Travel Time Annual Precipitation**

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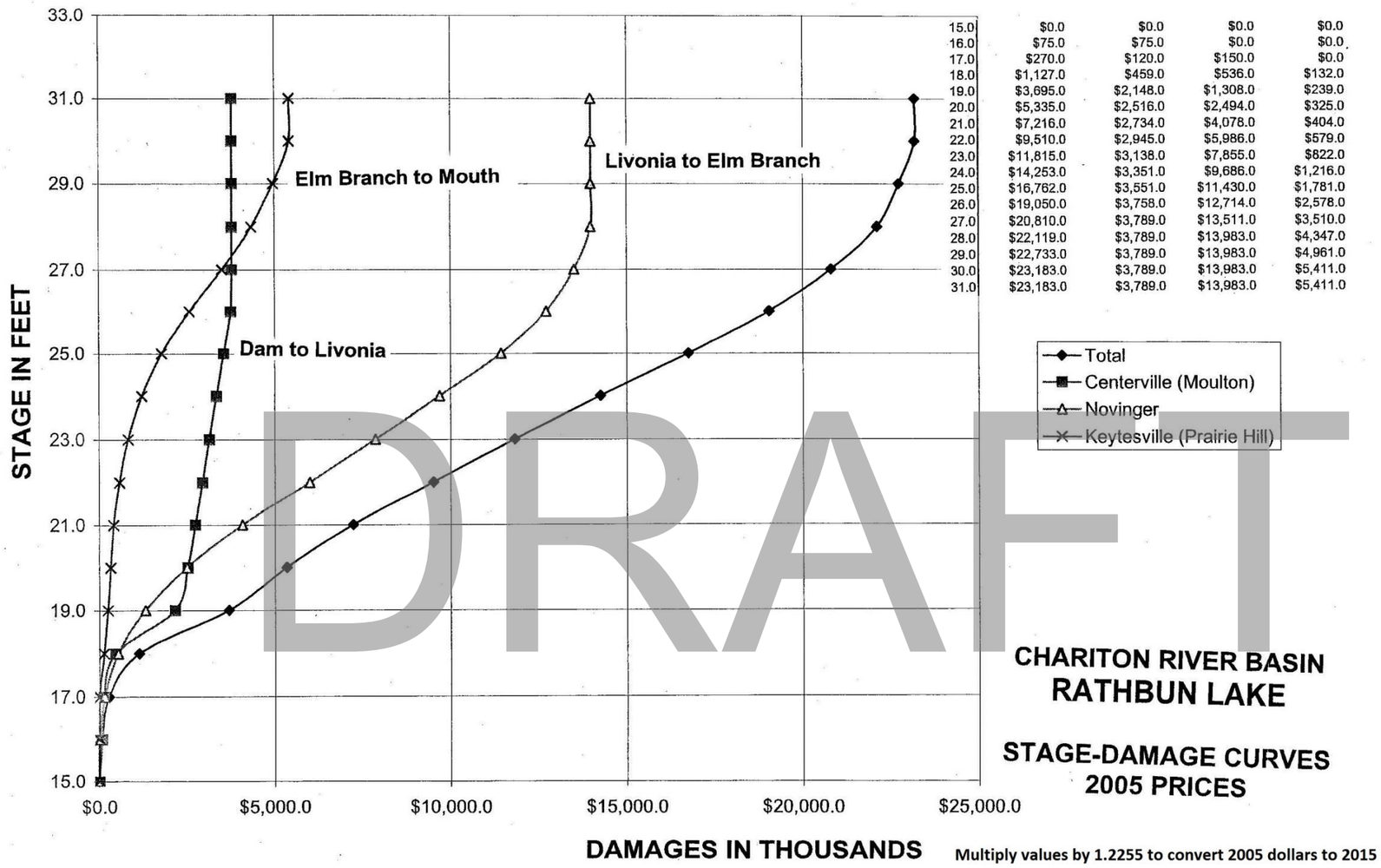
Kansas City District
Rathbun Water Control Manual
Travel Time Annual Precipitation
July 2015
**Plate NO. 4-3**

**Plate 4-4: Stage Damage Curves 2005 Prices**




| | | | | |
|---|---|---|---|---|
| 15.0 | $0.0 | $0.0 | $0.0 | $0.0 |
| 16.0 | $75.0 | $75.0 | $0.0 | $0.0 |
| 17.0 | $270.0 | $120.0 | $150.0 | $0.0 |
| 18.0 | $1,127.0 | $459.0 | $536.0 | $132.0 |
| 19.0 | $3,695.0 | $2,148.0 | $1,308.0 | $239.0 |
| 20.0 | $5,335.0 | $2,516.0 | $2,494.0 | $325.0 |
| 21.0 | $7,216.0 | $2,734.0 | $4,078.0 | $404.0 |
| 22.0 | $9,510.0 | $2,945.0 | $5,986.0 | $579.0 |
| 23.0 | $11,815.0 | $3,138.0 | $7,855.0 | $822.0 |
| 24.0 | $14,253.0 | $3,351.0 | $9,686.0 | $1,216.0 |
| 25.0 | $16,762.0 | $3,551.0 | $11,430.0 | $1,781.0 |
| 26.0 | $19,050.0 | $3,758.0 | $12,714.0 | $2,578.0 |
| 27.0 | $20,810.0 | $3,789.0 | $13,511.0 | $3,510.0 |
| 28.0 | $22,119.0 | $3,789.0 | $13,983.0 | $4,347.0 |
| 29.0 | $22,733.0 | $3,789.0 | $13,983.0 | $4,961.0 |
| 30.0 | $23,183.0 | $3,789.0 | $13,983.0 | $5,411.0 |
| 31.0 | $23,183.0 | $3,789.0 | $13,983.0 | $5,411.0 |

**Multiply values by 1.2255 to convert 2005 dollars to 2015**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Stage Damage Curves 2005 Prices
July 2015
**Plate NO. 4-4**

**Plate 5-1: Plan of Sediment and Degradation Ranges**

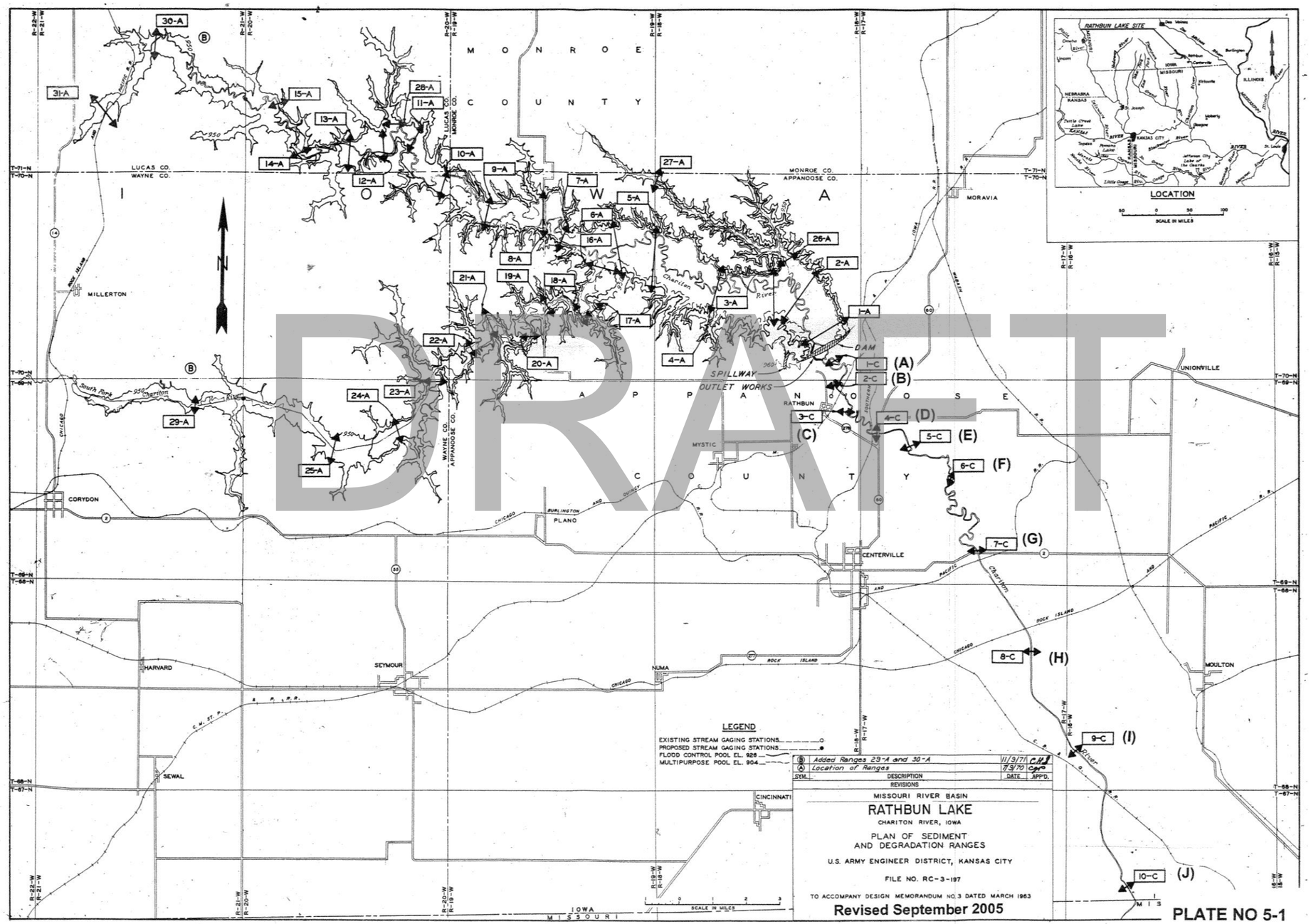



PLATE NO 5-1

## Six-Hour Unit Hydrographs - Chariton River Basin
(1,000 c.f.s.)

| Routed | To Rathbun Dam | To Centerville | To Novinger | To Elmer | To Prairie Hill | To Mouth Chariton | To Mussel Fork |
|---|---|---|---|---|---|---|---|
| Subarea No. | CH 1 | CH 2 | CH 3 | CH 4 | CH 5 | CH 6 | MF |
| Contributing DA in sq. mi. | 551 | 157 | 662 | 290 | 210 | 172 | 267 |
| Hours 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6 | 0.2 | 0.3 | 0.7 | 0.5 | 0.7 | 0.7 | 0.2 |
| 12 | 0.7 | 1.4 | 2.6 | 2.2 | 4.1 | 3.8 | 0.9 |
| 18 | 1.6 | 4.1 | 7.3 | 6.8 | 6.9 | 5.7 | 2.7 |
| 24 | 3.1 | 5.3 | 15.5 | 8.1 | 4.3 | 3.5 | 5.1 |
| 30 | 6.0 | 2.8 | 12.3 | 5.2 | 2.6 | 2.0 | 4.1 |
| 36 | 9.7 | 1.5 | 9.1 | 3.2 | 1.6 | 1.3 | 3.3 |
| 42 | 9.1 | 0.8 | 6.6 | 2.1 | 1.1 | 0.8 | 2.6 |
| 48 | 6.9 | 0.4 | 4.7 | 1.3 | 0.7 | 0.4 | 2.1 |
| 54 | 5.4 | 0.2 | 3.6 | 0.9 | 0.3 | 0.2 | 1.6 |
| 60 | 4.0 | 0.0 | 2.7 | 0.5 | 0.1 | 0.0 | 1.4 |
| 66 | 3.1 | | 2.0 | 0.2 | 0.0 | | 1.1 |
| 72 | 2.4 | | 1.4 | 0.0 | | | 0.9 |
| 78 | 1.9 | | 1.0 | | | | 0.7 |
| 84 | 1.5 | | 0.7 | | | | 0.6 |
| 90 | 1.1 | | 0.4 | | | | 0.5 |
| 96 | 0.8 | | 0.2 | | | | 0.3 |
| 102 | 0.6 | | 0.0 | | | | 0.2 |
| 108 | 0.4 | | | | | | 0.2 |
| 114 | 0.3 | | | | | | 0.1 |
| 120 | 0.0 | | | | | | 0.0 |
| Total | 58.8 | 16.8 | 70.8 | 31.0 | 22.4 | 18.4 | 28.6 |

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PLATE NO. 6-1

# Rathbun Reservoir
## Construction of Seasonal Guidelines

| | 1 Month - 10% Inflow | | | | 3 Month - 10% Inflow | | | | Phase Lines | | Phase Elevations | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1<br>Month | 2<br>Inflow<br>(Ac-Ft) | 3<br>Outflow<br>(Ac-Ft) | 4<br>Storage Req'd<br>(Ac-Ft) | 5<br>% F.C. Pool<br>used | 6<br>Inflow<br>(Ac-Ft) | 7<br>Outflow<br>(Ac-Ft) | 8<br>Storage Req'd<br>(Ac-Ft) | 9<br>% F.C. Pool<br>used | Phase I-II | Phase II-III | Phase I | Phase III |
| Jan | 22,108 | 22,108 | - | 0% | 180,634 | 90,000 | 90,634 | 26% | 50% | 90% | 916.83 | 924.38 |
| Feb | 49,453 | 30,000 | 19,453 | 6% | 281,360 | 90,000 | 191,360 | 55% | 50% | 90% | 916.83 | 924.38 |
| Mar | 107,864 | 30,000 | 77,864 | 22% | 340,201 | 90,000 | 250,201 | 72% | 50% | 90% | 916.83 | 924.38 |
| Apr | 140,120 | 30,000 | 110,120 | 32% | 344,517 | 90,000 | 254,517 | 73% | 10% | 60% | 907.05 | 918.83 |
| May | 146,278 | 30,000 | 116,278 | 33% | 317,792 | 90,000 | 227,792 | 65% | 10% | 60% | 907.05 | 918.83 |
| Jun | 106,363 | 30,000 | 76,363 | 22% | 235,199 | 90,000 | 145,199 | 42% | 10% | 60% | 907.05 | 918.83 |
| Jul | 93,429 | 30,000 | 63,429 | 18% | 197,497 | 90,000 | 107,497 | 31% | 10% | 60% | 907.05 | 918.83 |
| Aug | 46,724 | 30,000 | 16,724 | 5% | 146,041 | 90,000 | 56,041 | 16% | 50% | 90% | 916.83 | 924.38 |
| Sep | 50,502 | 30,000 | 20,502 | 6% | 124,510 | 90,000 | 34,510 | 10% | 50% | 90% | 916.83 | 924.38 |
| Oct | 36,714 | 30,000 | 6,714 | 2% | 103,252 | 90,000 | 13,252 | 4% | 50% | 90% | 916.83 | 924.38 |
| Nov | 31,963 | 30,000 | 1,963 | 1% | 79,507 | 79,507 | - | 0% | 50% | 90% | 916.83 | 924.38 |
| Dec | 42,649 | 30,000 | 12,649 | 4% | 101,424 | 90,000 | 11,424 | 3% | 50% | 90% | 916.83 | 924.38 |

Total Flood Control Storage = 349,173 Ac-Ft

Column

1 Month under consideration.
2 Inflow is 10% chance volume for month indicated in Col. 1.
3 Outflow is volume of 10 day release at Phase I rate or inflow, whichever is less.
4 Storage required is Col. 2 minus Col. 3.
5 Percent of flood-control pool used is Col. 4 divided by total flood-control storage.
6 Inflow is 10% chance volume for three consecutive months beginning with month indicated in Col. 1.
7 Outflow is volume of 30-day release at Phase I rate or inflow, whichever is less.
8 Storage required is Col. 6 minus Col. 7.
9 Percent of flood-control pool used is Col. 8 divided by total flood-control storage.

Maximum Phase I regulating discharge, Chariton River, Rathbun Dam to mouth 1,500 cfs

10 day release at Phase I rate = 1,500 cfs x 10 x 2 = 30,000 AF
30 day release at Phase I rate = 1,500 cfs x 30 x 2 = 90,000 AF

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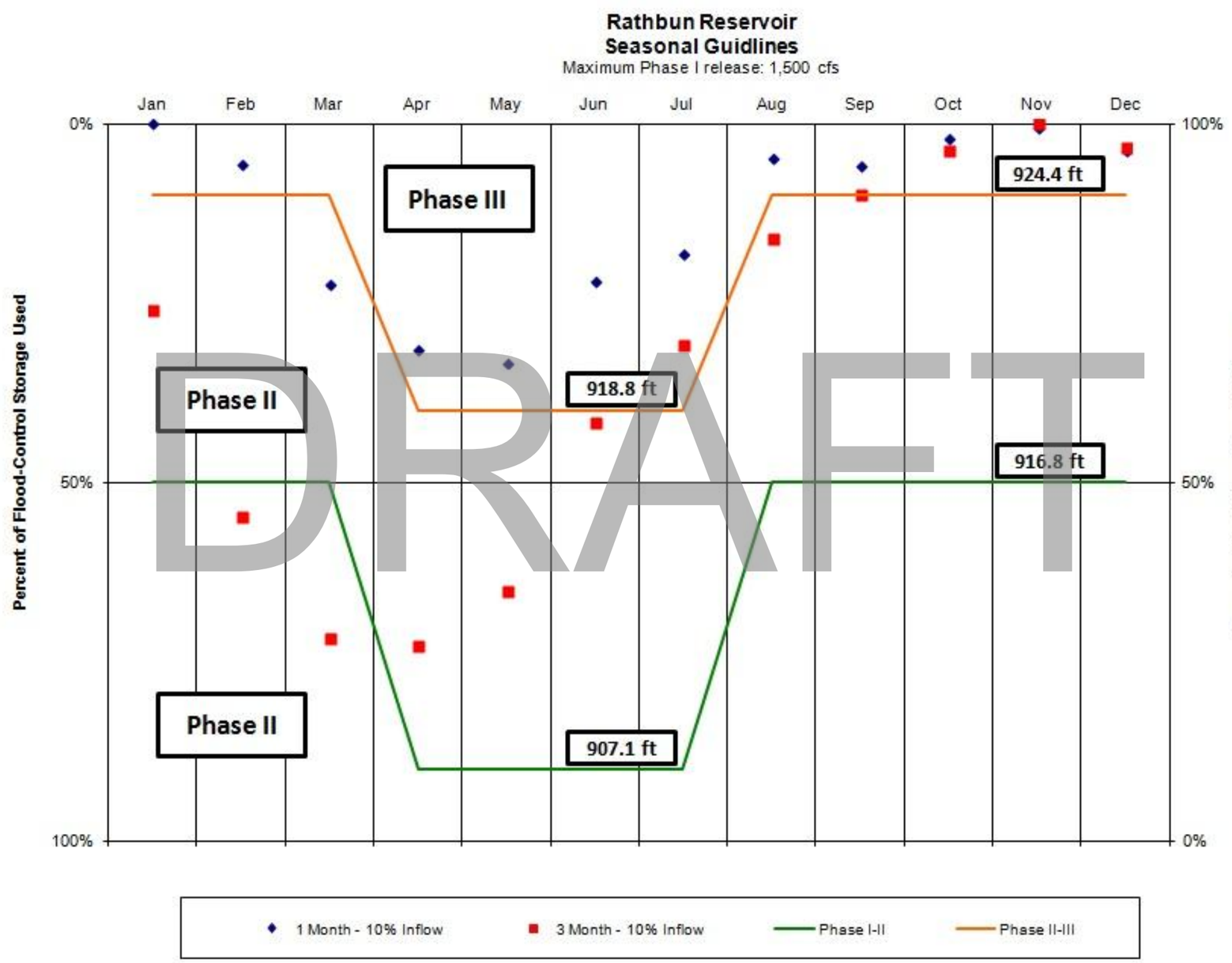
Kansas City District
Rathbun Water Control Manual
Table of Seasonal Guidelines
July 2015
**Plate NO. 7-2**

*

**Plate 7-2: Seasonal Guidelines Plot**




U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Seasonal Guidelines Plot
July 2015

**Plate NO. 7-2**

**Plate 8-1: Regulation of the Spillway Design Flood**

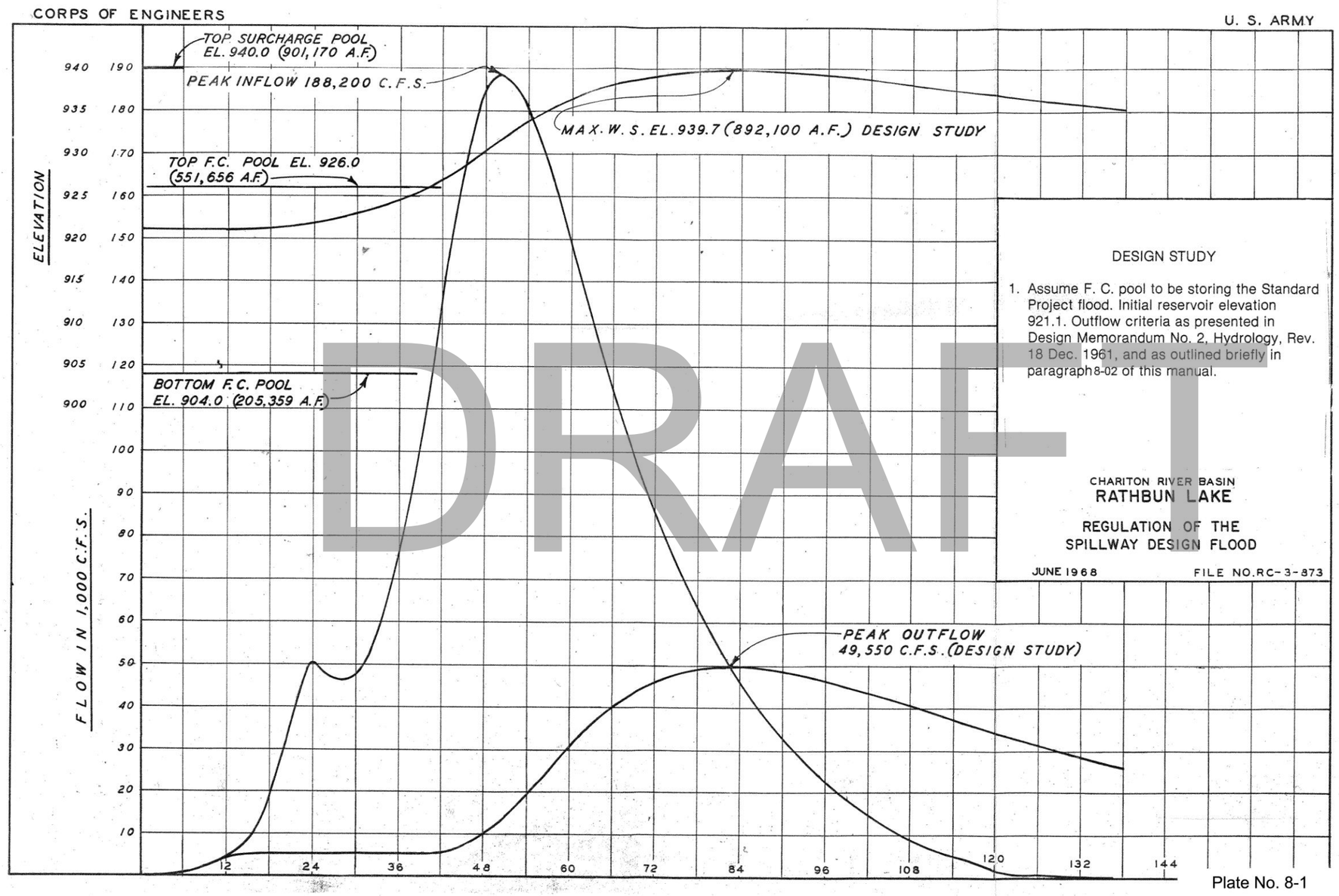



Plate No. 8-1

**Plate 8-2: Regulation of the Standard Project Flood**

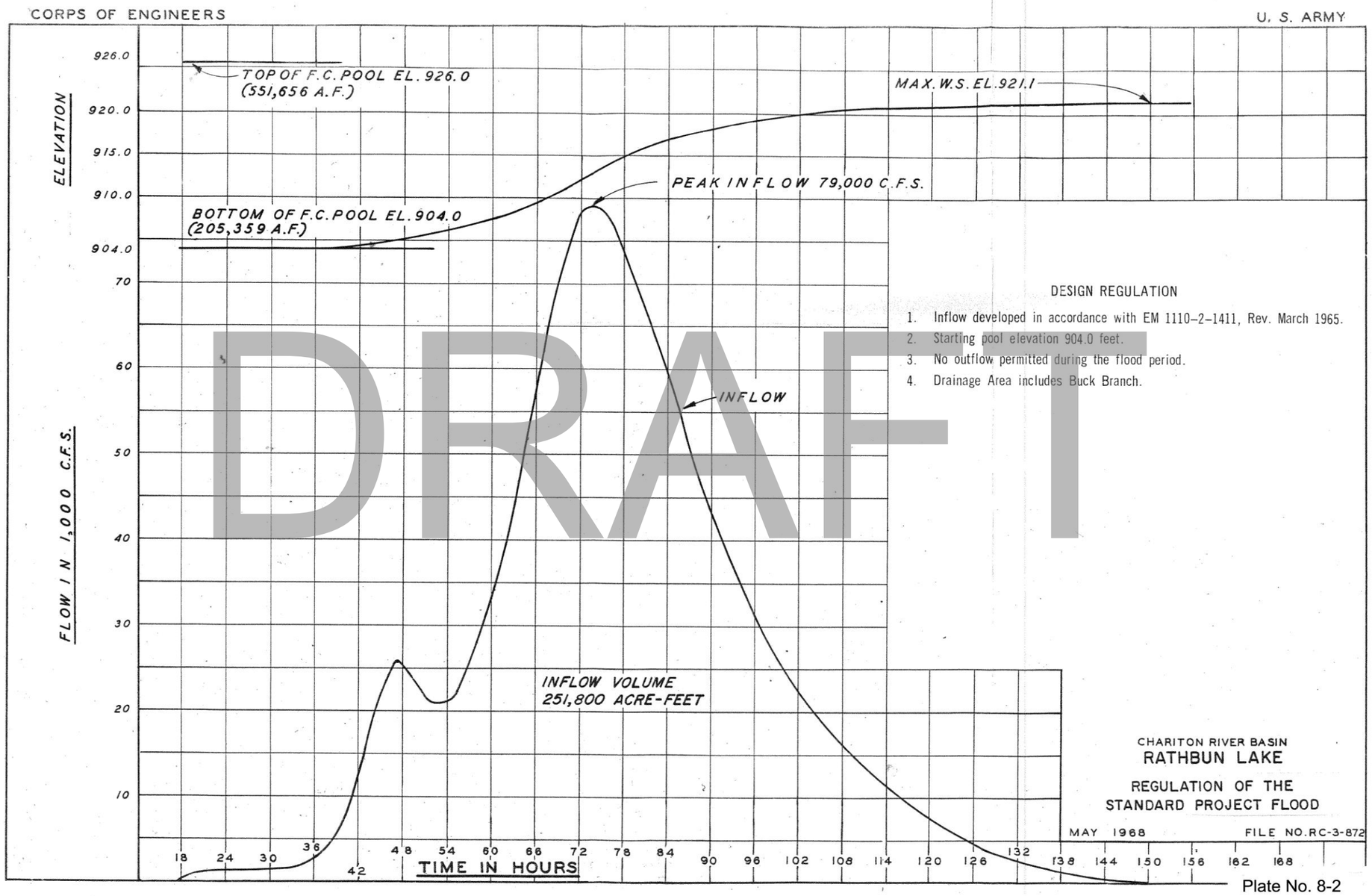



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Plate No. 8-2

**Plate 8-3: Regulation of the Lake Design Flood 1980**

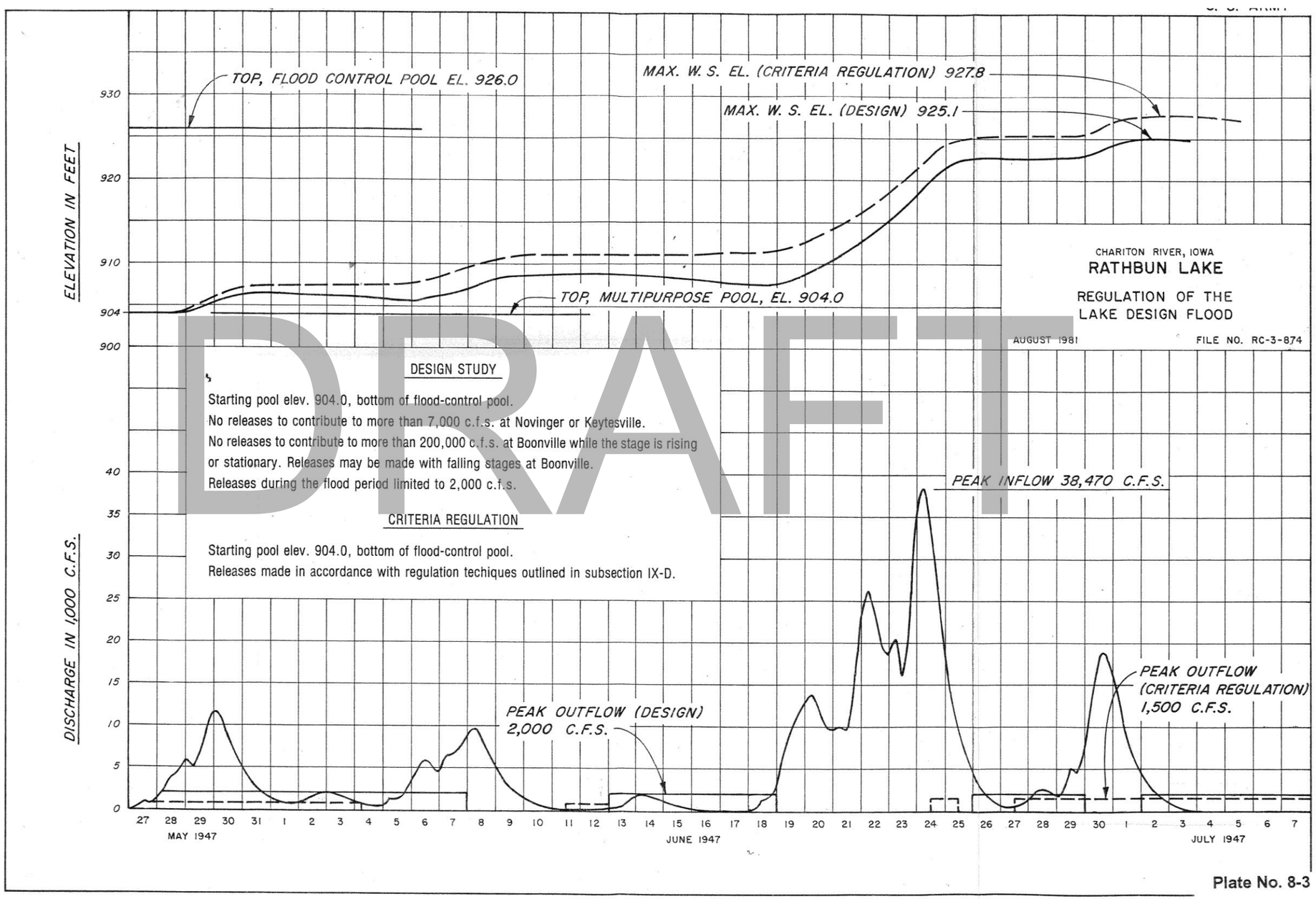


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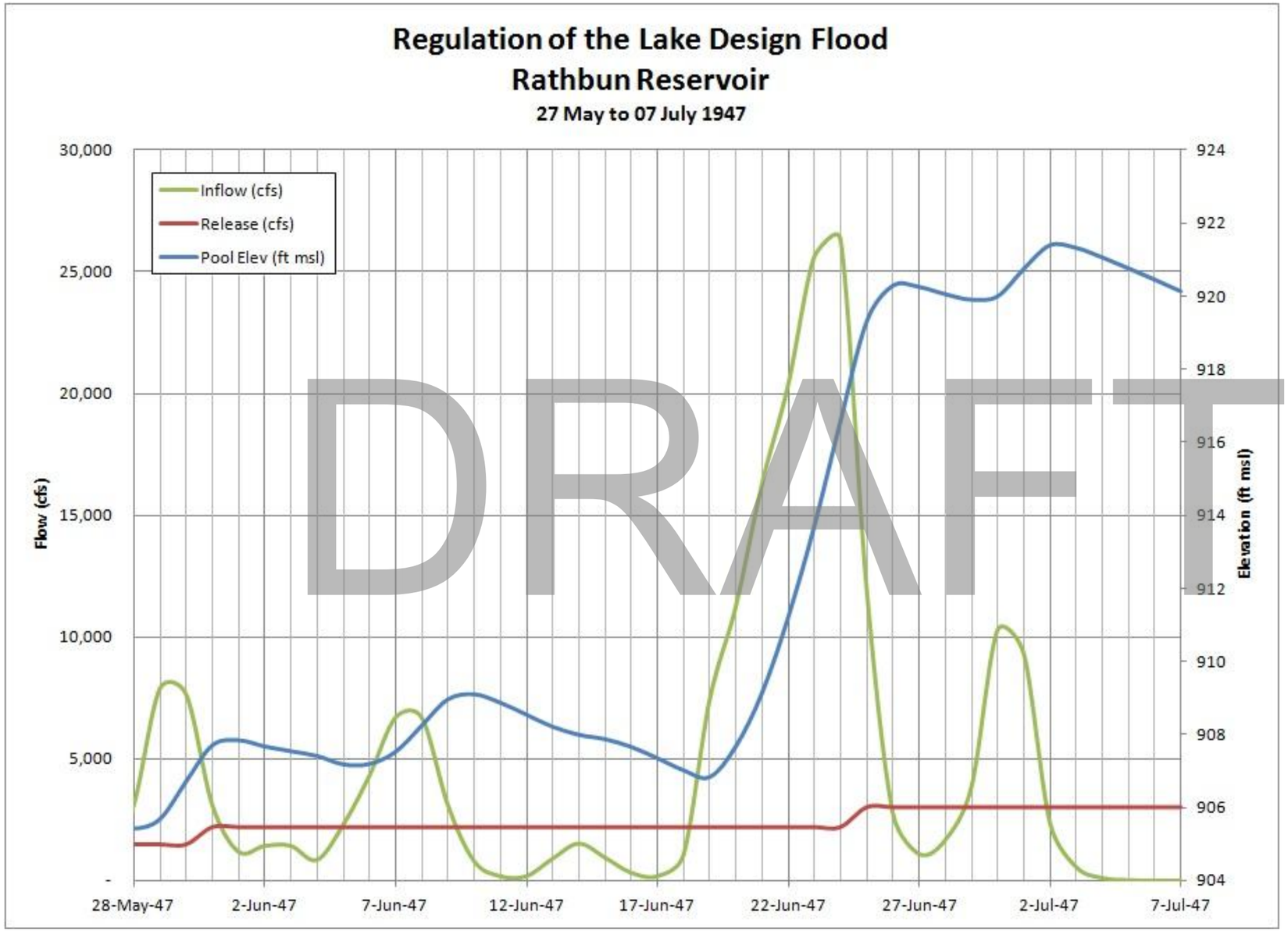
Plate No. 8-3

**Plate 8-4: Lake Design Flood Regulation 2015**

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Kansas City District
Rathbun Water Control Manual
Lake Design Flood Regulation 2015
July 2015

**Plate NO. 8-4**

**Plate 8-5: Inflow Frequency**

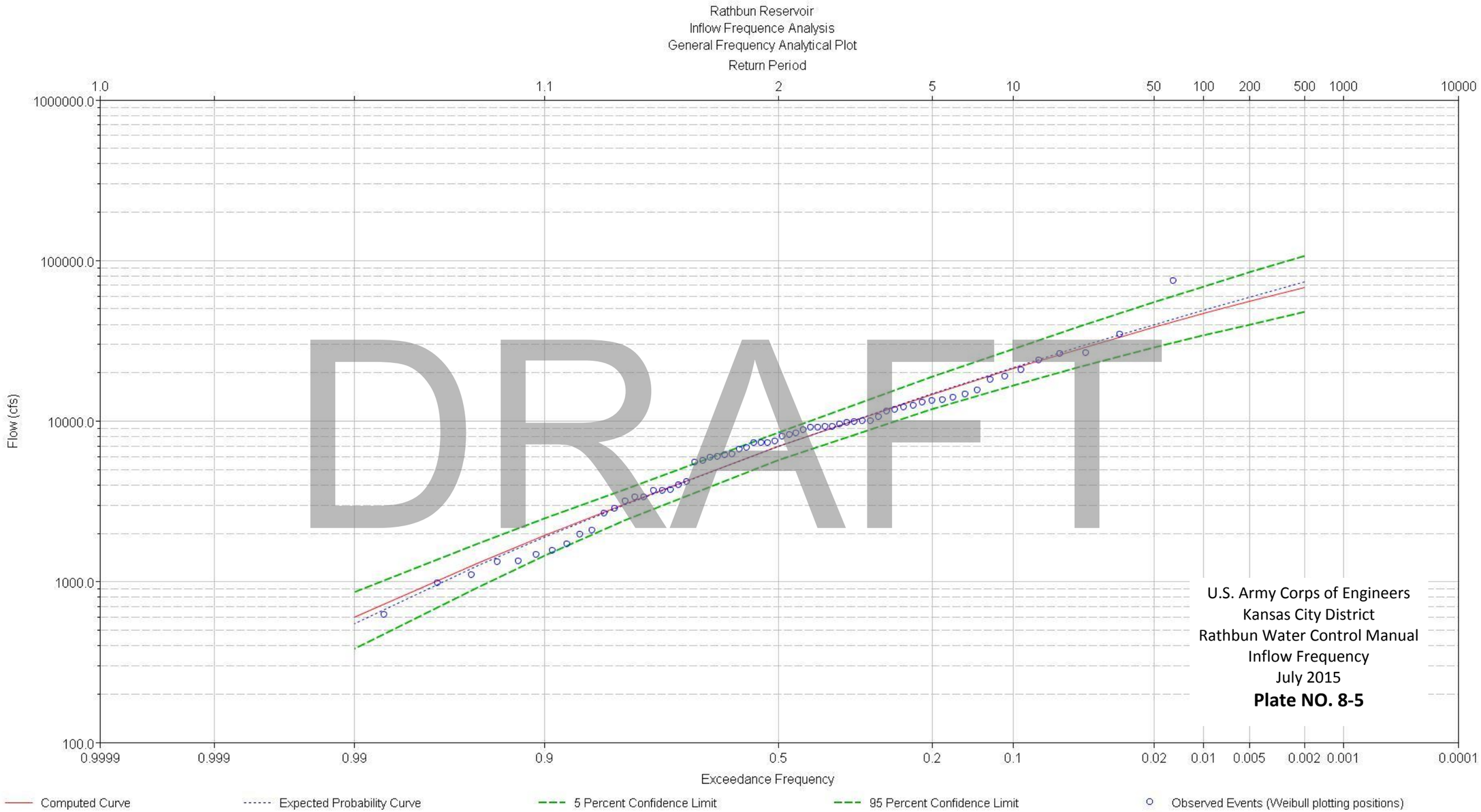

**Plate 8-6: Pool Elevation Duration Curve**

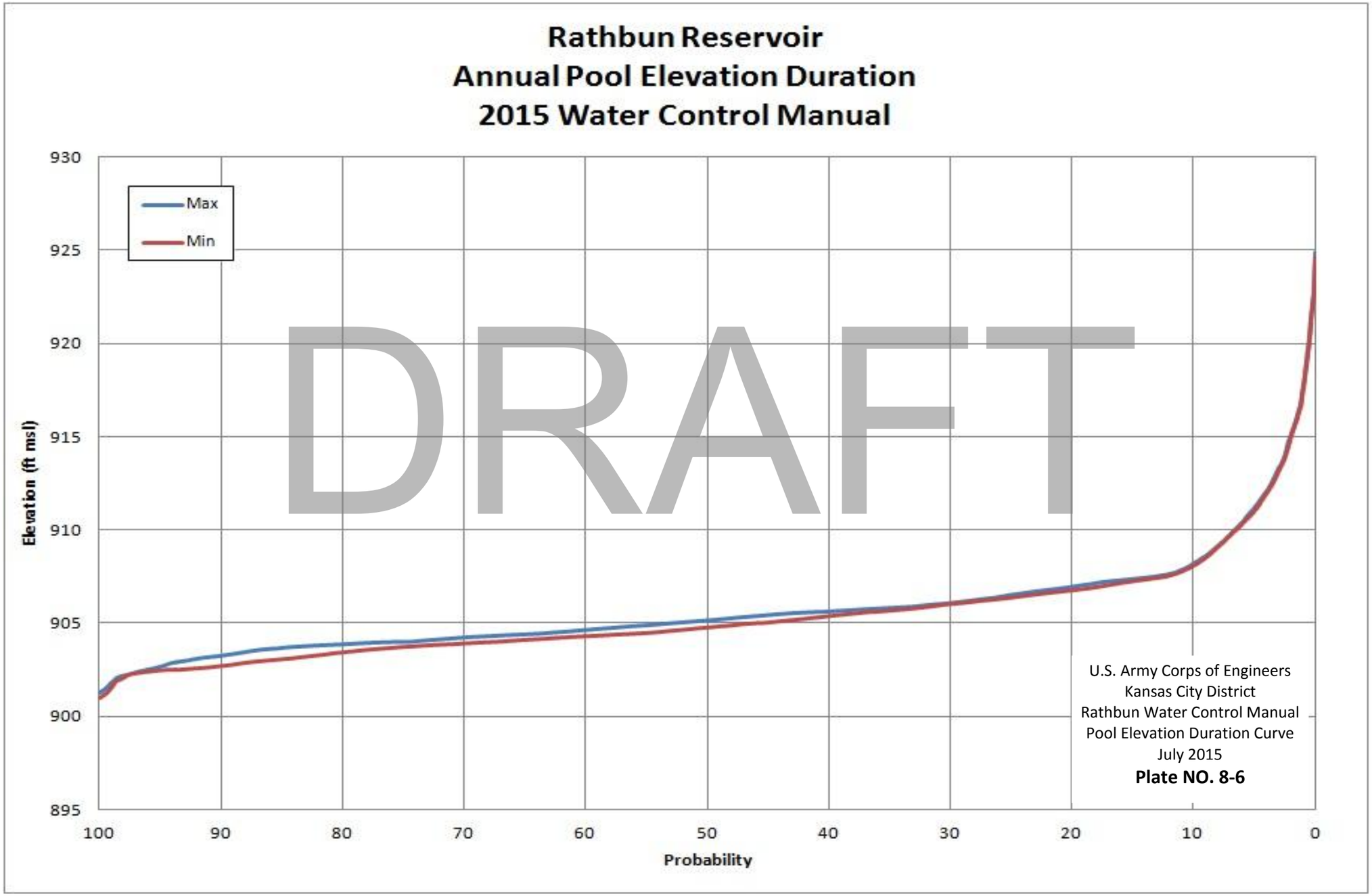

**Plate 8-7: Pool Elevation Frequency Curve**

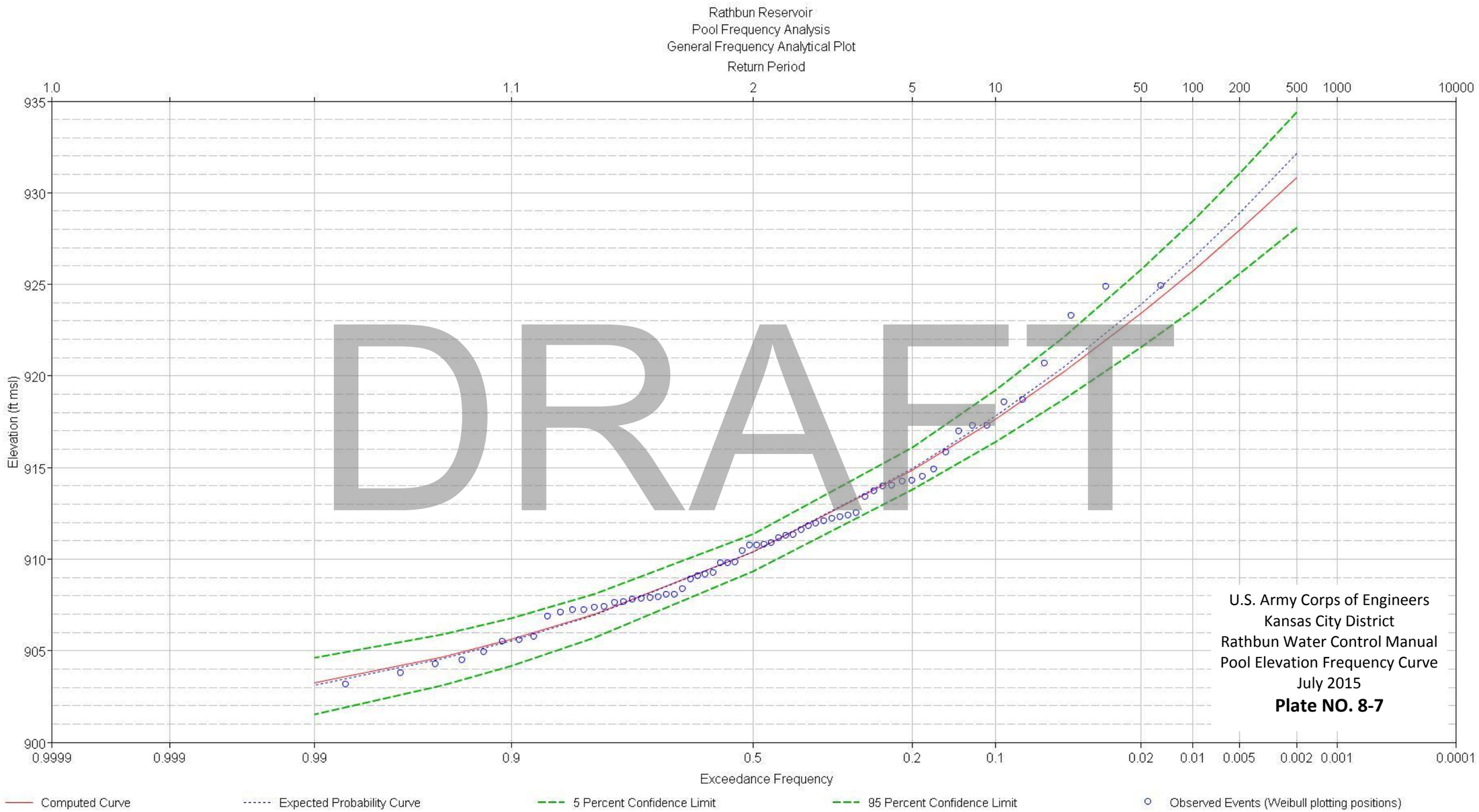

**Plate 8-8: Pool Elevations for Period of Record**

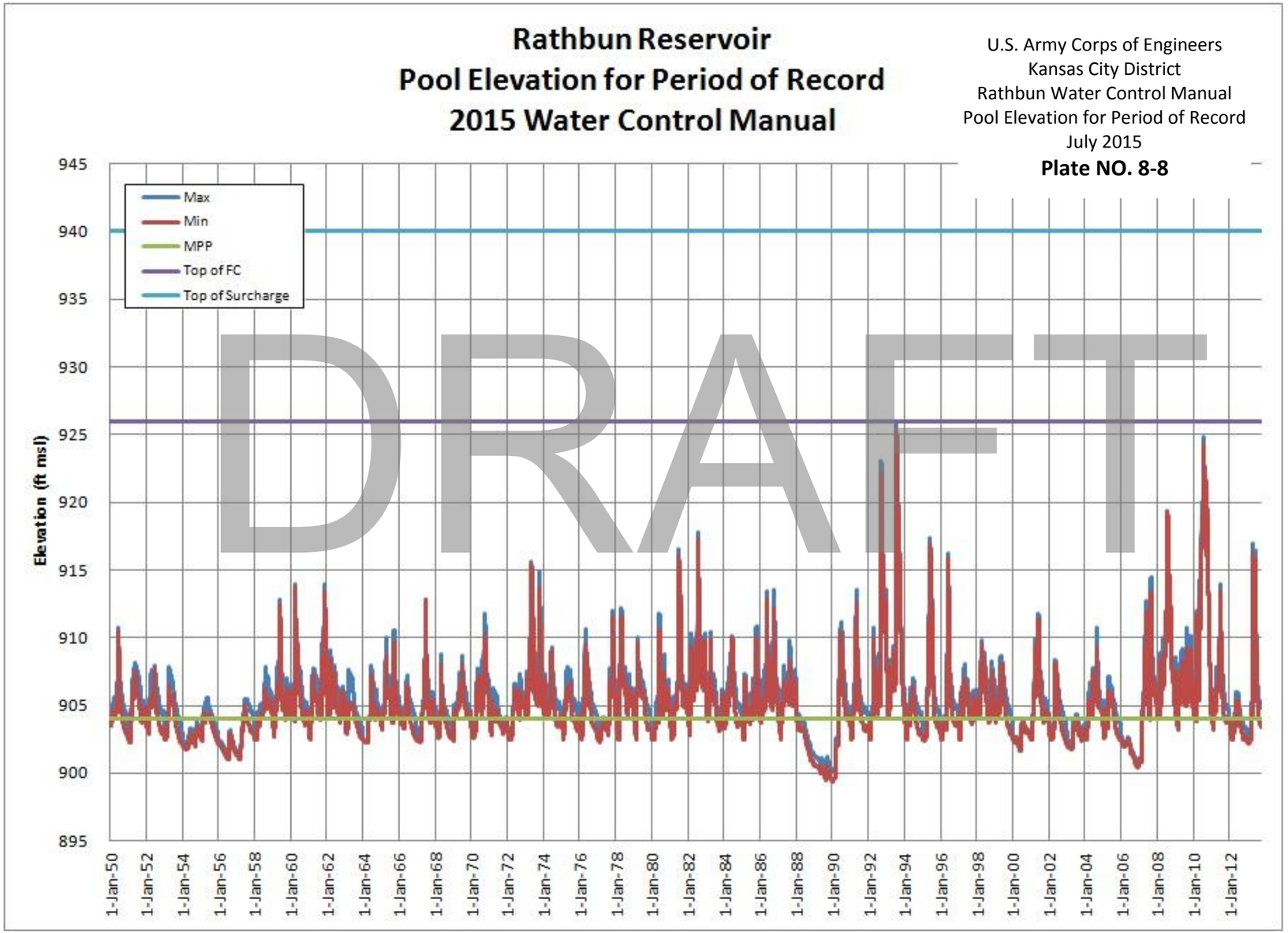

**Plate 8-9: Annual Peak Discharge**

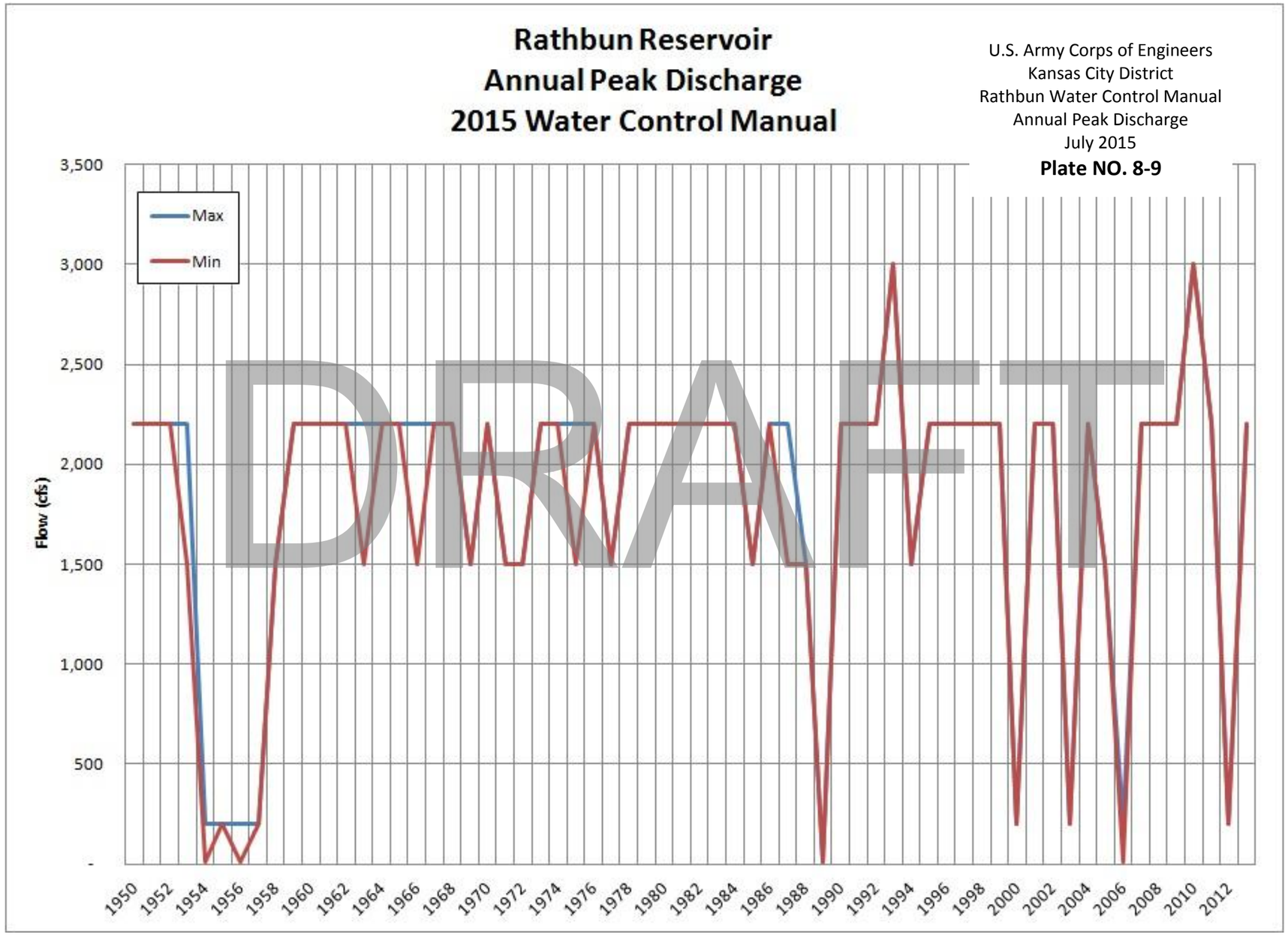

**Plate 8-10: Release Duration**

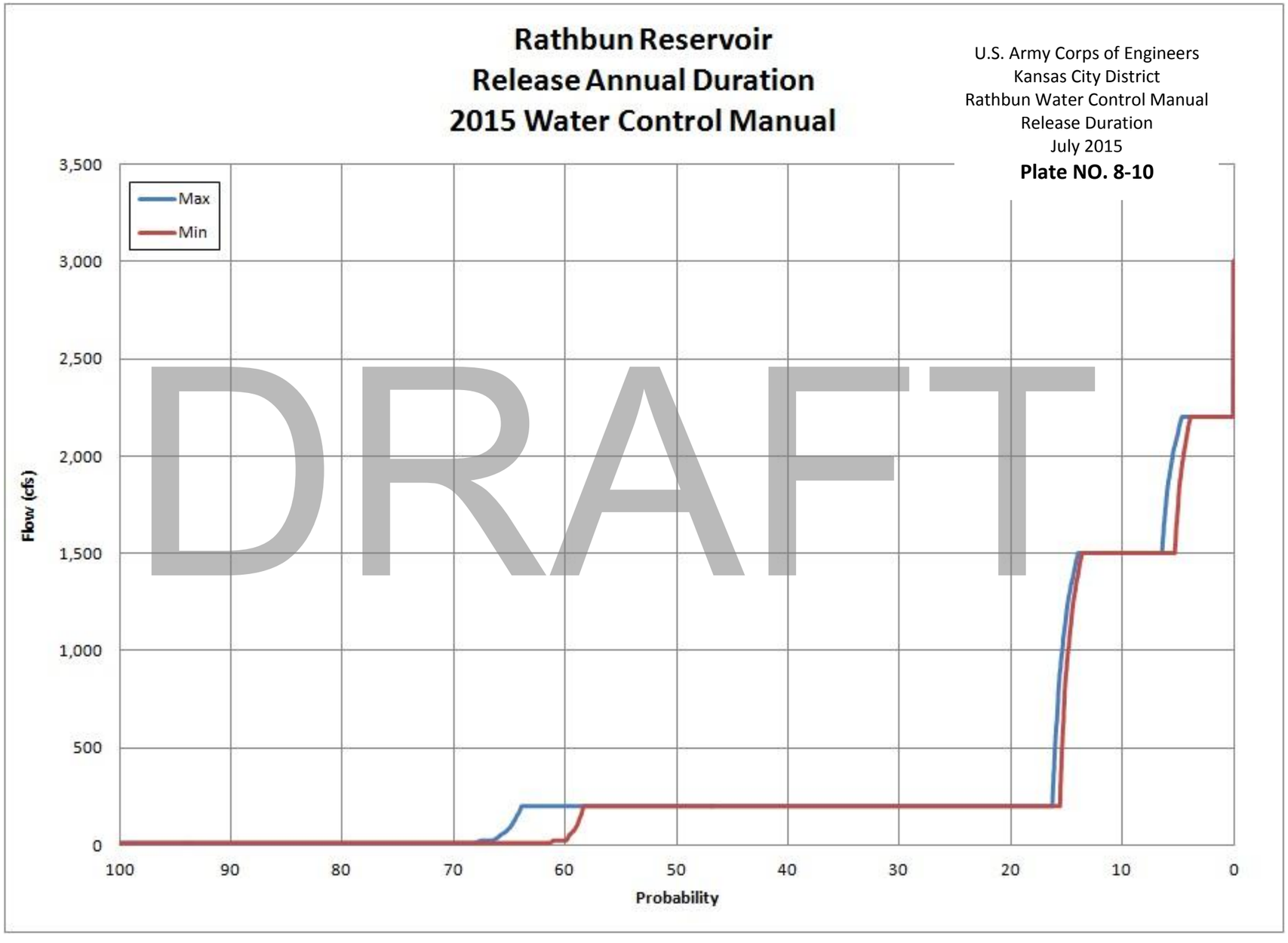

**Plate 8-11: Moulton - Annual Duration**

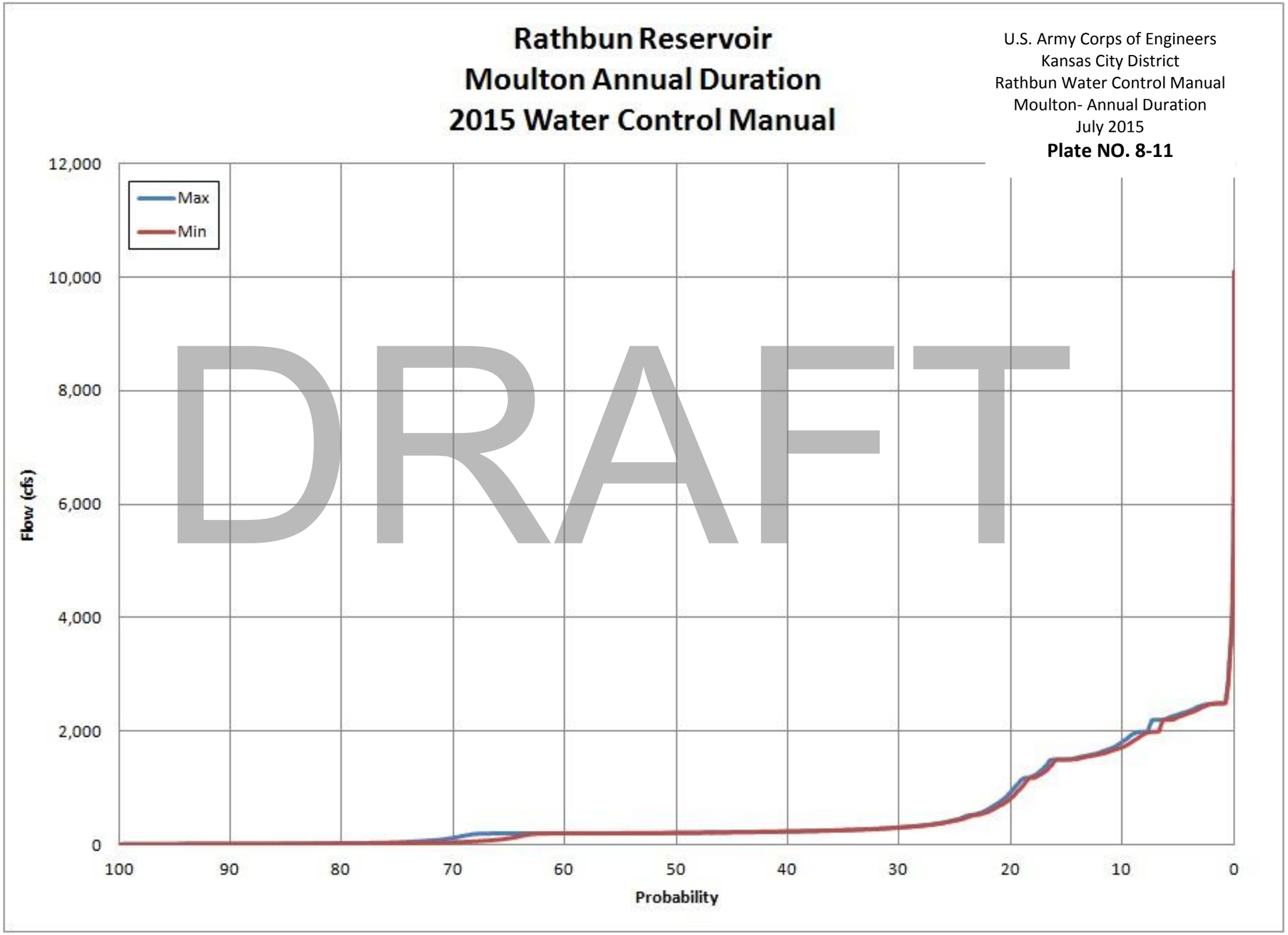

**Plate 8-12: Moulton - Q1**

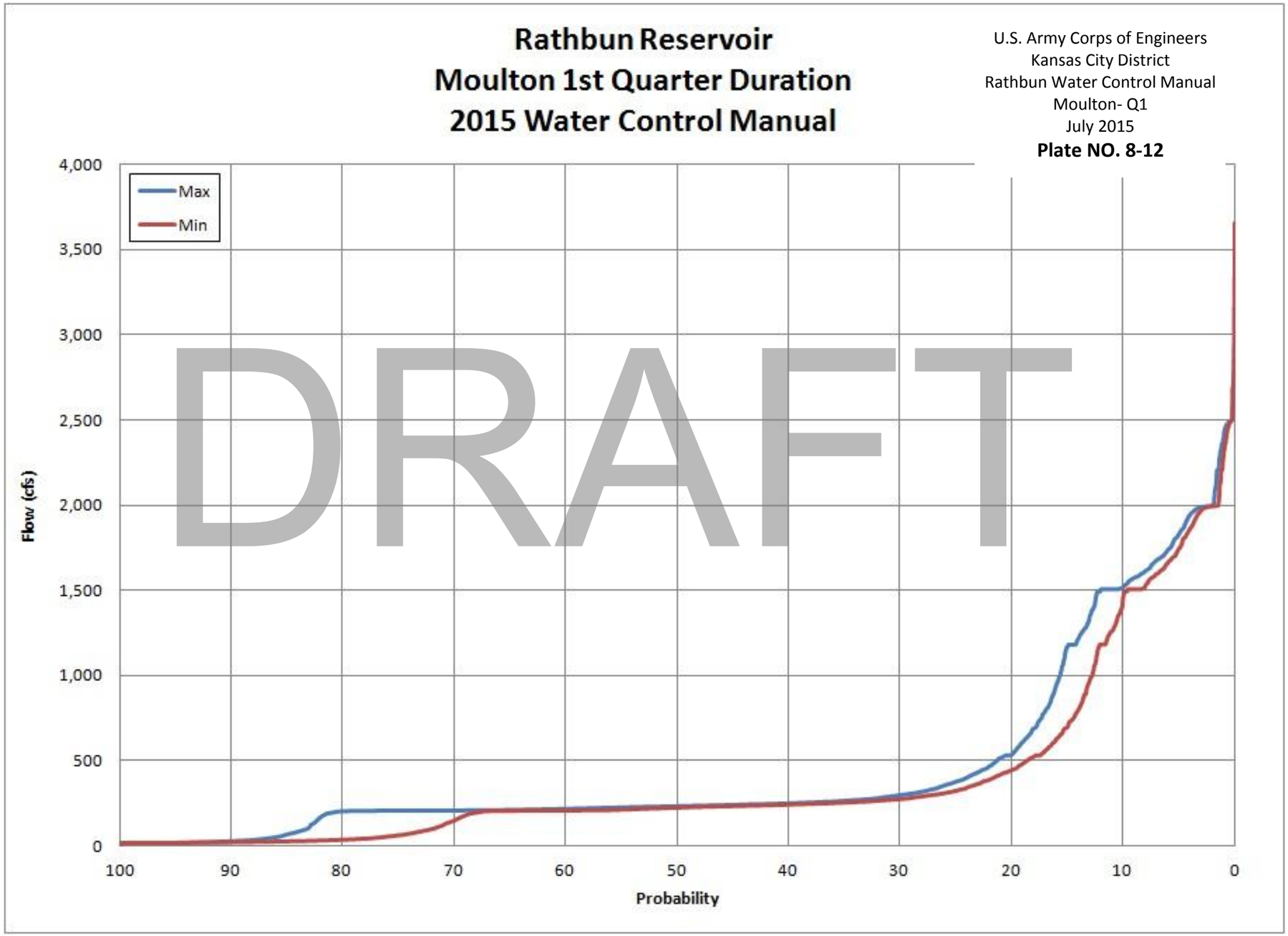

**Plate 8-13: Moulton – Q2**

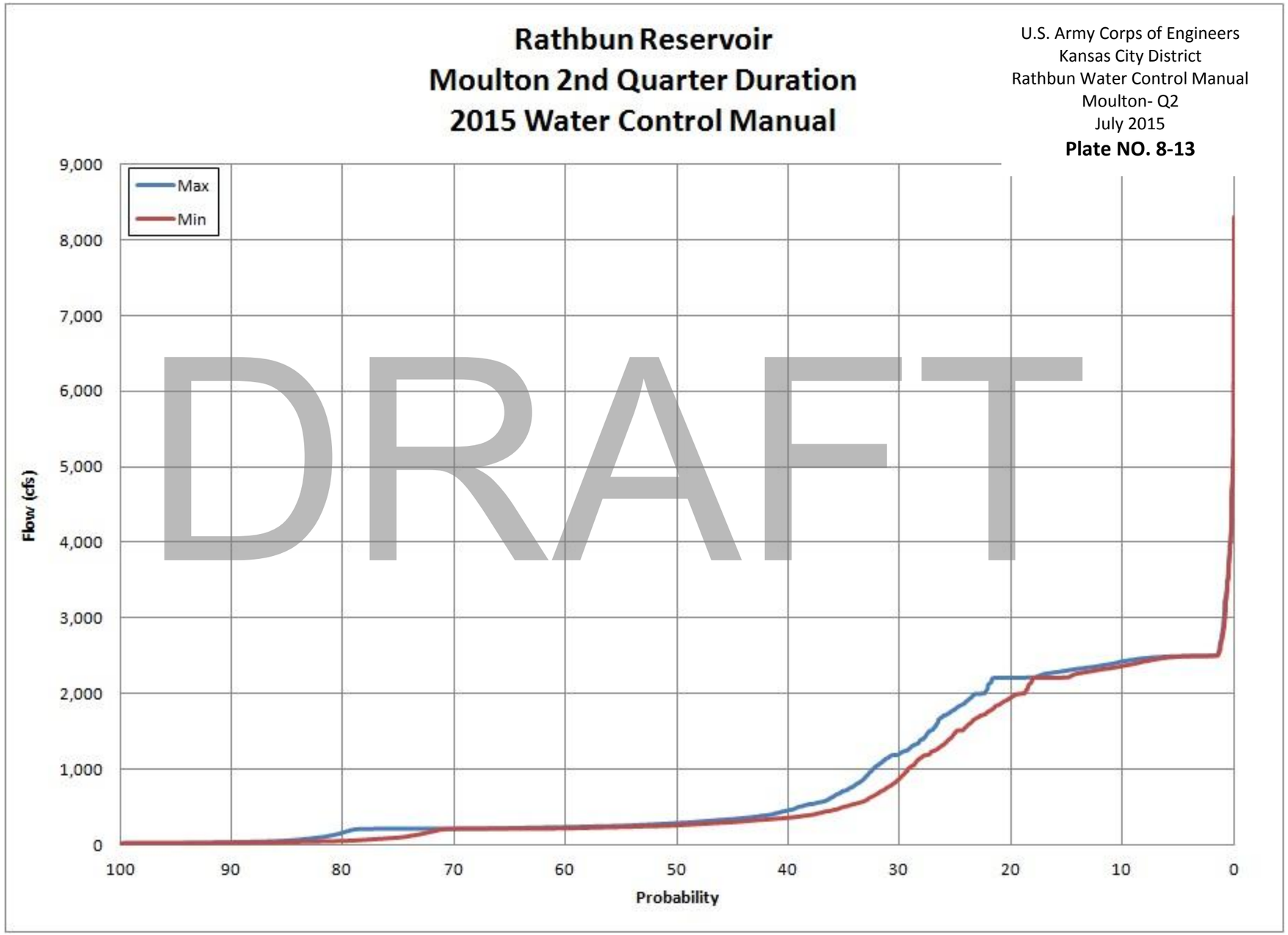

**Plate 8-14: Moulton - Q3**

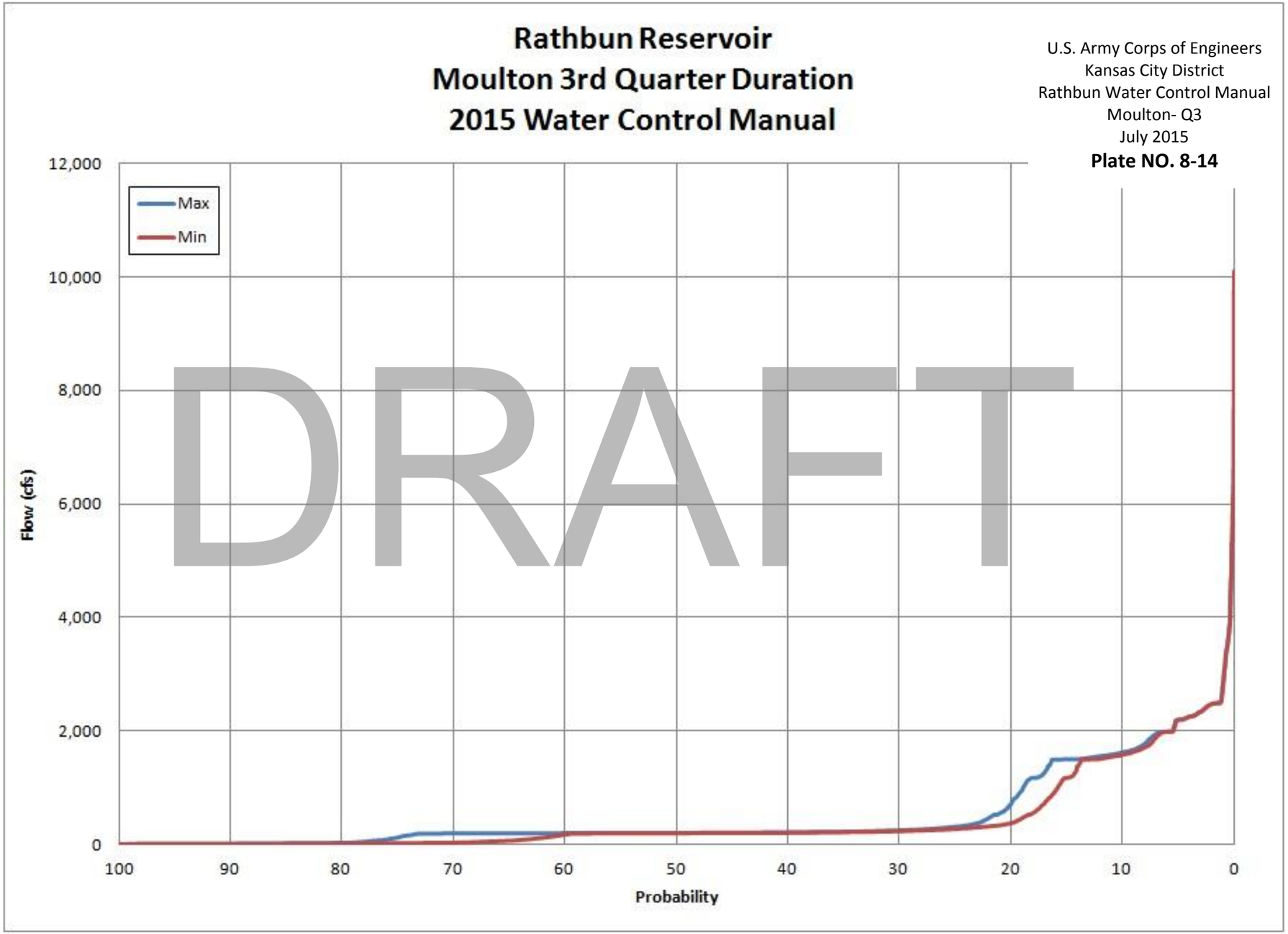

**Plate 8-15: Moulton - Q4**

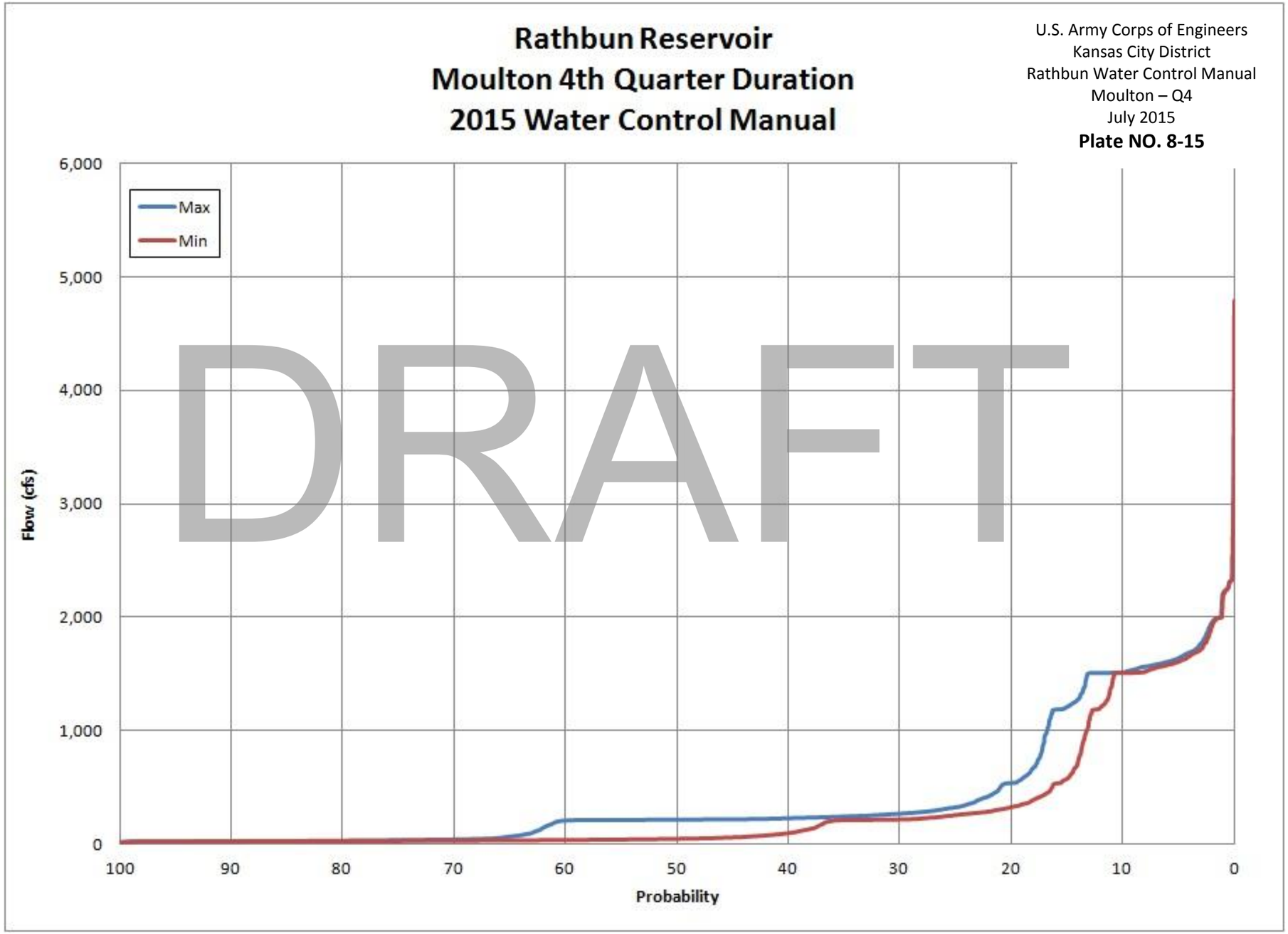

**Plate 8-16: Novinger - Annual Duration**

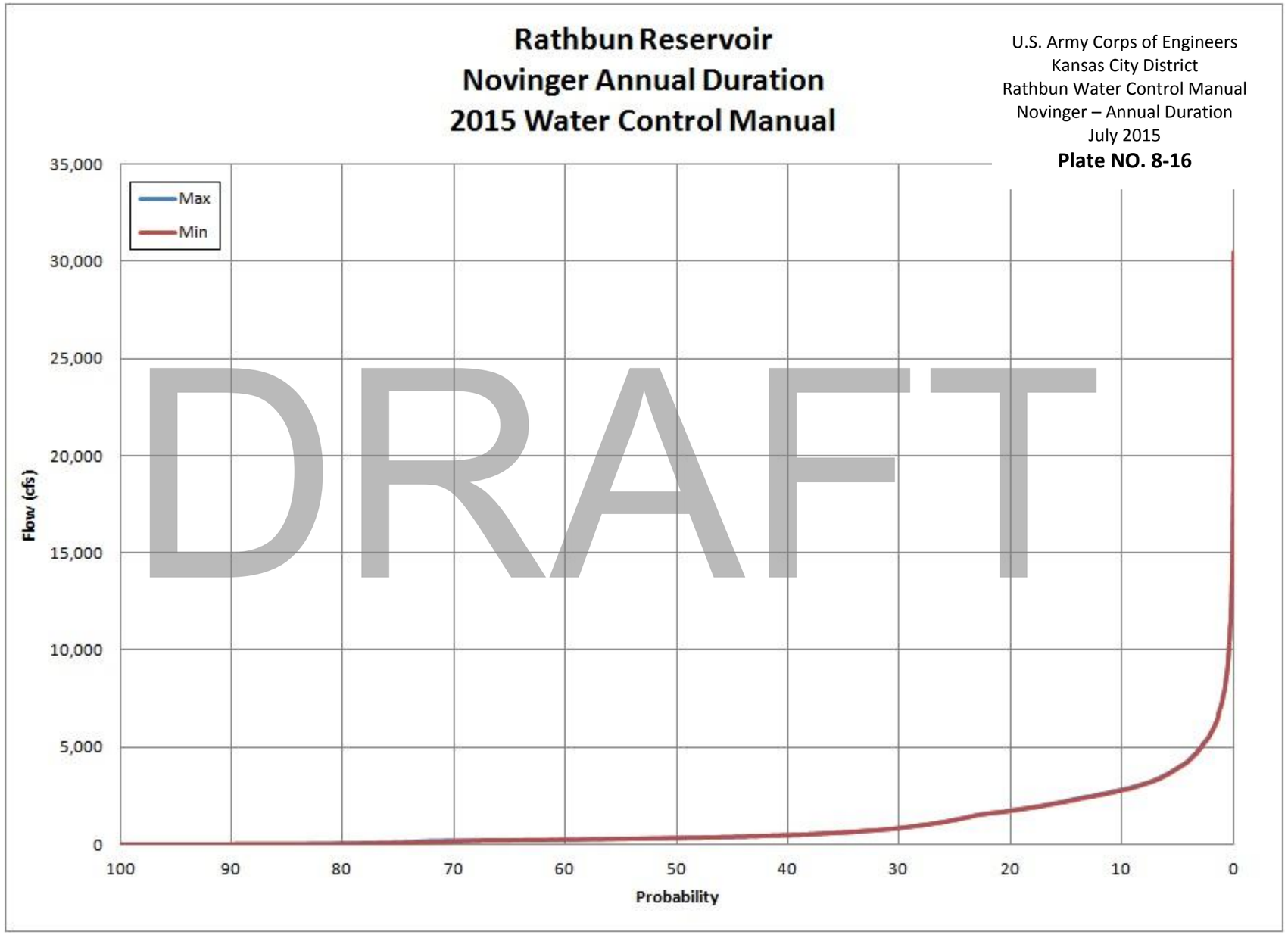

**Plate 8-17: Novinger - Q1**

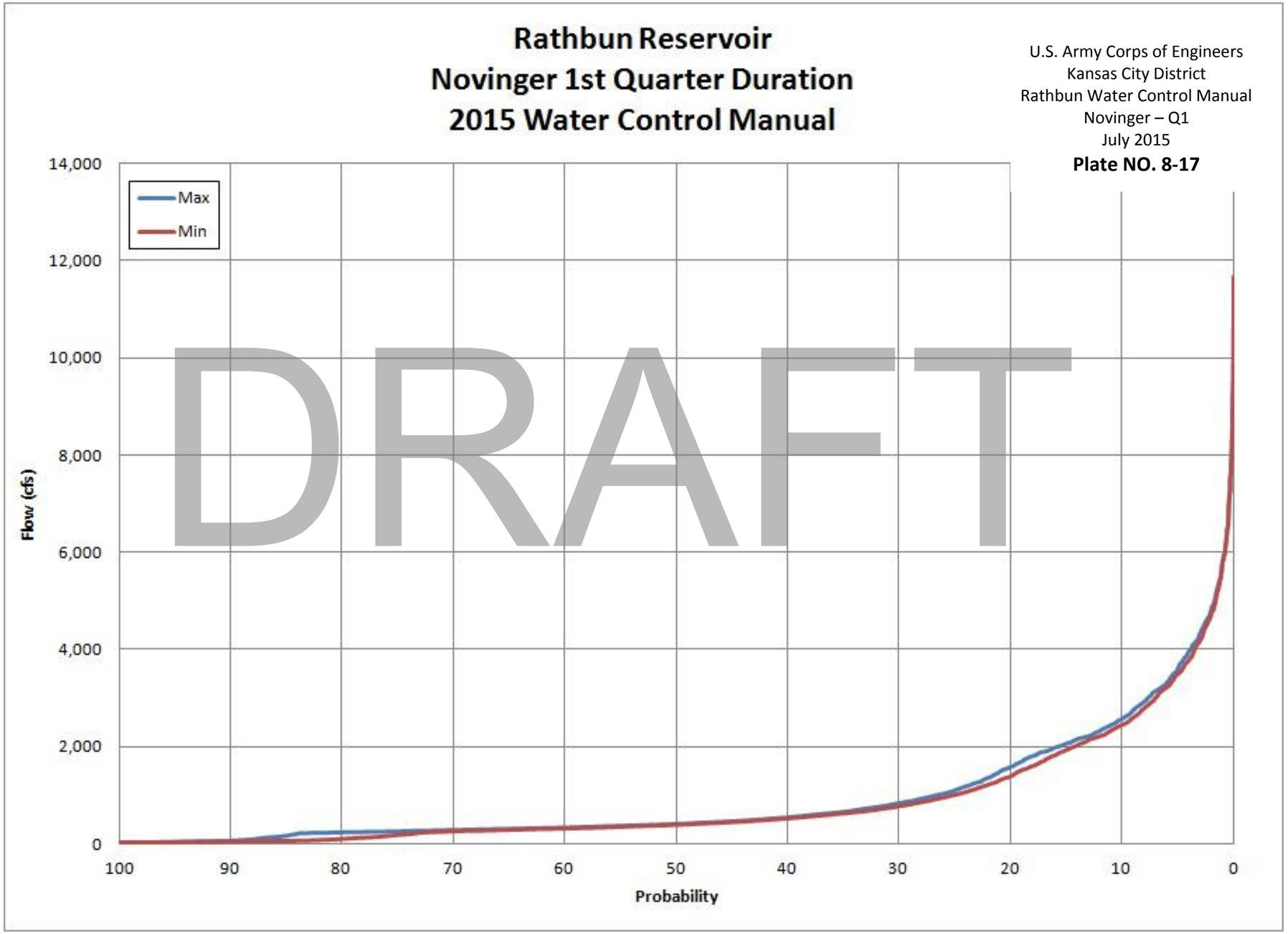

**Plate 8-18: Novinger - Q2**

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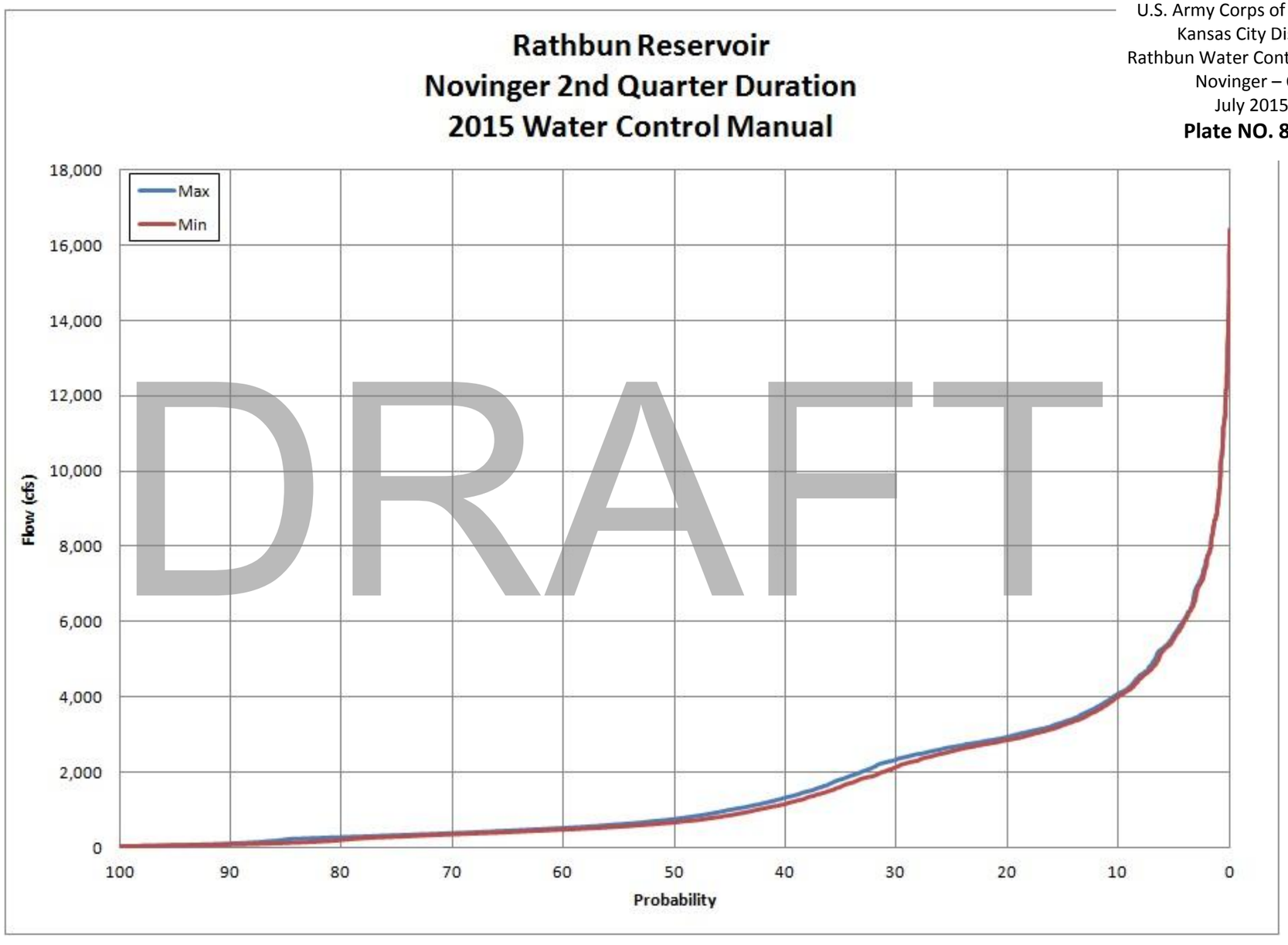
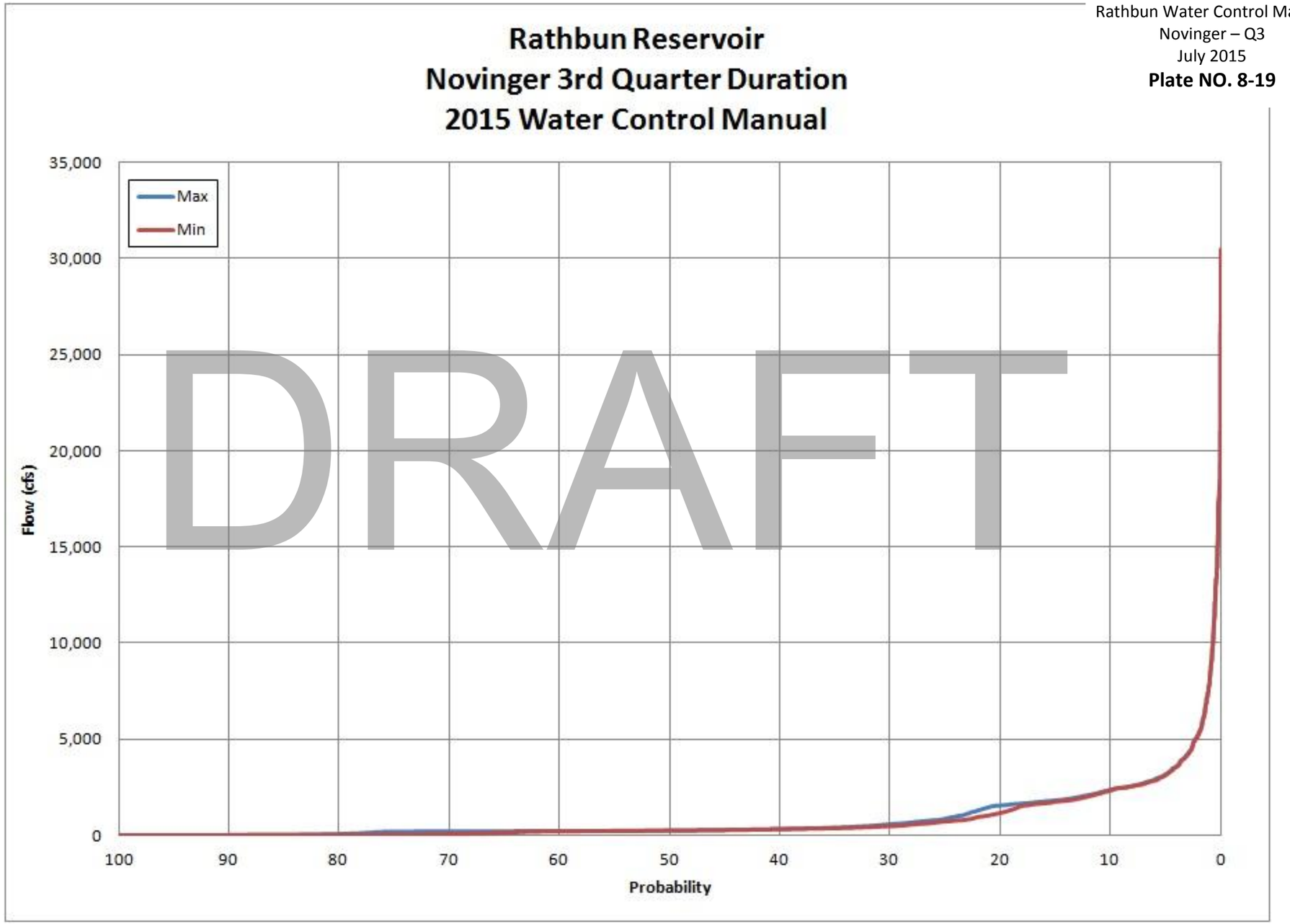
Kansas City District
Rathbun Water Control Manual
Novinger – Q2
July 2015
**Plate NO. 8-18**



U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Novinger – Q3
July 2015
**Plate NO. 8-19**



U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Novinger – Q4
July 2015
**Plate NO. 8-20**

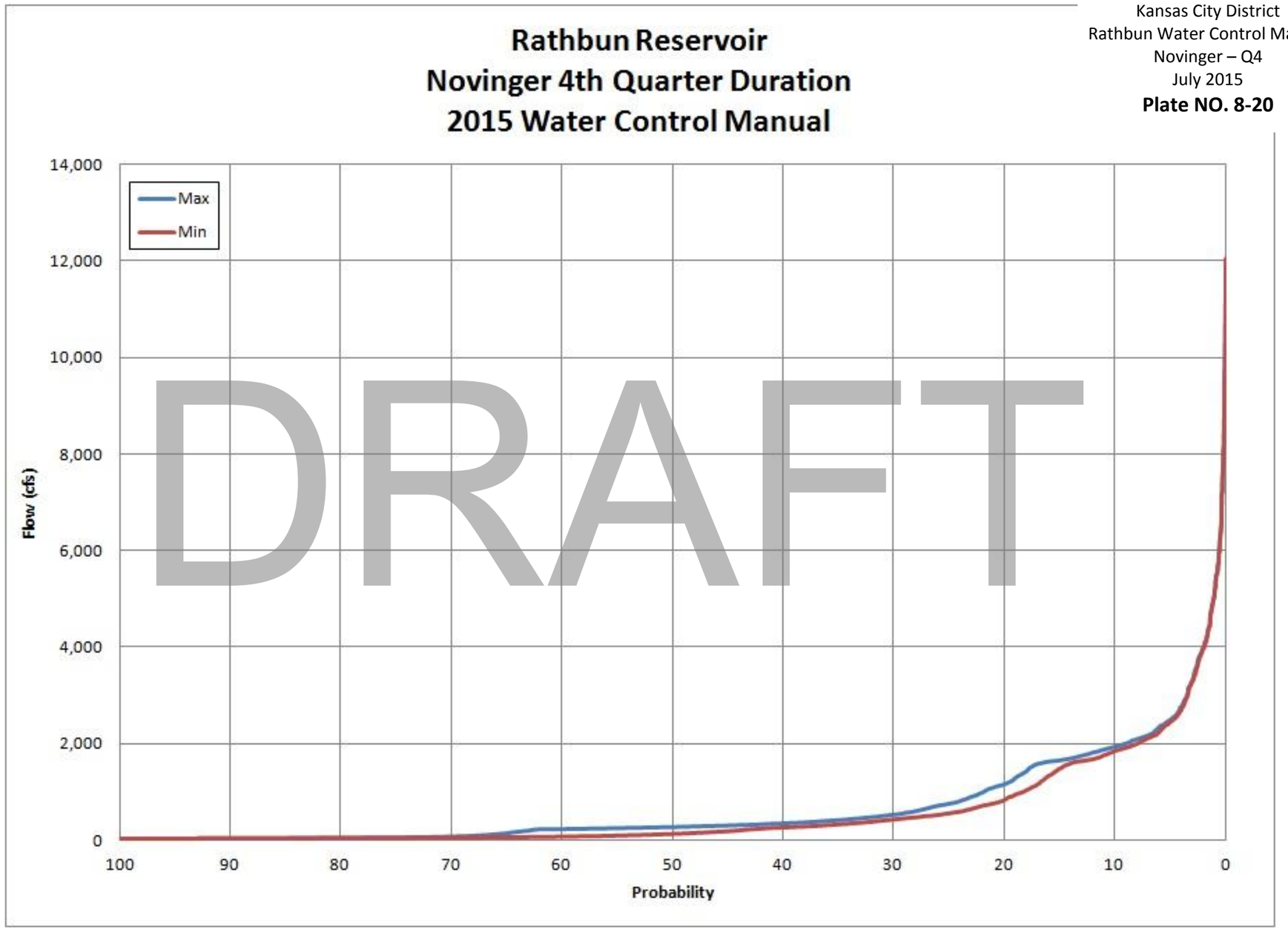


**Plate 8-21: Prairie Hill - Annual Duration**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Prairie Hill- Annual Duration
July 2015
**Plate NO. 8-21**

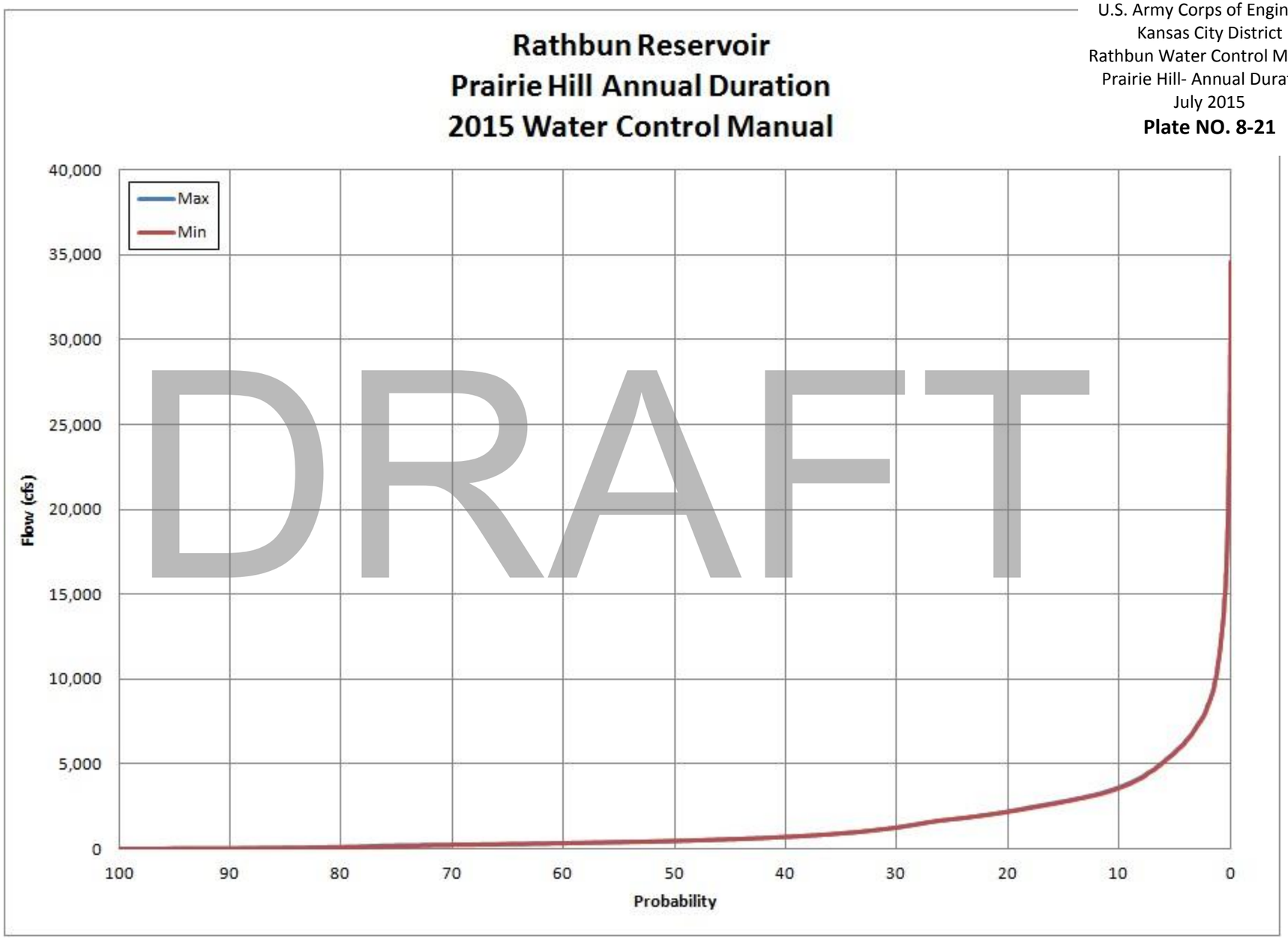


**Plate 8-22: Prairie Hill - Q1**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Prairie Hill- Q1
July 2015
**Plate NO. 8-22**

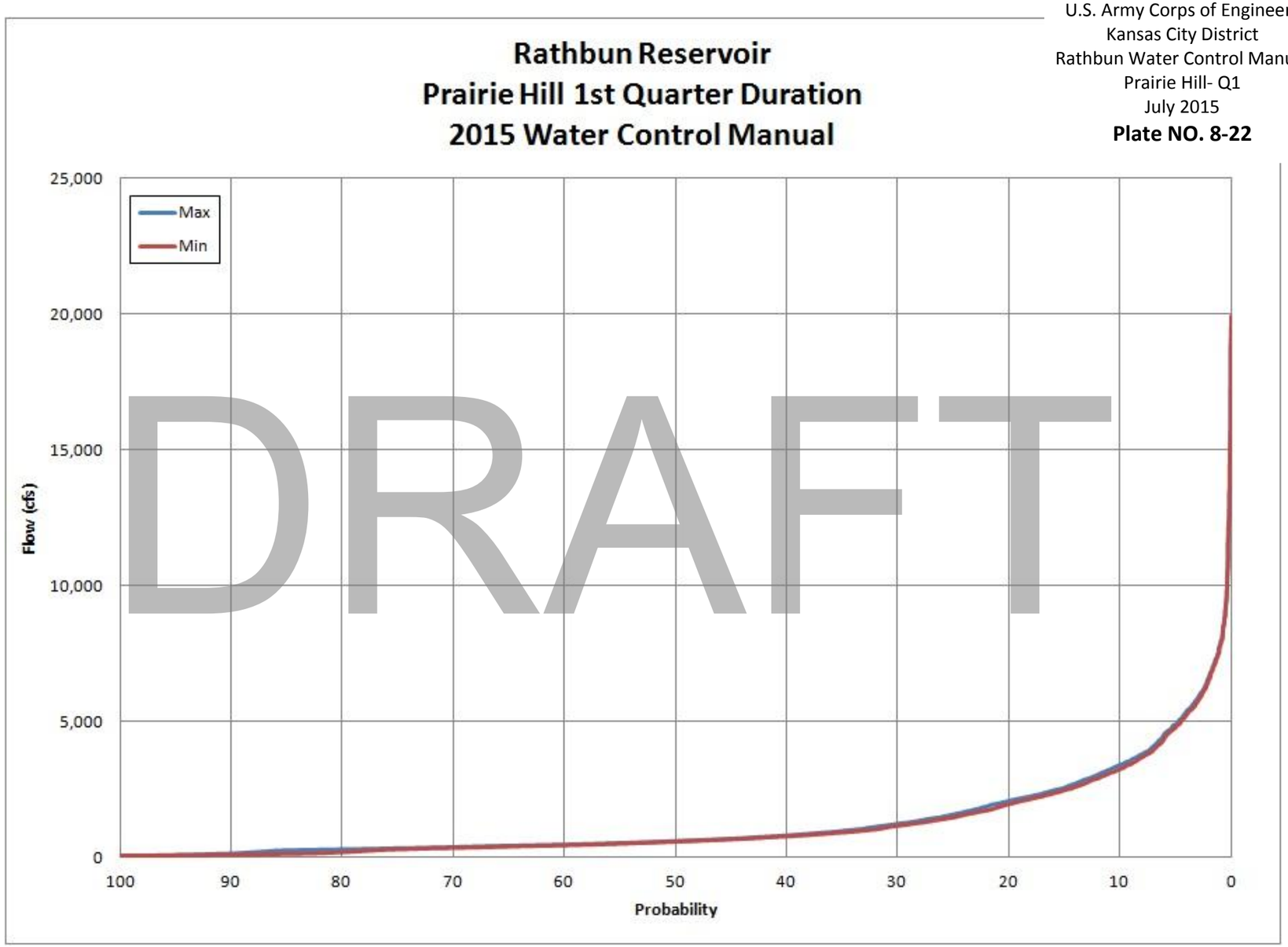
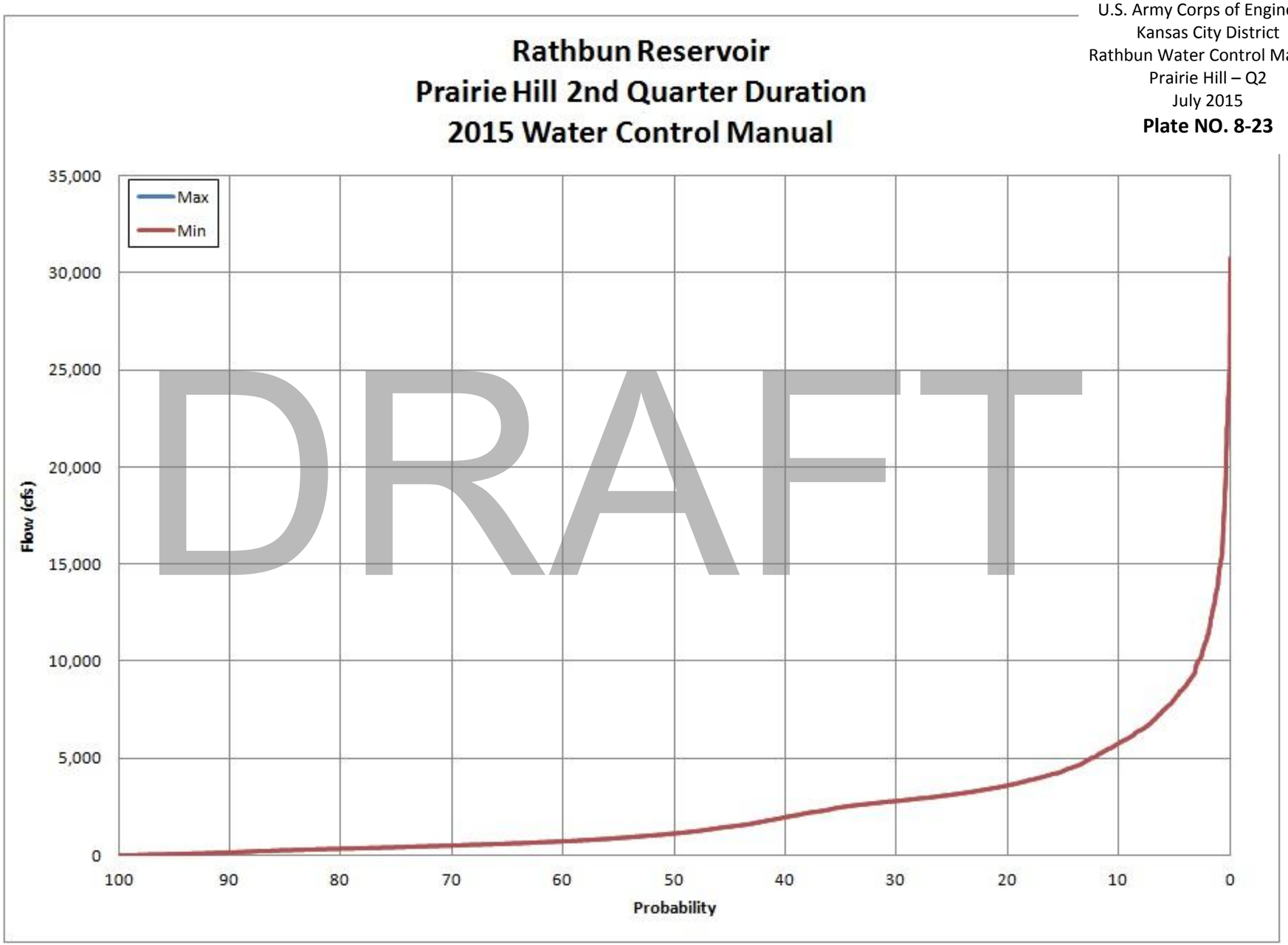
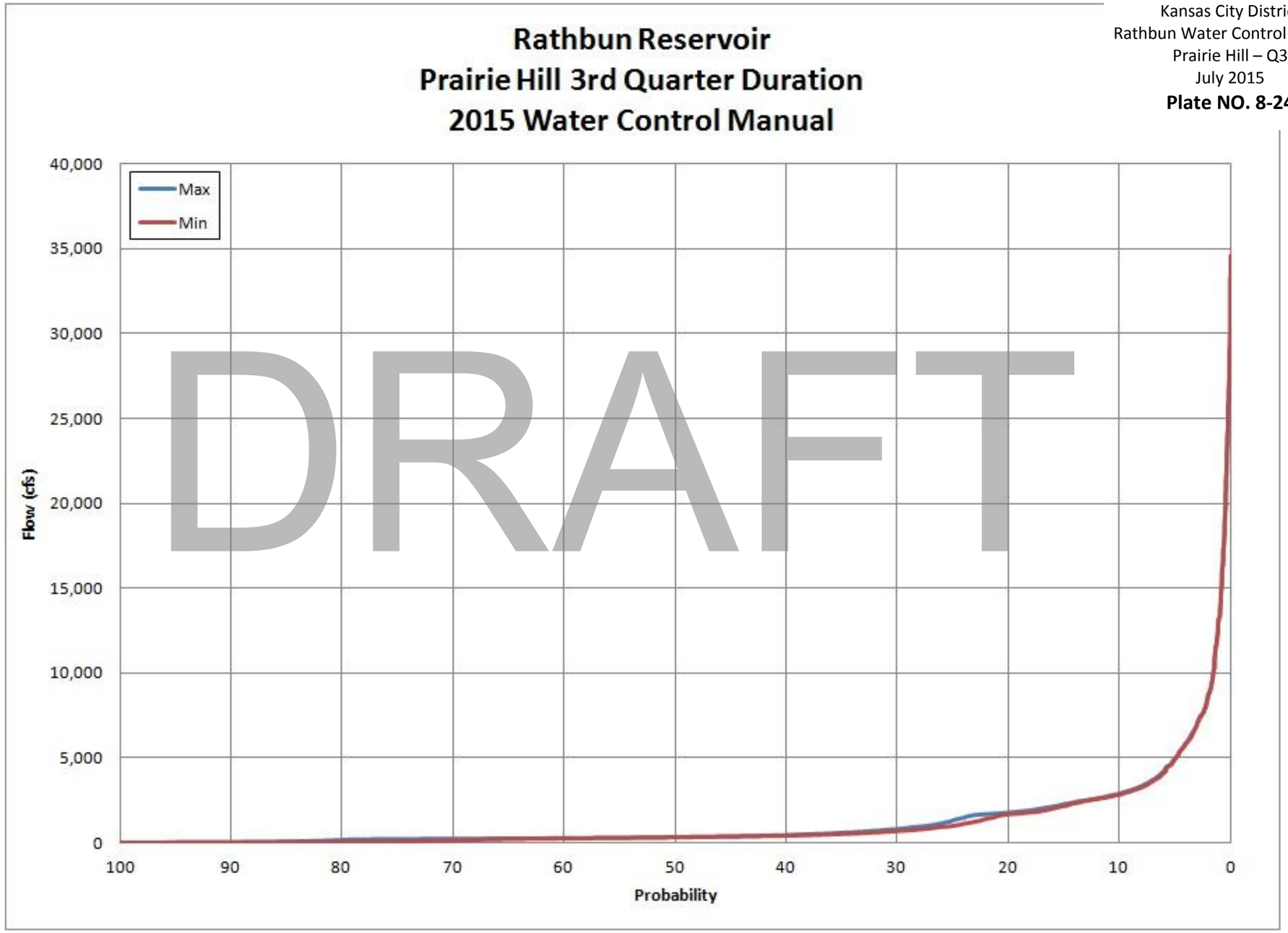


**Plate 8-23: Prairie Hill - Q2**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Prairie Hill – Q2
July 2015
**Plate NO. 8-23**



U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Prairie Hill – Q3
July 2015
**Plate NO. 8-24**



U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Prairie Hill – Q4
July 2015
**Plate NO. 8-25**

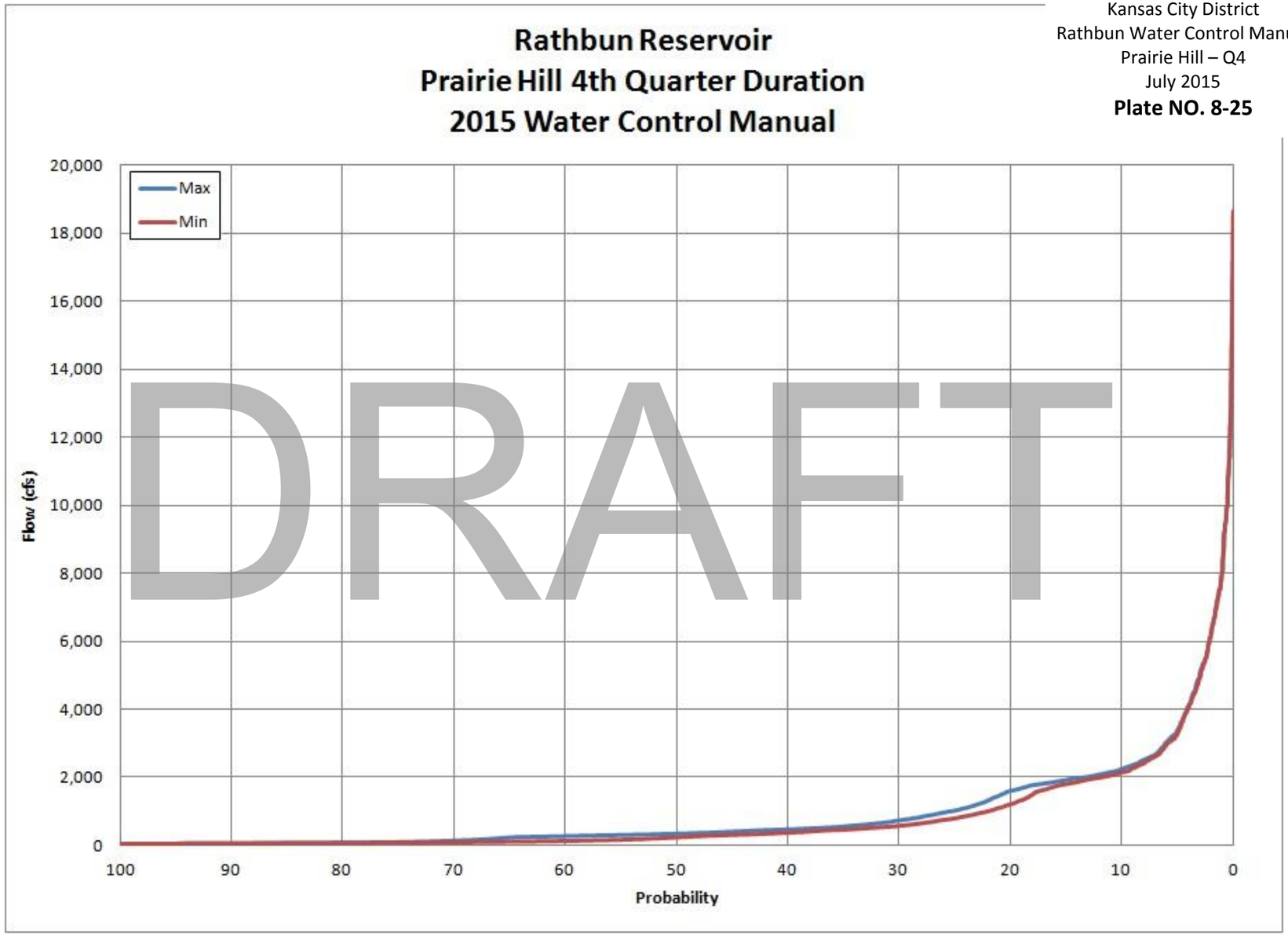


**Plate 8-26: Flood of 1993 Inflow and Pool**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Flood of 1993 Inflow and Pool
July 2015
**Plate NO. 8-26**

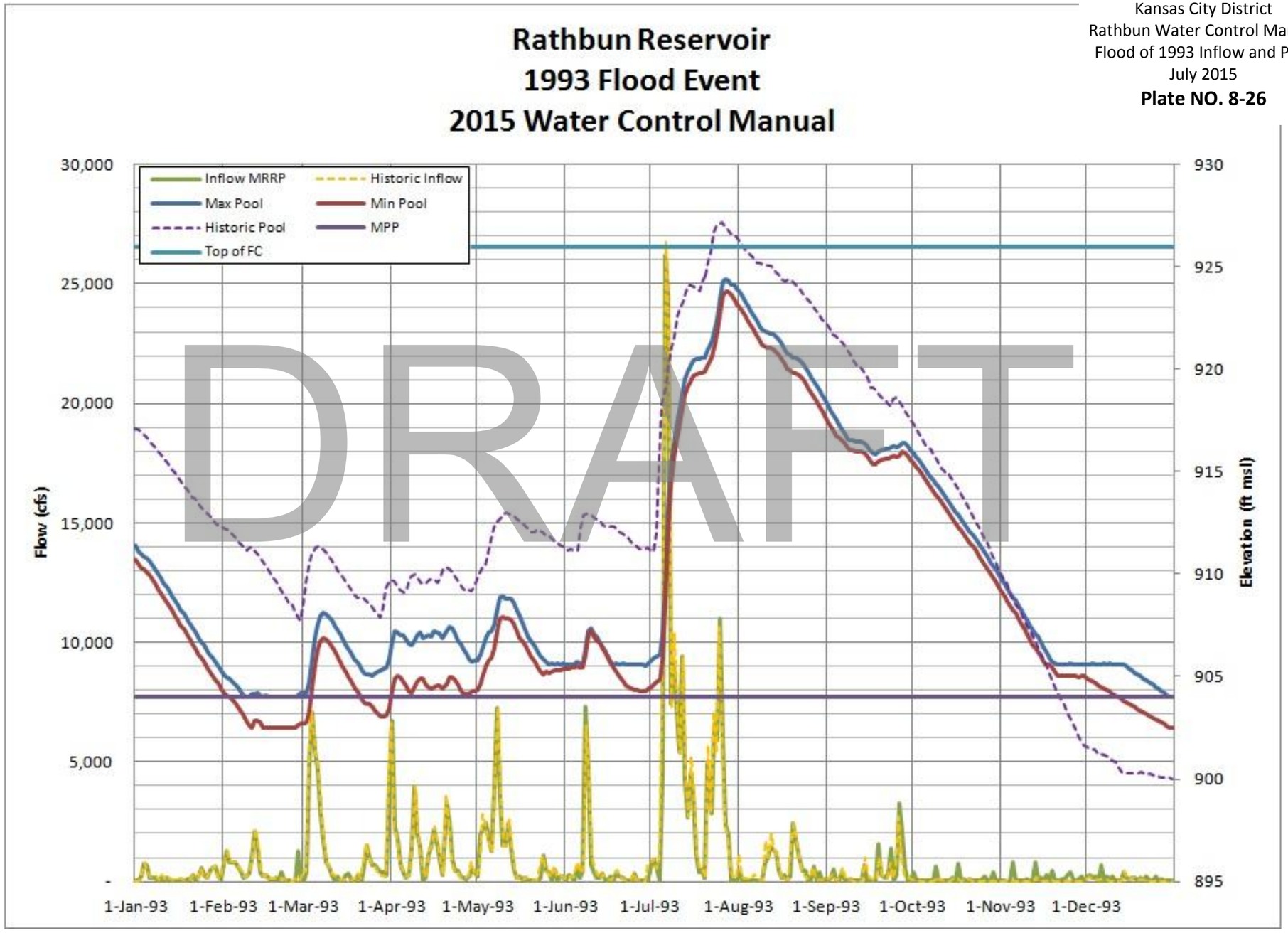
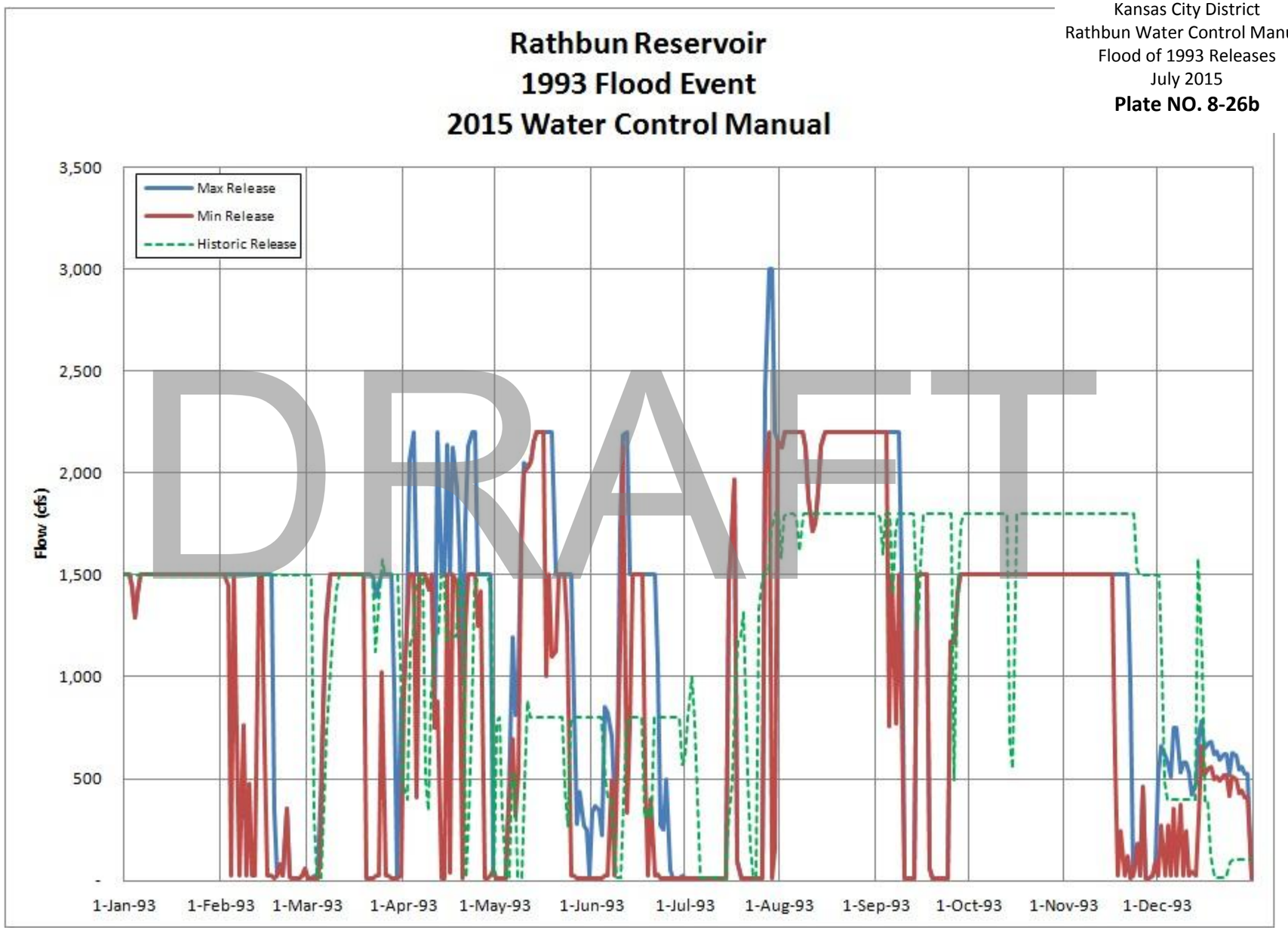


**Plate 8-26b: Flood of 1993 Releases**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Flood of 1993 Releases
July 2015
**Plate NO. 8-26b**



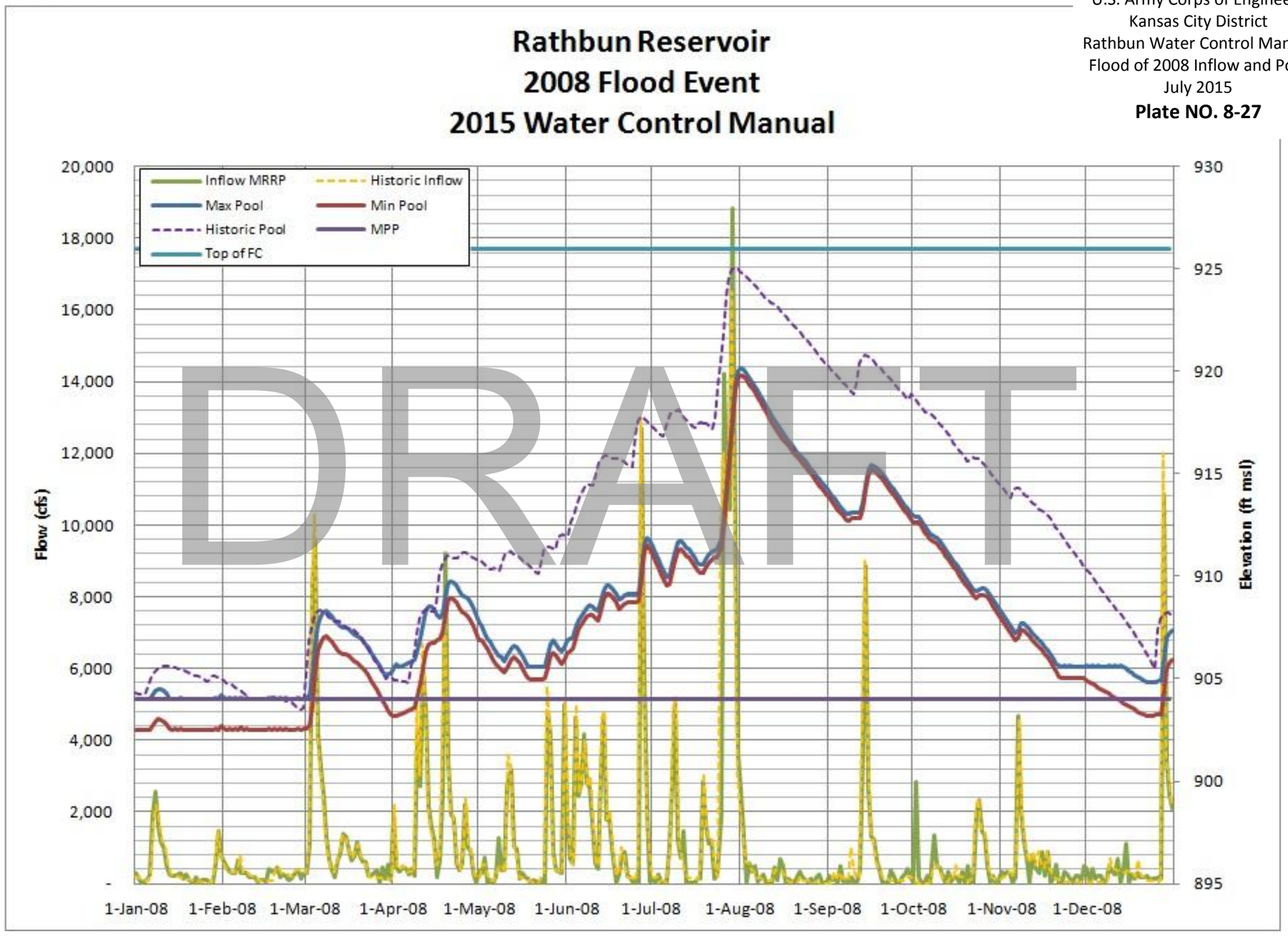

Rathbun Reservoir
2008 Flood Event
2015 Water Control Manual
Inflow MRRP
Historic Inflow
Max Pool
Min Pool
Historic Pool
MPP
Top of FC
Flow (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
Elevation (ft msl)
930
925
920
915
910
905
900
895
1-Jan-08
1-Feb-08
1-Mar-08
1-Apr-08
1-May-08
1-Jun-08
1-Jul-08
1-Aug-08
1-Sep-08
1-Oct-08
1-Nov-08
1-Dec-08
DRAFT

**Plate 8-27b: Flood of 2008 Releases**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Flood of 2008 Releases
July 2015
**Plate NO. 8-27b**

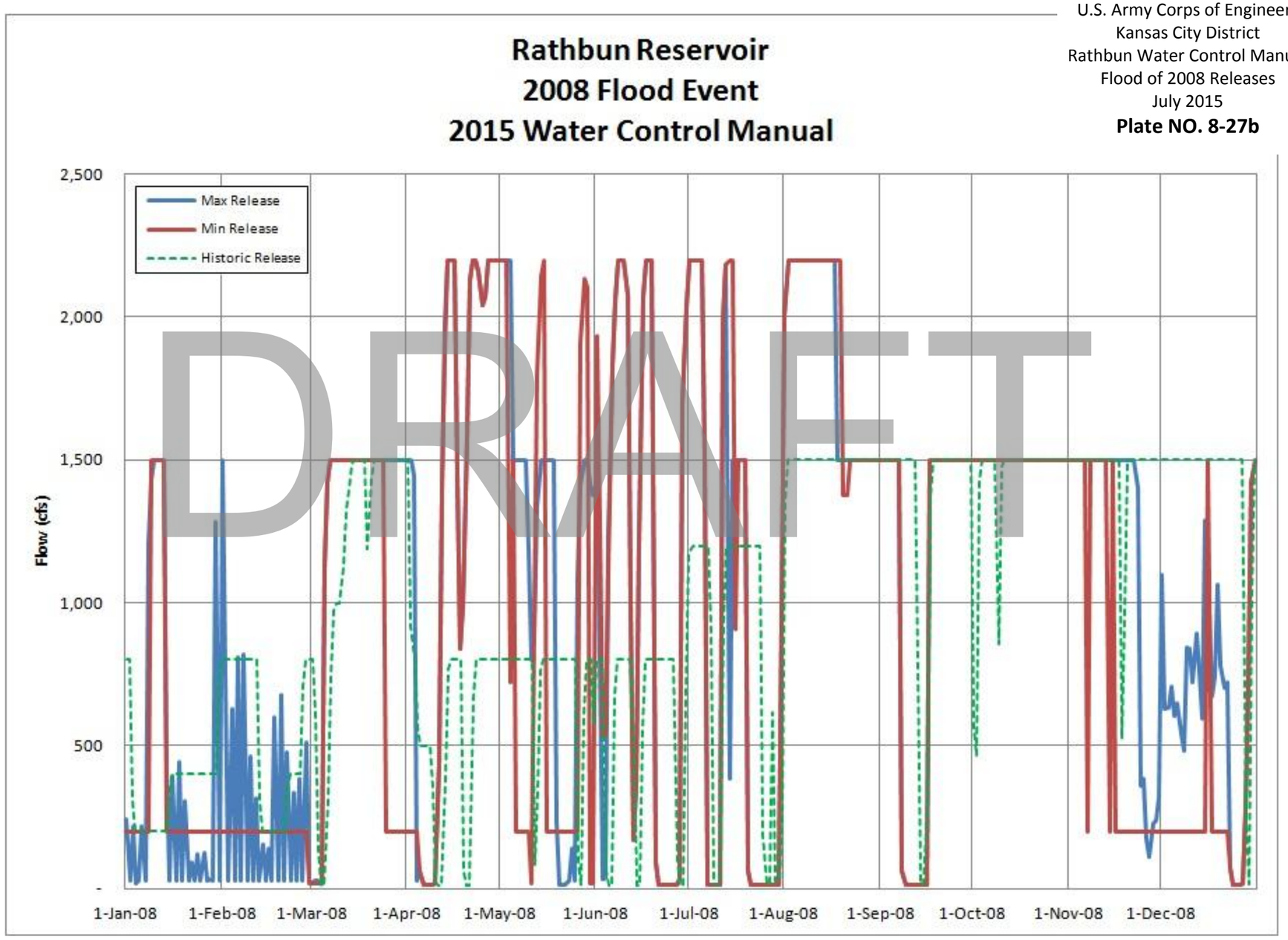


**Plate 8-28: Flood of 2010 Inflow and Pool**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Flood of 2010 Inflow and Pool
July 2015
**Plate NO. 8-28**

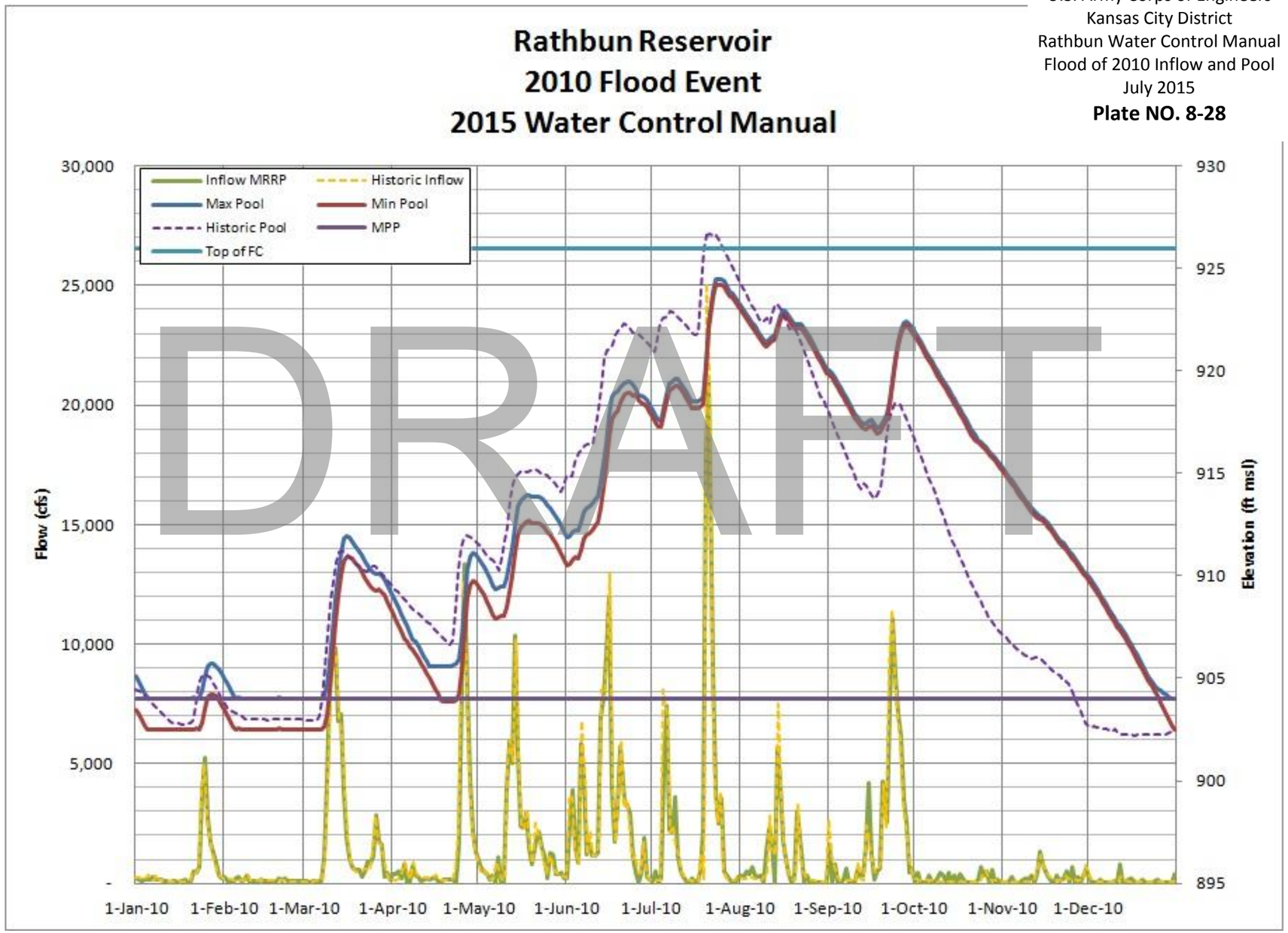
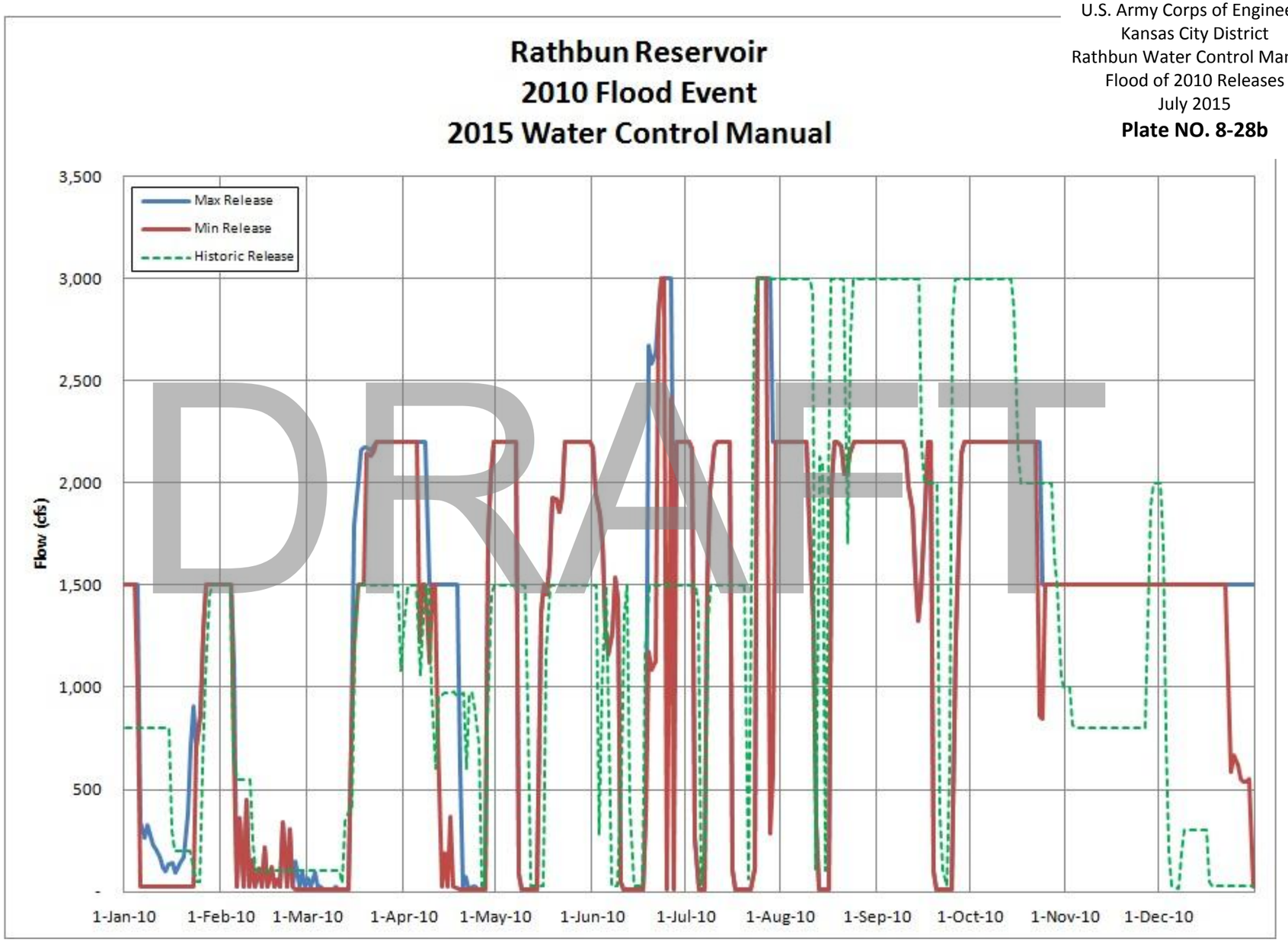


**Plate 8-28b: Flood of 2010 Releases**

U.S. Army Corps of Engineers
Kansas City District
Rathbun Water Control Manual
Flood of 2010 Releases
July 2015
**Plate NO. 8-28b**