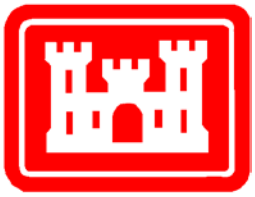
March 2016



U.S. Army
Corps of Engineers
Omaha District

Water Control Manual

JAMESTOWN DAM & RESERVOIR

JAMES RIVER BASIN

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, NORTHWESTERN DIVISION
1616 CAPITOL AVE, STE 365
OMAHA, NE 68102

REPLY TO
ATTENTION OF

CENWD-PDR 3 August 2016

MEMORANDUM FOR Commander, Omaha District, ATTN: CENWO-ED-HA

SUBJECT: Final Approval of Water Control Manual for Jamestown Dam and Reservoir, James River Basin

1. This office has reviewed the latest revisions to the subject manual and we approve this manual for use as a final Water Control Manual for Jamestown Dam and Reservoir.

2. We commend your staff for their professional and dedicated effort in updating this manual. We realize that updating a water control manual is a considerable undertaking.

3. We will retain a final hardcopy of the manual in our office for our use and will provide an electronic version of this manual to HQUSACE for Continuity of Operations (COOP) purposes.

4. If you have any questions, please contact Kevin Grode of my staff at (402) 996-3870 or kevin.r.grode@usace.army.mil.

FOR THE COMMANDER:

[redacted]
Chief, Missouri River Basin Water
Management Division

CF:
CENWO-ED-H[redacted]
CENWO-ED-H

WATER CONTROL MANUAL

JAMESTOWN DAM AND RESERVOIR

James River Basin
North Dakota

U.S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
NORTHWESTERN DIVISION
OMAHA, NEBRASKA

March 2016

Jamestown Dam and Reservoir

Looking north (upstream).

Jamestown Dam

Looking north (upstream).

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be published in a hard copy binder with 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 manual 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 nonduty hours, communication can be achieved by contacting, in the order listed, the personnel as listed in the phone directory table on pages v and vi. Pertinent data for Jamestown Dam and Reservoir is shown in the pertinent data table on page xv.

Jamesto
March 20

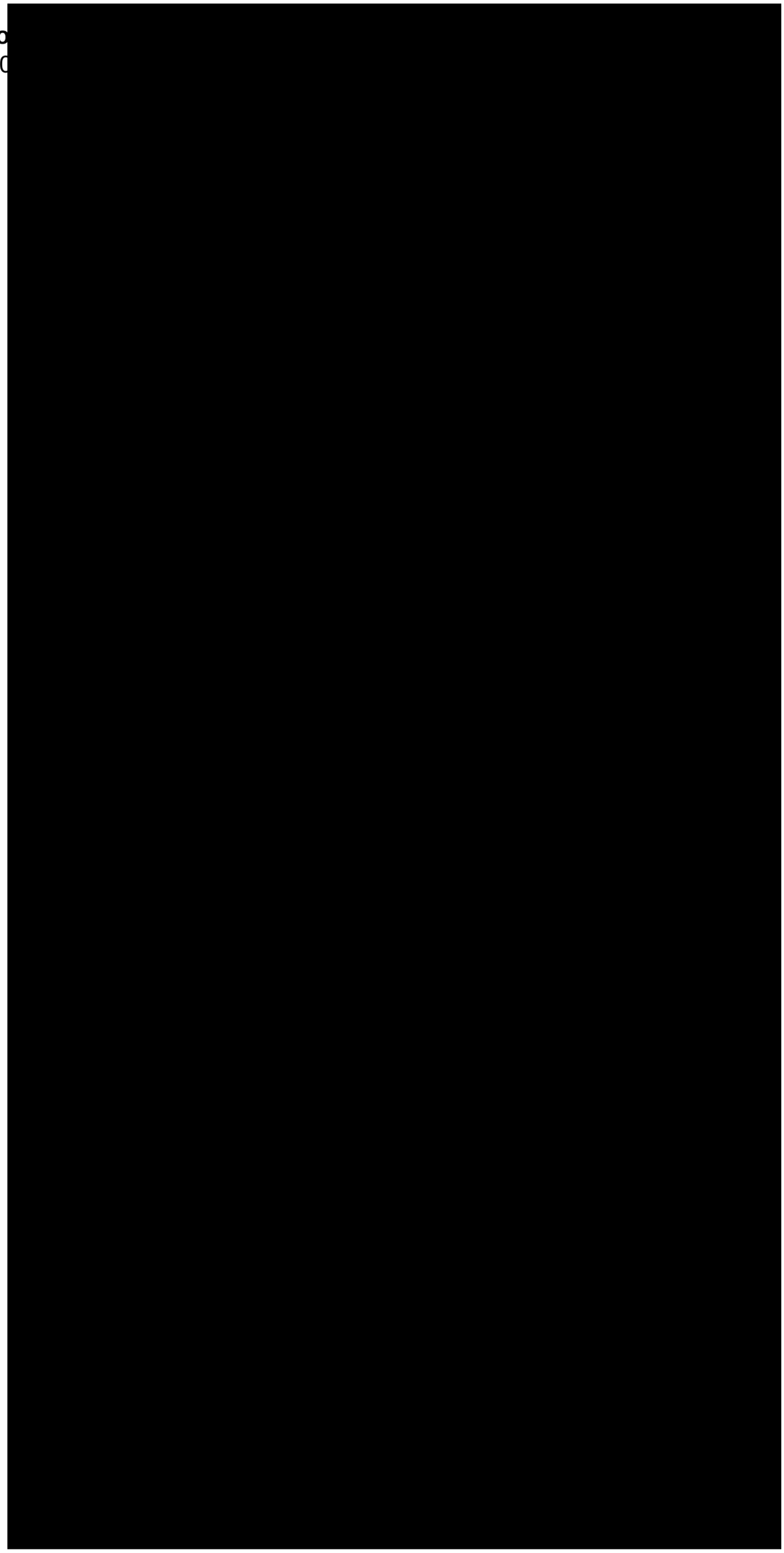


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TABLE OF CONTENTS

IV. WATERSHED CHARACTERISTICS

V. DATA COLLECTION AND COMMUNICATION NETWORKS

VI. HYDROLOGIC FORECASTS

VII. WATER CONTROL PLAN

VIII. EFFECT OF WATER CONTROL PLAN

IX. WATER CONTROL MANAGEMENT

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF EXHIBITS

Jamestown Dam and Reservoir Pertinent Data

GENERAL			
Location of Dam	1 mi. N of Jamestown, ND		
County	Stutsman		
River and River Mile	James, RM 580		
Gross drainage area (sq. mi)	1291		
Contributing drainage area (sq. mi)	1170		
DAM			
Type	Rolled earth fill		
Crest elevation (feet NGVD29)	1471.0		
Maximum base width (feet)	730		
Top width (feet)	30		
Height above streambed (feet)	81		
Length (feet)	1418		
Date of closure	February 1954		
SPILLWAY			
Location	Right abutment		
Type	Glory-hole		
Crest elevation (feet NGVD29)	1454.0		
Capacity at maximum water surface elev. 1464.4 feet NGVD29 (cfs)	2930		
Diameter of circular conduit (feet)	9.5		
Length of conduit (feet)	221		
OUTLET WORKS			
Location	Left abutment		
Diameter of circular conduit upstream of gate chamber (feet)	9.5		
Dimensions of horseshoe conduit downstream of gate chamber	13.5-ft W x 13.5-ft H		
Total length of enclosed conduits (feet)	443.75		
Elevation at which flow begins (feet NGVD29)	1400		
Number and Size of service gates	2 – 5-ft W x 6-ft H		
Number and Size of emergency gates	2 – 5-ft W x 6-ft H		
Type of service and emergency gates	Vertical slide		
Maximum discharge capacity at elev. 1428.0 feet NGVD29 (cfs)	2016		
Maximum discharge capacity at elev. 1454.0 feet NGVD29 (cfs)	2767		
RESERVOIR USE	Elevation Limits (feet NGVD29)		Capacity (af)
Surcharge zone	1454.0-1464.4		158,917
Exclusive Flood Control zone	1431.0-1454.0		190,502
Portion of Joint Use zone for flood control	1429.8-1431.0		2,680
Portion of Joint Use zone for other project purposes	1428.0-1429.8		3,582
Active Conservation zone	1400.0-1428.0		23,934
Dead Storage zone	1390.0-1400.0		292
RESERVOIR POOLS	Elevation (feet NGVD29)	Gross Area (acres)	Gross Storage (af)
Maximum Pool for Updated Inflow Design Flood	1472.8		
Top of Original Flood Surcharge Storage	1464.4	17,519	379,907
Top of Exclusive Flood Control Storage	1454.0	13,213	220,990
Top of Joint Use Storage	1431.0	2342	30,488
Top of Active Conservation Storage	1428.0	1875	24,226
Top of Dead Storage	1400.0	122	292
Streambed Elevation	1390.0	0	0
DESIGN FLOODS			
1950 Reservoir Design Flood	Storage requirement (af)		200,000
1951 Original Inflow Design Flood (IDF)	Maximum Elevation (feet NGVD29)		1464.4
1986 Probable Maximum Flood (PMF)	Maximum Elevation (feet NGVD29)		1472.8
Jamestown Dam capable of holding 91% of PMF			

ACRONYMS AND ABBREVIATIONS

af	acre-feet
CFR	Code of Federal Regulations
cfs	cubic feet per second
Corps	Corps of Engineers
CWMS	Corps Water Management System
DCP	Data Collection Platform
EAP	Emergency Action Plan
EM	Engineering Manual
ER	Engineering Regulation
°F	degrees Fahrenheit
FWA	Field Working Agreement
FWS	United States Fish and Wildlife Service
FY	Fiscal Year
GDU	Garrison Diversion Unit
GOES	Geostationary Operational Environmental Satellite
IDF	Inflow Design Flood
JRWDD	James River Water Development District
MBRFC	Missouri Basin River Forecast Center
MRBWM	Missouri River Basin Water Management
NAVD88	North American Vertical Datum of 1988
NDGFD	North Dakota Game and Fish Department
NGVD29	Feet above mean sea level, National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
NOHRSC	National Operational Hydrologic Remote Sensing Center
NWR	National Wildlife Refuge
NWS	National Weather Service
OTA	Oakes Test Area
Park Board	Stutsman County Park Board
PD	Project Datum in feet
PMF	Probable Maximum Flood
RDF	Reservoir Design Flood
RDG	Rapid Deployable Gage
Reclamation	United States Bureau of Reclamation
SOP	Standing Operating Procedures
SWE	Snow Water Equivalent
USGS	United States Geological Survey
2000 WCP Review	Jamestown Reservoir and Pipestem Reservoir, Water Control Plan Review and Update Study, July 2000
WCP	Water Control Plan
WCWQS	Water Control and Water Quality Section

I - INTRODUCTION

1-01. Authorization. This water control manual has been prepared in compliance with the following authorities and directives:

- **a.** Engineering Regulation (ER) 1110-2-8156: Engineering and Design, Preparation of Water Control Manuals, August 31, 1995.
- **b.** ER 1110-2-240: Engineering and Design, Water Control Management, October 8, 1982.
- **c.** ER 1110-2-241: Engineering and Design, Use of Storage for Flood Control Systems and Navigation at Non-Corps Projects, May 24, 1990.
- **d.** Engineering Manual (EM) 1110-2-3600: Engineering and Design, Management of Water Control Systems, November 30, 1987.
- **e.** Code of Federal Regulations (CFR), Title 33, Part 208.11, subparagraph d-4, entitled, “Water Control Plan and Manual”.

1-02. Purpose and Scope. The purpose of this manual is to outline the pertinent information and plan of regulation for Jamestown Dam and Reservoir during periods when the water levels are in the flood control zone and as set forth in the authorizing legislation. Included in this manual is information which is believed to be accurate at the time of publication and includes project authorized purposes, project description, project history, watershed characteristics, data collection and communications 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 Jamestown Dam, elevations on design drawings and reservoir levels referenced the Sea Level Datum of 1929. This was based on 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). The NAVD88 is based on a single point as the reference point from which all other elevations are measured. The NAVD88 is more accurate than the NGVD29, and takes into account variations in earth surface due to subsidence and rebounding, and distortions caused by gravity. As such, the conversion from the NGVD29 to the NAVD88 varies depending on location. As specified in ER 1110-2-8160, long-term efforts shall be programmed to transition from older datums to NAVD88.

In this water control manual, elevations for reservoir levels and project drawings are based on the Project Datum (PD), which for Jamestown Dam is close to the NGVD29. The PD has not been converted to the NAVD88 in an effort to provide elevation data that is consistent with historical events and the original design drawings for the project. To calculate the NAVD88 at Jamestown Dam, add 1.25 feet to the PD elevation. Additionally, within this manual there are elevation references at Pipestem Dam and

Reservoir also based on a PD, which is slightly different than the NGVD29. Elevations can be referenced to NAVD88 by the conversion equations are shown in Table 1-1.

Table 1-1
Conversion between Methods of Calculating Vertical Datum

Elevation Reference	Jamestown	Pipestem
Project Datum (feet)	w	x
NAVD88 (feet)	y = w + 1.25	z = x + 1.04

1-04. Related Manuals and Reports. Other pertinent information is contained in the Pipestem Water Control Manual. Table 1-2 shows a list of manuals and reports for Jamestown Reservoir. This water control manual is subject to future revision and updating as circumstances warrant.

Table 1-2
List of Project Reports for Jamestown Dam

Report	Title	Published By	Date
1	Report of the Drainage and Flood Control Investigations in the James River Valley through South Dakota	Chief Drainage Engineer of SD	1922
2	James River, North and South Dakota (published as House Document No. 83)	73rd Congress, 1st Session, Corps	1930
3	Water Supply and Sewage Disposal, James and Sheyenne River Basins, North and South Dakota	Corps	1935
4	House Document 475, 78th Congress, 2nd Session	Corps	1943
5	Senate Document 191, 78th Congress, 2nd Session (Conservation, Control, and Use of Water Resources of the Missouri River Basin)	Reclamation	1944
6	Section 9 of the Act of Congress (referred to as the Flood Control Act of 1944)	CFR	1944
7	Review Report on Flood Control for the James River and Its Tributaries, North and South Dakota	Corps, Garrison District	1945
8	Flood Control Supplement for the Definite Plan Report on Jamestown Reservoir	Corps, Garrison District	1951
9	Jamestown Dam and Reservoir Regulation Manual, Flood Regulation Only	Corps, Garrison District	1956
10	Federal Register, at Page 864, Volume 22, issue of February 12, 1957	Corps and Reclamation	1957
11	Technical Record Design and Construction	Reclamation	1957
12	Final Reservoir Regulation Manual for Flood Control for Jamestown Dam and Reservoir	Corps	1957
13	September 1968 Field Working Agreement (FWA)	Corps and Reclamation	1968
14	June 1972 FWA	Corps and Reclamation	1972

Table 1-2
List of Project Reports for Jamestown Dam

Report	Title	Published By	Date
15	January 1974 FWA	Corps and Reclamation	1974
16	July 1975 FWA	Corps and Reclamation	1975
17	Alternative Operation of Jamestown and Pipestem Reservoirs to Reduce Flooding in South Dakota	Reclamation	1987
18	Arrowwood National Wildlife Refuge, Final Environmental Impact Statement, September 1997	Reclamation	1997
19	Jamestown Reservoir and Pipestem Reservoir, Water Control Plan Review and Update Study, July 2000	Corps	2000
20	Water Control Manual Jamestown Dam and Reservoir	Corps	2008
21	James River, North Dakota 905(b) Flood Risk Management Feasibility Study	Corps	2014

1-05. Project Owner. The project owner is the U.S. Bureau of Reclamation (Reclamation), Great Plains Region.

1-06. Operating Agency. The operating agency is Reclamation, Great Plains Region. The primary Dam Tender for this project is located at Reclamation's Dakotas Area Office in Bismarck, ND. However, routine or emergency operation of the gates at Jamestown Dam can be performed by personnel at the Stutsman County Parks Office in Jamestown, ND. In addition the Dam Tender for Pipestem Dam is authorized to perform gate changes at Jamestown Dam.

1-07. Regulating Agency. Reclamation is the regulating agency for Jamestown Dam. During periods of flood control regulation, it becomes the responsibility of the U.S. Army Corps of Engineers (Corps) to regulate the reservoir according to the WCP. ER 1110-2-1400, dated September 30, 1993, assigns the Corps reservoir regulation responsibilities in the Missouri River basin to the Northwestern Division (formerly known as Missouri River Division) Engineer. This engineering regulation permits delegation of certain reservoir regulation responsibilities to the District Engineer. The responsibilities for assembly or interpretation of data affecting current reservoir regulation and for carrying out routine regulation of Jamestown Reservoir, according to plans agreed on in advance, have been delegated to the District Engineer of the Omaha District. The Omaha District Water Control and Water Quality Section (WCWQS) makes recommendations to the District Engineer concerning specific releases from the reservoirs. The Division Engineer, through the Northwestern Division's Missouri River Basin Water Management (MRBWM) office, monitors and reviews the regulation activities performed by the Omaha District.

During periods when Jamestown Reservoir is in the flood control pool it will be regulated in concert with Pipestem Reservoir as a parallel system. During these periods, regulation of the two reservoirs will be coordinated and releases prescribed as presented in the WCP in this manual and the Pipestem Dam and Reservoir water

control manual. During periods when the reservoir is not in the flood control zone Reclamation regulates Jamestown Reservoir. The address and phone number of Reclamation's Dakotas Area Office is listed below. In the event of unusual conditions during nonduty hours, please consult the Regulation Assistance Procedures on page iv and the Directory of Regulation Personnel on pages v and vi for other phone numbers.

Bureau of Reclamation
Dakotas Area Office
304 East Broadway Avenue
Bismarck, ND 58502-1017
701-250-4242

II – DESCRIPTION OF PROJECT

2-01. Location. Jamestown Dam is located on the James River about one mile north of the City of Jamestown in Stutsman County, North Dakota (Plate 2-1). Jamestown Dam is about 700 river miles above the confluence of the James River with the Missouri River on the South Dakota-Nebraska state line, and 99 river miles above the North Dakota-South Dakota state line.

2-02. Purpose. Jamestown Dam is a multipurpose feature of the Pick-Sloan Missouri River Basin Project. It impounds the James River to help regulate natural runoff for the authorized purposes of flood control, irrigation, municipal water supply, stream pollution abatement, recreation and wildlife, and potential power generation. Storage allocations include 23,934 acre-feet (af) to be used for conservation purposes, 6,262 af for joint use (flood control and conservation purposes), and 190,502 af for flood control.

2-03. Physical Components. The physical components of Jamestown Dam consist of the embankment, outlet works, and the emergency spillway shown in Plate 2-2.

a. Embankment. The embankment is rolled earth fill, is 1,418 feet long at the 1471.0 feet crest elevation, and has a top width of 30 feet (Plate 2-3). Maximum embankment height is approximately 110 feet above the lowest foundation and 81 feet above the streambed. The upstream dam face is protected by riprap up to the crest. A paved surface road crosses the dam along its crest.

b. Outlet Works. A profile of the outlet works is shown on Plate 2-4. The outlet works are located near the left abutment of the dam and consist of: (1) an unlined approach channel, (2) a concrete intake structure, (3) a circular concrete conduit 9-feet 6-inches in diameter and 292 feet long extending from the intake structure to (4) the gate chamber, which contains two high-pressure 5-feet by 6-feet hydraulically operated slide gates in tandem with two emergency gates of the same type and size, (5) a 10-inch diameter bypass line extending from emergency gate number 1 to the discharge conduit, (6) a 13-feet 6-inch concrete horseshoe conduit 152 feet long extending from the gate chamber to (7) the concrete lined chute (outlet channel) and stilling basin, and (8) an unlined discharge channel leading to the river. The sill of the intake structure is at elevation 1400 feet. Other details of the intake structure are shown on Plate 2-5. Detail drawings of the gate chamber are shown on Plate 2-6. Gates are electronically operated from the control house, which is located near the downstream end of the horseshoe conduit. The gate chamber is accessed via a 5-foot by 7-foot adit. Details of the control house and outlet channel are on Plate 2-7. Plate 2-8 shows details of the stilling basin. Provision is made in the gate chamber for possible future installation of a power penstock and for municipal water supply service to the City of Jamestown. Maximum discharge capacity of the outlet works at elevation 1428 feet (base of joint use pool) is 2,050 cubic feet per second (cfs), and at elevation 1454 feet (top of flood control pool), 2,750 cfs. Discharge rating curves for the two main gates are shown on

Plates 2-9 and 2-10. Tables of discharges for one gate opening, two gate openings, and the bypass valve are shown on Plate 2-11.

c. Spillway. The spillway is located near the right abutment. It consists of a concrete glory-hole type inlet structure with an uncontrolled crest, circular conduit 9-feet 6-inches in diameter and 221 feet long, the outlet channel and 225-foot long stilling basin, and an unlined discharge channel leading to the river. The general plan and sections of the spillway are on Plate 2-12. Details of the inlet structure are shown on Plate 2-13 and details of the outlet channel and stilling basin are on Plate 2-14. The spillway crest is at elevation 1454 feet, the top of flood control pool, and therefore does not begin to discharge until the flood control pool is full. Spillway discharge capacity at the top of the surcharge pool (elevation 1464.4 feet) is 2,930 cfs. The spillway discharge curve is shown on Plate 2-15.

d. Reservoir. At elevation 1454.0 feet, the top of the flood control pool, the reservoir has a gross capacity of 220,990 af. Storage allocations for the reservoir are shown on the Pertinent Data on page xiv and on Plate 7-2. In 2009, hydrographic and topographic surveys were conducted and a new elevation-area-capacity table and curve were developed. Area and capacity tables are shown in Exhibit 4.

2-04. Public Facilities. The Stutsman County Park Board (Park Board), by Contract No. 02-LM-60-5659, leases cabin sites, recreation sites and concessions and provides and maintains public use facilities such as beaches, picnic areas, boat ramps, camping areas, sanitation facilities, etc. The Park Board administers the contract and manages Jamestown Reservoir lands in accordance with a Resource Management Plan developed by Reclamation in cooperation with the Park Board in 2004. The Park Board also leases 70 year-round and seasonal cabin sites on Jamestown Reservoir. Proceeds from the leasing program are used for construction and maintenance of public recreation facilities.

III – HISTORY OF PROJECT

3-01. Authorization. In 1922, the Chief Drainage Engineer of South Dakota published the report entitled "Report of the Drainage and Flood Control Investigations in the James River Valley through South Dakota". The report concluded that complete flood control for the James River Basin was possible but not economically feasible. The report recommended channel clearing and cutoffs.

In 1927, the State Engineer of North Dakota submitted a report proposing that Missouri River water be diverted to the James and Sheyenne Rivers for irrigation. The plan included a dam on the James River, called Arrowwood Dam, located 9 miles north of Jamestown. Maximum storage capacity of the dam was to be 200,000 af.

In 1930, the Corps submitted a report "James River, North and South Dakota" published as House Document No. 83, 73rd Congress, 1st Session that rejected the State's 1927 plan as impracticable because costs exceeded benefits. The report concluded that the James River was not susceptible to improvements for navigation or hydroelectric power development, and that irrigation and flood control were impracticable or economically infeasible at that time. An alternative plan was recommended consisting of two smaller reservoirs, one near the site of the originally proposed Arrowwood Dam with a capacity of 32,000 af and the other near New Rockford, ND with 2,500 af capacity.

In 1935, the Corps prepared the report entitled, "Water Supply and Sewage Disposal, James and Sheyenne River Basins, North and South Dakota", for the Federal Emergency Administration of Public Works. An investigation was made of the existing water supply and sewage disposal conditions and problems in both basins. Plans were presented both for solution of individual problems by local means, and for regulation of streamflow by storage reservoirs in the upper reaches of both streams, including Arrowwood Reservoir on the James River above Jamestown and Pipestem Reservoir on Pipestem Creek.

In 1935, the Arrowwood National Wildlife Refuge (NWR) was established.

Studies were initiated in 1940 by Reclamation for the present Jamestown Dam, which was to be an integral part of the Missouri-Souris Project. The purpose of the dam and associated reservoir included conservation and regulation of return flows from irrigation in the Crosby-Mohall area transported to the James River for downstream irrigation, with storage space provided for flood control. A "technically sound" plan of improvement for flood control was presented. Key features included Jamestown Dam, a dam on the Elm River, and improvement of the James River channel from Columbia, SD to the mouth. The report recommended that the plan of improvement for the Missouri River Basin be expanded to include this project.

On November 10, 1943, Congress requested that the Board of Engineers for Rivers and Harbors review the Corps' 1930 document "with a view to determining the advisability of improvements for flood control on the James River and tributaries."

In 1943, the Corps presented a plan for improvement of the Missouri River Basin as House Document No. 475, 78th Congress, 2nd Session. The Jamestown Reservoir on the James River was contemplated as an element in a diversion plan from Garrison Reservoir, and the cost of construction of this reservoir was included in the estimate.

In May 1944, results of Reclamation's studies were presented to Congress in a report entitled "Conservation, Control, and Use of Water Resources of the Missouri River Basin." This report was printed as Senate Document No. 191, 78th Congress, 2nd Session. These plans were later coordinated with the general comprehensive plans of the Corps as revised by Senate Document No. 247, 78th Congress, 2nd Session. The plans for the Missouri River Basin, as set forth in House Document No. 475 and Senate Document No. 191, and as revised and coordinated by Senate Document No. 247, were approved by the Flood Control Act of December 22, 1944.

Jamestown Dam and Reservoir was authorized by Section 9 of the Act of Congress approved December 22, 1944 (58 Stat. 887,891), Public Law 534, referred to as the Flood Control Act of 1944. The adopted plan is generally referred to as the Pick-Sloan Plan.

3-02. Planning and Design. On April 30, 1945, the Garrison District Engineer issued the report "Review Report on Flood Control for the James River and Its Tributaries, North and South Dakota". A plan to provide municipal water supplies for cities on the James River was included in the Corps' report. This plan did not involve Missouri River diversions but proposed the construction of two dams on the James River above Jamestown, one near the site of the originally proposed Arrowwood Dam with a capacity of 32,000 af and the other near New Rockford with a 2,500 af capacity. In 1949, Congress supplied Reclamation with funding to build Jamestown Dam.

3-03. Construction. Following the severe flood of May 1950 in the upper James River, construction of Jamestown Dam and Reservoir was an early element of the Garrison Diversion Unit (GDU) under a special appropriation made by Congress to provide urgently needed flood protection to the City of Jamestown, ND. In October 1951, Congress appropriated $500,000 in the Second Supplemental Act of Fiscal Year (FY) 1952 to start construction. Construction by Reclamation was started in February 1952 and completed in September 1953. The dam was closed in February of 1954 and the conservation pool was first filled in 1965. Congressionally authorized purposes to be served by the dam include flood control, irrigation, municipal water supply, stream pollution abatement, recreation and wildlife, and potential power generation.

3-04. Related Projects. There are a number of reservoirs in the James River basin that affect streamflow conditions on the James River. Table 3-1 lists the more pertinent reservoirs. In addition there are numerous small reservoirs built in the 1930s under the Works Projects Administration and Civilian Conservation Corps federal programs for recreation and water supply. Pipestem and Jamestown Reservoirs are the only two reservoirs in the James River basin with storage authorized for flood control.

Table 3-1
Pertinent Reservoirs in the James River Basin above Columbia, SD

Reservoir	Stream	Capacity* (af)	Year Closed	Operating Agency or Owner
Juanita Lake Outlet	Offstream	3,168	1950	Foster County, ND
Arrowwood Lake	James River	8,450	1935	FWS
Mud Lake	James River	1,385	1935	FWS
Jim Lake	James River	5,379	1935	FWS
Depuy Marsh Lake	James River	818	1935	FWS
Jamestown	James River	220,978	1953	Reclamation
Pipestem	Pipestem Cr.	147,883	1973	Corps
Jamestown Ice House	James River	75	1943	City of Jamestown, ND
LaMoure	James River	104	1935	City of LaMoure, ND
Cottonwood Cr.	Cottonwood Cr.	8,076	1974	LaMoure County, ND
Dakota Lake	James River	2,124	1936	FWS
Houghton	James River	10,100	1936	FWS
Columbia Road	James River	20,215	1936	FWS

* Capacity at the uncontrolled spillway crest

3-05. Modifications to Regulations. Because Jamestown and Pipestem Dams form a parallel reservoir system, regulation of the flood storage of both projects must be coordinated. Since the beginning of the design of Jamestown Dam in the early 1950s to the present there have been six (6) signed Field Working Agreements (FWAs) between the Reclamation and the Corps regarding the regulation of the two dams. Copies of the previous field working agreements are attached as Appendix C to the report "Jamestown Reservoir and Pipestem Reservoir, Water Control Plan Review and Update, July 2000" (2000 WCP Review). The following paragraphs summarize the agreements.

a. March 1, 1957 Agreement. During the planning phase of Jamestown Dam in the late 1940s and early 1950s, the Corps was tasked with developing the flood control benefits of the dam. This would be used in calculating the Benefit to Cost ratio that would justify the construction of the dam. The Corps realized that because of the uniqueness of the James River (i.e. long travel times, reduced channel capacity in South Dakota, large uncontrolled incremental drainage area below the dam) it would be impossible to control all flooding below the dam. However, in order to control as much flooding as possible and to maximize the flood control benefits, it would be necessary to limit releases to zero during times of flooding. Therefore the Corps recommended a flood control storage volume that would hold the entire volume of the design snowmelt flood assuming no releases would be made during the flood period.

In the Corps' December 5, 1951 report, "Flood Control Supplement for the Definite Plan Report on Jamestown Reservoir" it was stated "Consequently, releases from the reservoir should be maintained at or near zero throughout the flood period. For this reason flood control storage should be provided to contain the entire project design

flood, or 200,000 acre-feet." The condition of zero releases during flood events was the Corps' position until March 1953.

In a July 28, 1952 meeting, Reclamation warned of the impacts of zero releases during flood events on Arrowwood NWR and recommended funding the Corps' Garrison District to review upstream versus downstream flood control in the water control plan. In Reclamation's initial studies and presentations, Reclamation stated that they were in a difficult position with the U.S. Fish and Wildlife Service (FWS) relative to the effect of Jamestown Dam on the Arrowwood NWR. In Reclamation's initial studies and presentation to the FWS, Reclamation had considered flood control only through the City of Jamestown and had theoretically regulated the reservoir to maintain a discharge of 1,800 cfs at the James River at Jamestown streamgaging site during a flooding event. These studies indicated insignificant effects on Arrowwood NWR.

In June 1953, the Corps began investigating different regulation alternatives. The final adopted plan, as presented in the Jamestown Water Control Manual, was agreed to by FWS, Reclamation, and Corps representatives at a conference held in Reclamation's Bismarck, North Dakota office on July 26, 1955. The plan balanced downstream flood control damages with the cost of relocating the refuge or its facilities. This plan recognized both the impracticality of the "zero release" plan which would have required very high releases in the late summer and also the difficulty in regulating for flooding in South Dakota. The final plan eliminated the target point at Columbia, SD and kept Jamestown as the primary downstream target point. In the Corps' Garrison District's May 1956 report "Jamestown Dam and Reservoir Regulation Manual, Flood Regulation Only" a draft plan operation was set forth and is shown in simplified form as Table 3-2. As outlined in Table 3-2, the maximum allowable release (assuming no incremental flow between Jamestown Dam and the James River at Jamestown streamgaging station) during the early portion of the flood was 400 cfs, with an increase to 750 cfs and eventually to 1,800 cfs as the pool level rises higher into the flood control zone.

Table 3-2
1956 Jamestown Dam Flood Control Regulation Procedure

Pool Elevation (feet)	Target Flow at Jamestown Gage(cfs)
1429.8 – 1445.4	400
1445.4 – 1450.0	750
1450.0 – 1454.0	1,800

The significance of these pool levels and the maximum releases is as follows:

1) 400 cfs was considered the channel capacity from Oakes, ND to the North Dakota-South Dakota state line.

2) The derivation of the 750 cfs release is not so clear from the correspondence. It is most likely related to the presumed James River channel capacity in the Columbia area of South Dakota. Early damage

studies conducted by the Garrison District indicated that 800 cfs was the channel capacity in the Columbia area. Several of the regulation alternatives considered in the Corps studies from 1953 to 1955 included a target flow of 800 cfs at Columbia. Columbia and LaMoure were later dropped from the final plan as downstream control points. Later correspondence in the 1970s indicated the 750 cfs was derived from the plan of diverting 690 cfs for the Garrison Diversion Project and that channel improvements in the Oakes area would allow this discharge.

3) It was required that one-half of the flood control storage pool be assumed as being available at the start of the inflow design flood. This is the basis for increasing the release to 750 cfs at elevation 1445.4 feet.

4) Reclamation determined that 1,800 cfs was considered the channel capacity of the James River through the City of Jamestown. At the time, the Corps' Garrison District believed the capacity to be closer to 1,600 cfs.

On March 1, 1957, the Corps and Reclamation signed the Flood Control Regulations governing the operation of Jamestown Dam and Reservoir. These regulations were published in the Federal Register, Volume 22, Page 864, dated February 12, 1957. In March of 1957, Reclamation and the Bureau of Sport Fisheries and Wildlife entered into a Memorandum of Understanding relating to the effects of the Jamestown Reservoir on Arrowwood Refuge.

The approved reservoir regulation manual for Jamestown was published in July 1957.

b. September 26, 1968 Agreement. The 1957 agreement was modified to raise the permanent pool to elevation 1432.0 feet to benefit recreation. At the same time that the pool was raised, the WCP was changed to include a downstream control point flow of 1,800 cfs at the James River at Jamestown streamgaging site if conditions at LaMoure allowed. Elevation 1445.4 feet results in 100,000 af available in flood storage (based on the 1957 storage capacity curve), which is the amount of storage necessary to route the spillway design flood. The most current storage capacity curve based on 2009 survey data also shows 100,000 af available in flood storage at elevation 1445.4 feet.

c. June 1972 Agreement. The 1968 agreement was modified to include a provision for a summer flow of 10 – 20 cfs to alleviate stagnant conditions in the James River. To accomplish this, the joint-use pool was raised from 1432.0 feet to 1432.67 feet.

d. January 29, 1974 Agreement. This was the first agreement that followed the construction of Pipestem Dam. In the March 1967 report "Pipestem Creek Dam and Reservoir Design Memorandum No. JP-1 Hydrology" it was stated that "Pipestem Dam would be regulated to retain all the volume of floods up to and including the Standard Project Flood" with no release. This would provide the maximum flood benefit to the

City of Jamestown and downstream areas to the North Dakota-South Dakota state line. The construction of Pipestem Dam allowed the release of 1,800 cfs from Jamestown Dam at a much lower elevation (1440.0 feet) than in previous agreements (1445.4 feet). Other changes from earlier agreements were to maintain the highest release achieved until the flood pool was emptied and the elimination of LaMoure as a downstream control point.

e. July 25, 1975 Agreement. This agreement sought to correct several perceived flaws in the 1974 agreement. The problems included;

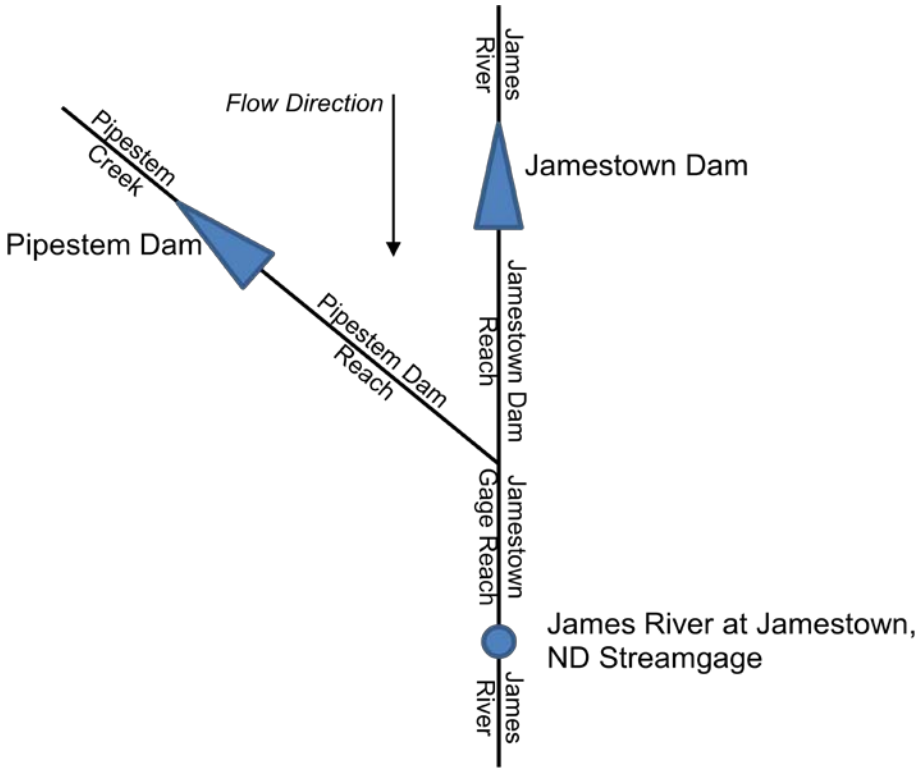
1) Radical departure from previous regulation of Jamestown Dam – the 1974 FWA calls for much higher releases at lower pool elevations.

2) Wide release fluctuations would result from using Table 1 of the 1974 FWA.

3) Maintenance of high releases which contribute to significant downstream flooding until all flood storage is evacuated is inconsistent with normal regulation practice.

As a result of these concerns the 1975 agreement differs from the 1974 agreement primarily in two procedures. The 1975 plan delays higher releases until more flood storage is utilized and the 1975 plan does not maintain the maximum release attained until the flood pool is evacuated.

Factors considered in the development of the 1975 Jamestown and Pipestem Reservoirs flood control regulation plan can be summarized in the following paragraphs. Figure 3-1 depicts a simple representation of the James River and Pipestem Creek through the City of Jamestown. The significant river reaches are described in detail in the figure.



Jamestown Dam reach: James River from Jamestown Dam to the confluence of the James River and Pipestem Creek

Pipestem Dam reach: Pipestem Dam to the confluence of the James River and Pipestem Creek

Jamestown Gage reach: confluence of the James River and Pipestem Creek to the James River at Jamestown, ND Streamgaging site

Figure 3-1. Definition of River Reaches in the City of Jamestown, ND

1) The channel capacity below Jamestown and Pipestem Dams is very restricted. The minimum downstream non-damaging channel capacity in the Jamestown Gage reach and downstream of the James River at Jamestown streamgaging site is approximately 450 cfs. Combined project releases would have to be limited to less than 450 cfs in order to eliminate downstream damaging flows. While this is a normal objective in the development of regulation schemes, it becomes impracticable when significant amounts of flood control storage are accumulated.

2) Although some urban flooding may occur in the City of Jamestown and in the Jamestown Gage reach with flows in excess of 750 cfs, this flow amount is a downstream flow target at the James River at Jamestown streamgaging site whenever it becomes evident that satisfactory flood storage evacuation will not occur at the 450 cfs downstream channel capacity release. Even higher rates may be required at times.

3) Urban flooding becomes significant when flows at the James River at Jamestown streamgaging site exceed 1,800 cfs. The approved WCP states that this be the maximum flow rate at the James River at Jamestown streamgaging site any time some flood control storage space remains available in either of the two reservoirs.

4) Design of Jamestown Reservoir assumed that the upper half of the flood control pool (storage above elevation 1445.4 feet) would be vacated and available to assist in controlling the spillway design flood. Therefore, regulation should be based on evacuating this upper zone at maximum allowable rates (1,800 cfs at the James River at Jamestown streamgaging site) and the evacuation of stored flood waters should have priority over flood storage evacuation from Pipestem Reservoir. The Pipestem spillway was designed assuming the occurrence of the Probable Maximum Flood (PMF) on a full flood pool (storage above elevation 1496.3 feet PD).

5) The achievement of a moderate reserve of flood control storage space in Pipestem Reservoir for control of subsequent flooding should have precedence over complete evacuation of the Jamestown Reservoir flood control storage space. A reserve equivalent to about one-quarter of the total flood control storage space (elevation 1489.0 feet to elevation 1496.3 feet PD) would appear quite adequate. Regulation should be based on evacuating this upper zone at the maximum allowable rate of 1,800 cfs at the James River at Jamestown streamgaging site, provided the upper half of the Jamestown Reservoir flood pool is evacuated.

6) Evacuation of all flood control storage space from both Pipestem and Jamestown Reservoirs should normally be completed prior to the onset of the winter season when ice can be expected to severely restrict the downstream channel capacity. Flows should be maintained as high as 1,800 cfs at the James River at Jamestown streamgaging site if necessary to assure evacuation. It may be necessary to carry over a minor amount of flood control storage through the winter season rather increasing downstream flows during the fall. Evacuation with flow rates maintained in excess of the downstream channel capacity (450 cfs at the James River at Jamestown streamgaging site) should be based on the total storage remaining in the combined Pipestem and Jamestown Reservoirs and the time remaining prior to the winter season.

7) Arrowwood NWR is located within the Jamestown Reservoir area and is subject to increasing damage with sustained high reservoir levels. The Jamestown project was developed with the intent of providing the most effective flood control to downstream areas. However, to the extent practical, an effort should be made to evacuate storage from the refuge area and Jamestown Reservoir by giving priority to this over Pipestem Reservoir storage evacuation. For this reason, releases from Pipestem

Dam will be limited to a maximum of 100 cfs while its pool level is below 1478.2 feet PD.

8) In order to give more assurance to the evacuation of storage space at moderate downstream flow rates, as well as providing additional space for the control of future flooding, evacuation of additional space more than given in 4) and 5) should be scheduled at the intermediate 750 cfs flow rate past the City of Jamestown. Evacuation of combined flood control storage to about the 100,000 af level would appear appropriate. This is equivalent to pool elevation 1440 feet at Jamestown Reservoir and a Pipestem Reservoir pool elevation of 1478.2 feet PD. The Jamestown Reservoir pool elevation of 1440 feet is also a level where the Arrowwood Refuge would be at least partially operable.

9) Evacuation of minor amounts of storage contained in these two reservoirs should be at rates up to the downstream channel capacity of 450 cfs through the Jamestown Gage reach and downstream of the James River at Jamestown streamgaging site unless higher rates are warranted for storage evacuation prior to formation of a downstream ice cover.

f. December 14, 2015 Agreement. This agreement incorporated revisions to the water control plan as a result of the 2000 WCP Review. Factors considered in the development of the 2015 agreement can be summarized in the following paragraphs.

1) The overall joint use zone in Jamestown Reservoir includes the storage capacity between elevations 1428.0 and 1431.0 feet. In addition to other project purposes, the portion between 1429.8 and 1431.0 feet is also used for flood control storage, which, based on 2009 surveys, includes 2,680 af of storage. The remaining portion of the joint use zone, between 1428.0 and 1429.8 feet and includes 3,582 af of storage, is for other project purposes such as irrigation, municipal and industrial water supply, and recreation and wildlife conservation. The target pool levels in the overall joint use zone vary seasonally based on mutual agreement between agencies for conservation uses.

2) The flood control plan for the joint regulation of Pipestem and Jamestown Reservoirs was developed according to Flexible Plan B, which was the preferred regulation plan as outlined in the 2000 WCP Review. This plan is flexible and is designed to allow the water control managers to make adjustments based on hydrologic conditions in the James River Basin both upstream and downstream of the reservoirs. In order to meet the management objectives and considerations, regulation guidelines have been developed for the type of flow year (calendar year) that is forecasted to assist in preparing an annual operating plan. The type of flow year is classified into one of three following categories: low flow year, medium flow year, and high flow year. The flow category is based on the total

combined forecasted annual inflow volume for both Jamestown and Pipestem Reservoirs for the calendar year. Additional guidance in determining releases for each type of flow year is contained in Chapter 7.

3) Releases from Jamestown Dam eventually flow into the Missouri River. The James-Missouri confluence is a few miles downstream of Gavins Point Dam, the lowermost of the six Missouri River mainstem dams. During large floods on the Missouri River, releases of flood storage in Jamestown Reservoir may be adjusted in order to meet basin-wide flood control goals of the Missouri River mainstem reservoir system. In the case of Jamestown Dam, requests for flood control release adjustments (e.g. deviation request) outside of the approved WCM will be made to the MRBWM office. The Omaha District WCWQS will coordinate those release adjustments with Reclamation's Reservoir and River Operations Branch, Great Plains Regional Office in Billings, Montana. Coordination should be done via conference call or email and confirmed via email and/or signed memorandum the same day.

g. Clarification of Flow Targets in the City of Jamestown. Previous agreements had targeted a combined flow of 1,800 cfs at the James River at Jamestown streamgaging site when the reservoirs are at high elevations. The 2000 WCP Review indicated a combined target flow of 1,800 cfs at the James River at Jamestown streamgaging site (Table 7-2). The WCP, as outlined in the October 2008 Pipestem and Jamestown Reservoir Water Control Manuals, does not specifically mention whether the 1,800 cfs combined flow is based on releases at the dams or the flow at the James River at Jamestown streamgaging site. After high prolonged releases in 2009, 2010, and 2011, partner agencies indicated a desire for a 1,800 cfs "flow target" based on total releases from the dams in order to prevent confusion. The streamflow at the James River at Jamestown streamgaging site could change based on local inflow downstream of the dams as well as flow measurements. These factors would possibly cause confusion as to the need for release changes to maintain a target flow at the James River at Jamestown streamgaging site. **The current WCP indicates release targets from the reservoirs, <u>not</u> a flow target at the James River at Jamestown streamgaging site.** The issue was discussed at the April 4, 2012 James River annual operations meeting, and no objections were raised to this clarification. If there are constraints to high releases due to runoff from the intervening drainage area between the dam and the James River at Jamestown streamgaging site, the reservoir releases will be made to accommodate these constraints as much as possible per the WCP.

3-06. Principal Regulation Problems. Several areas of concern exist in the Jamestown Dam reach (see Figure 3-1) when high releases are being made from Jamestown Dam. In 2011, the maximum release, without emergency levees in-place, was 1,600 cfs. At this release, Nickeus Park was flooded and water was out of bank in other low-lying areas in the reach. Water was close to inundating several city streets.

Sand bags were placed near the Ann Carlsen Center on the 8th Avenue NW street gutter to prevent water ponding on the edge of the street.

Channel capacity on the James River has historically been a regulation problem for Jamestown and Pipestem Dams. When Jamestown and Pipestem Dams were constructed, the channel capacity downstream of the confluence was capable of handling the design discharge of 1,800 cfs. From the time Pipestem Dam was built in July of 1973 until 1993, there was a steady reduction in the downstream channel capacity. Before 1993, combined releases from Jamestown and Pipestem Dams never exceeded 450 cfs. Since 1993 the downstream channel has been restored to nearly its original capacity of 1,800 cfs through channel clearing, removal of a bridge, construction of a bypass channel and scouring of the channel during high flows. However, at flows of 1,200 cfs water begins to back up storm drains into city streets, and the city must install storm drain plugs. These plugs cause some internal drainage issues requiring pumps to drain local runoff into the river. In the Jamestown Dam reach, complaints of basement seepage are received with releases from Jamestown Reservoir over 1,200 cfs. With prolonged releases, seepage into the sanitary sewer system increases. In 2009, significant seepage into the sanitary sewer occurred and raw sewage had to be pumped directly into the James River.

In 1997, 2009, and 2010, emergency levees were required for releases of 1,200 cfs or more from Jamestown Reservoir. As flows approach 1,800 cfs, water is very close to touching the low steel of many bridges. In 2011, combined releases of 1,800 cfs (1,600 cfs from Jamestown Reservoir and 200 cfs from Pipestem Reservoir) required the construction of only a few emergency levees because of channel clearing and scouring from the previous high flow years. Plugs for several storm drains were still required for the duration of high flows. Later in the year, sandbag and clay levees were constructed by the City of Jamestown to allow a combined release of 2,400 cfs to evacuate stored flood waters before the winter. Table 3-3 lists potential issues or impacts that may develop at various release rates from Pipestem and Jamestown Dams.

Table 3-3
Impacts in the City of Jamestown from
Combined Releases out of Jamestown and Pipestem Reservoirs

Combined Release	Impact/Action Required
450 cfs	(1) At this level, there is a noticeable increase in both basement seepage and the volume of water being pumped by the sanitary sewer lift stations. Both of these problems increase as the discharge increases. (2) The gate in the upstream dike of the oxbow closure structure is closed to prevent water from entering the oxbow.
650 cfs	The gate on the downstream dike of the oxbow closure structure is closed. Pumps will automatically activate to regulate the oxbow water level.
1,200 cfs	The city places plugs in the storm sewers to prevent water from backing up into streets.
1,600 cfs	Water touches the base of the temporary emergency dikes placed in 1997. These dikes were not removed after the flooding in 1997. Sandbags may need to be placed to prevent water from entering some city streets near the river. Because the river is nearly at capacity with release water, very little channel capacity remains for local rainfall and runoff in the City of Jamestown, and releases may need to be reduced during local rainfall.

The impact of releases from Jamestown and Pipestem Dams reduces closer to the North Dakota-South Dakota state line, but the Lake Plain Region in northern South Dakota poses significant flooding problems. Flooding has plagued the James River in northern South Dakota throughout recorded history. Because the river valley is so flat, flow is sluggish and floodwater tends to spread out over great distances across farmland. Snowmelt and rainfall runoff and tributary flows are the primary contributors to the flooding problems in this region.

Another regulation problem is the inability of Jamestown Dam to safely pass the PMF. The PMF for Jamestown Dam is characterized by a peak inflow of 243,900 cfs and a volume of 574,000 af. Floods exceeding 91 percent of the PMF will overtop Jamestown Dam. The probability of overtopping of the Jamestown Dam embankment is very remote, however, the consequences of failure would be catastrophic.

A dam safety evaluation study was conducted by Reclamation to determine the appropriate measures needed to mitigate the effect of the potential overtopping condition. Options considered were: 1) raising the dam embankment, 2) constructing a larger spillway, and 3) installation of an early warning system. The study concluded that installation of an early warning system would be used to reduce the potential for loss of life associated with a hydrologically induced failure. An early warning communication network has been implemented and a description of the Emergency Action Plan (EAP)

for the early warning system can be found in Reclamation's Standing Operating Procedures (SOP) for Jamestown Dam and Reservoir.

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IV – WATERSHED CHARACTERISTICS

4-01. General Characteristics. The James River headwaters are located in central North Dakota. The river then flows eastward about 50 miles through New Rockford, ND and then generally southward through the City of Jamestown, ND and South Dakota to its confluence with the Missouri River near Yankton, SD (Plates 4-1 to 4-10). Its total length is about 700 river miles. The basin is 370 miles long and has a maximum width of about 100 miles. The total drainage area is 22,100 square miles, 1,300 of which lie above Jamestown Dam.

4-02. Topography. The topography of the basin is flat to gently rolling, consisting of glacial till, old lake beds and low glacial moraines. The valley of the main stem which varies in width from a few hundred feet to 3 miles is the remnant of the last ice age - cut by great flows from the melting of the receding ice sheet. The valley has since filled with alluvium to a depth of about 25 to 100 feet below the level of the adjacent plains. The area from Oakes, ND to Ashton, SD is referred to as the Lake Plain Region. The Lake Plain Region was formerly an ice age lake that began draining southward to the James River and is characterized by an extremely flat gradient.

4-03. Geology and Soils. Jamestown and Pipestem reservoirs lie within the Drift Prairie section of the Interior Lowland Province. The youngest geological formations in the area are the alluvial deposits in the valleys of both streams. Most of this material was deposited by post-glacial streams flowing through the deeper valleys and filling them to the level of the present valley floors. The alluvial deposits prevail over a relatively small portion of the surface area, and in the vicinity of Jamestown Reservoir extend to a maximum depth of approximately 100 feet. The most important formation is glacial drift, which blankets the entire basin and is composed of coarse sand and gravel interlaced with seams of clay. Outcroppings of the underlying Pierre shale, which forms bedrock for practically the entire area, are rare. Underlying the Pierre shale, in successive order, are the Niobrara and Benton shales and the Dakota sandstone. Groundwater is continually percolating through the coarse glacial drift, and in some instances is found only a few feet below the surface. This groundwater flow is generally independent of surface flow, having been sealed off by mud and silt deposited by streams.

4-04. Sediment. Periodic surveys of the reservoir sediment and re-evaluation of the remaining storage capacity of Jamestown Reservoir will be made by Reclamation. Surveys were taken near the time of dam construction, in 1965 and in 2009. Table 4-1 shows the storage changes between the historical surveys. For more information on sediment, see Reclamation’s SOP for Jamestown Dam and Reservoir.

Table 4-1
Historical Jamestown Reservoir Storage Capacity Survey Results

Storage Zone with Pool Elevation range (feet)	Original (1952)	1965			2009		
	Capacity (af)	Capacity (af)	Rate of Change (af/yr)	Percent of Original	Capacity (af)	Rate of Change (af/yr)	Percent of Original
Surcharge 1454.0 to 1464.4	159,100	158,860	-18.46	99.8	158,917	1.30	99.9
Flood Control 1429.8 to 1454.0	200,000	192,068	-610.15	96.0	193,182	25.32	96.6
Joint Use Flood Control Pool* 1400.0 to 1429.8	29,180	28,088	-84.00	96.3	27,516	-13.00	94.3

*1429.8 feet was used as the top of conservation storage in the Reclamation 604-D-15 document dated 1952.

4-05. Climate.

a. Climatological Norms. In general, the climate of the James River basin is classified as dry subhumid. Located near the geographical center of the North American continent, the basin is subject to extreme variations in temperature. Summers are short and hot, while the winters are long and generally very cold. The City of Jamestown, ND, which is located near the Jamestown dam site, has a mean annual temperature of 41.5 degrees Fahrenheit (°F). Freezing temperatures normally can be expected from the latter part of September through mid-May. Recorded temperature extremes at the City of Jamestown State Hospital weather station have ranged from 118 °F in July to minus 42 °F in February.

Precipitation amounts in the region surrounding the City of Jamestown are moderate and fluctuate widely from year to year. Approximately twenty precipitation stations are located in the North Dakota portion of the James River basin. Of these, the station located at the City of Jamestown State Hospital has the longest period of record, as shown in Table 4-2. The mean annual precipitation at the City of Jamestown State Hospital weather station, on the basis of the most recent 30 years of climatological record (1981-2010), is 18.77 inches. The greatest annual precipitation recorded was 30.19 inches in 1993 and the least annual precipitation was 9.57 inches in 1976.

More than 75 percent of the annual precipitation occurs during the six-month period from April through September. Most of the rain in the summer months occurs during thunderstorms, often with heavy downpours of short duration. Snowfall at the City of Jamestown State Hospital weather station averages about 35 inches per season, with extremes ranging from less than 10 inches (1958) to more than 100 inches (1949 and 1996). Temperature and precipitation records for the City of Jamestown State Hospital weather station are summarized in Table 4-2.

Table 4-2
Temperature and Precipitation – City of Jamestown State Hospital, ND
(Period of Record: 1892-July 2014; Climatological Means 1981-2010)

	Temperatures (°F)			Precipitation (inches)				
Month	Record Highest	Mean	Record Lowest	Maximum	Mean Total	Minimum	Max. in 24 Hrs.	Snowfall Mean
Jan	56	10.1	-41	2.98	0.45	T	0.93	6.7
Feb	64	15.1	-42	2.12	0.40	T	1.57	5.9
Mar	80	27.6	-29	3.48	0.84	0	1.40	6.4
Apr	97	42.6	-8	6.61	1.20	0	2.10	3.2
May	107	55.2	8	7.30	2.66	.10	2.96	0.1
Jun	107	64.5	27	11.31	3.19	.33	4.90	0.0
Jul	118	69.9	35	11.98	3.35	.41	6.35	0.0
Aug	107	68.2	29	9.30	2.10	.43	6.45	0.0
Sep	107	57.6	15	5.77	2.00	0	2.94	Trace
Oct	94	44.1	-8	4.49	1.55	T	1.74	1.0
Nov	77	27.8	-27	3.50	0.63	0	1.56	5.5
Dec	67	14.2	-39	1.97	0.40	0	1.22	6.3
Annual	**118**	**41.4**	**-42**	**30.19[1]**	**18.77**	**9.57[1]**	**6.45**	**35.1**

[1]Maximum and Minimum annual precipitation occurred in 1993 and 1976, respectively.

b. Climate Variability. Much research has been conducted over the past several decades concerning the impacts of climate variability on different regions of the planet. One of the more frequent studied phenomena is the El Niño/Southern Oscillation (ENSO) cycle that is observed across the central and east-central equatorial Pacific. The impacts in the continental United States from the different cycles of ENSO (El Niño and La Niña) are typically more pronounced along the Pacific coast and the southern tier states. However, some impacts have been attributed to the sub-basins of the Missouri River Basin. It is also important to note that impacts from the ENSO cycle are generally between the months of November and March, or from late fall into early spring.

The precipitation impacts in the upper portions of the James River basin are not as pronounced, so a solid correlation between El Niño conditions and moisture does not exist in this region. Essentially the entire James River basin, however, has been warmer than normal during most El Niño episodes. These milder temperatures, however, could indirectly impact snowfall because warmer air can contain greater amounts of moisture and those same above-normal temperatures would likely result in an earlier Plains snowmelt and runoff during the March and April time-frame.

As is the case with El Niño, a strong correlation between La Niña episodes and precipitation anomalies does not exist in the Dakotas. This area has experienced both record (to near-record) wet and dry conditions during La Niña winters. The effect on temperature in the upper portion of the James River basin is more significant. A composite of the temperature anomalies during the La Niña episodes from 1981 through 2010 shows a cooler pattern in parts of the Northern Plains and Upper Midwest surrounding the basin. This would result in increased possibilities of heavier snowfall occurring later in the season during a La Niña event as well as a delayed snowmelt.

4-06. Storms and Floods. Although the flood history of the James River in North Dakota dates back to 1876, very few details are known of the early floods. Flood data prior to 1943 is meager and stems from the testimony of early residents and a few high water marks recorded by the Northern Pacific Railway Company at its bridge No. 93, which runs through the City of Jamestown (see Plate 4-4). Floods that have occurred in the City of Jamestown area are described in the following paragraphs. Events that occurred after Jamestown Dam was built include a description of the storm and a description of regulation including peak stages and flows is found in Section 8-12. See Figure 8-1 for a reference of peak stages at the James River at Jamestown streamgaging site for these events.

a. Flood of 1876. Early residents reported that flooding occurred in the City of Jamestown in 1876. Peak river stage, discharge, and flood damages are not available.

b. Floods of 1881, 1882, and 1883. Historic accounts indicate that the flood, which crested April 10, 1881, drove many people out of their homes. However, no information as to the magnitude or duration of the flood is available. Per newspaper articles, the James River crested at the present James River at Jamestown streamgaging site on April 11, 1882 and on April 9, 1883. Information furnished by the Northern Pacific Railway Company indicated that the 1883 peak stage reached an elevation of 1400.35 feet, or a stage of approximately 19.2 feet adjusted to the present James River at Jamestown, ND streamgaging site. This peak was approximately 3.4 feet higher than the May 1950 flood peak. The 1882 flood peak stage was estimated to equal the 1883 peak stage. There is some question as to the accuracy of the elevation of the 1883 flood peak stage, as the measurement was made from a point on the railroad bridge which may have been raised since that date. However, early residents' documentation supported the railroad's information that the flood of 1883 exceeded all subsequent floods through 1957.

c. Flood of 1897. Information furnished by the Northern Pacific Railway Company, local newspapers, and early residents, indicated that the flood of 1897 peaked in the City of Jamestown on April 27 at an elevation of 1398.15 feet, equating to an approximate stage of 16.9 feet at the present James River at Jamestown streamgaging site. During this flood, high stages continued for approximately one week. This flood peaked 2.2 feet lower than the flood of 1883 and approximately 1.1 feet higher than the May 1950 flood.

d. Flood of 1902. High water during the spring of 1902, adjusted to the present James River at Jamestown streamgaging site, registered a peak stage of 13.8 feet on March 27. This was approximately 2.0 feet lower than the May 1950 flood.

e. Flood of 1919. Records indicate that the river crested on April 11. The peak flood stage, when adjusted to the present James River at Jamestown streamgaging site, registered 14.9 feet, which was approximately 0.9 foot lower than the May 1950 flood.

f. Flood of 1943. The primary causes of the 1943 flood, aside from topographic features and channel conditions, were: 1) a heavy winter snowfall, which exceeded normal snowfall by about 44 percent and covered the headwater areas of the James River and Pipestem Creek, 2) heavy snow events which occurred from March 11-17, and 3) temperatures that rose abnormally high during the last 10 days of March and resulted in a rapid snowmelt. The James River at Jamestown streamgaging site was not in operation prior to March 29; however, from March 29 to 31, a rising stage was indicated at the site with a maximum reading of 12.77 feet and an estimated discharge of 1,820 cfs on March 31. The flood peak was unofficially reported to have occurred on March 25, and the high water mark from this flow transferred to the James River at Jamestown streamgaging site indicated a stage of 13.6 feet with a corresponding discharge of 4,000 cfs.

g. Flood of 1948. Flooding occurred in April and May of 1948 in the upper James River basin as a result of snowmelt augmented by rain during the flood period. Flows at the James River at Jamestown, ND and Columbia, SD streamgaging sites were the highest of record to date. No other streamgaging stations were in operation upstream of Columbia. Field observations made during the flood indicated that during the season preceding the 1948 flood, precipitation was above normal. Above the City of Jamestown, the October and November 2-month precipitation basin average was 3.7 inches (average is just over 2 inches) and the December through March 4-month precipitation basin average was 2.2 inches, which is near average. The March mean temperature of 16 °F was below normal. A forecast was made assuming that normal precipitation would occur during the April 1 to May 15 period, which would result in approximately 1.4 inches of basin average runoff from the contributing area, much of which would be from the fall and winter precipitation during October-March. Precipitation continued to occur over the upper basin during April. A heavy snowstorm occurred on April 7 and an April 23-24 rainfall event resulted in moderate to heavy precipitation. The total April 1 to May 15 precipitation averaged 3.1 inches above the City of Jamestown and the basin average runoff amounted to about 1.5 inches. Substantial flows through the City of Jamestown occurred during the last week of March and the first two weeks of April. Warm temperatures in mid-April resulted in a rapid melting of the remaining snow cover. A peak discharge of 3,250 cfs was observed at the James River at Jamestown streamgaging site on April 23. Following the crest, the river slowly receded with discharges falling below bankfull levels of 1,800 cfs at the James River at Jamestown streamgaging site by May 1. The James River was above bankfull flows for a total of 12 days at the Jamestown streamgaging site. As the flood progressed downstream, the James River hydrograph flattened. The James River at Columbia, SD, which is the nearest gaging station operating downstream from Jamestown, recorded a peak discharge of 1,950 cfs. The streamflow at the Columbia, SD streamgaging site exceeded the channel capacity of 800 cfs for 48 days.

h. Floods of 1950. Precipitation during the fall of 1949 was well above normal. Above the City of Jamestown, the October-November precipitation averaged 3.9 inches, nearly 2 times normal. March temperatures averaged 19 °F, about 8 °F cooler than normal. From these data, a forecast of 2.9 inches of basin average runoff from the

contributing area was made on April 1. During the first flood period, overbank flow started on April 4 in the Pipestem Creek watershed west of Buchanan, ND. On the same day, James River flows overtopped the spillway on Arrowwood Dam. Flooding occurred in the City of Jamestown beginning on April 7, but the flooding was retarded when cold weather entered the basin the next day. As the weather warmed over the next week, all but the deeper drifts of the winter's snow accumulation melted. Flooding through the City of Jamestown resumed starting on April 15, cresting on April 17, and continuing through April 28. During the last week of April and first ten days of May, daily maximum temperatures were near the freezing point. Precipitation during this period was heavy, with amounts totaling up to 6 inches in the City of Jamestown. This precipitation was in the form of snow, rain, and a mixture of the two, which caused little runoff until the second week of May. Total precipitation for the April 1 to May 15 period averaged 4.2 inches in the contributing area above the City of Jamestown. The second crest on May 13 was a result of snowmelt runoff on top of the recession of the earlier flood. The James River peak discharges at the James River at Jamestown streamgaging site were 6,020 cfs on April 17 and 6,390 cfs on May 13. The May 13 event correlated to a peak stage of 15.82 feet. To date, the May 13 peak is the record peak at the James River at Jamestown streamgaging site, which began its record in 1928; this was prior to the construction of either dam. Basin average runoff above the City of Jamestown, totaling about 3.3 inches during the flood, resulted in above-bankfull stages at the Jamestown streamgaging site from April 15-29 and from May 10-26. A James River peak discharge at LaMoure, ND of 5,730 cfs occurred on May 16. At Columbia, SD the peak discharge was 5,370 cfs on May 24. Discharges exceeded the channel capacity in the vicinity of Columbia for 66 days.

i. Flood of 1952. Snow cover in the upper part of the basin was relatively light, with a Snow Water Equivalent (SWE) ranging from 1.5 to 2.5 inches. SWE at and below the City of Jamestown measured between 4.0 and 4.5 inches and 3.5 inches at the North Dakota-South Dakota state line. Ice on the James River ranged from 2.1 to 2.8 feet thick. Runoff from the rapid snowmelt caused extensive flooding in the James River basin. Flooding began along Pipestem Creek on March 31 and moved progressively downstream. On April 15, an extensive area continued to be inundated along the James River near the North Dakota-South Dakota state line. Subsequent drainage of the inundated area was retarded due to the flat valley gradient in the lower reach, thus prolonging the period of flooding. Stages and discharges at the James River at Jamestown streamgaging site did not approach the maximums of record. The peak stage of 11.2 feet occurred on April 8 with a corresponding discharge of 1,620 cfs.

j. Flood of 1966. Snowmelt runoff produced minor flooding in the City of Jamestown on March 19 with an approximate peak discharge of 2,360 cfs and a stage of 13.0 feet at the James River at Jamestown streamgaging site. This peak stage was the primarily the result of Pipestem Creek runoff (Pipestem Dam was constructed in 1973), since no releases from Jamestown Dam were made during the time of the downstream flooding in the City of Jamestown.

k. Flood of 1969. Classified as one of the worst floods on record, the 1969 flood caused extensive damage throughout the basin. The SWE in the James River basin in North Dakota was heavy, ranging from 1.75 inches to more than 5 inches. The SWE above the City of Jamestown averaged about 3.6 inches. The flood peak was a direct result of Pipestem Creek runoff (Pipestem Dam was constructed in 1973), since no releases from Jamestown Dam were made during the time of the downstream flooding in the City of Jamestown. Nearly a third of the City of Jamestown was inundated. The peak streamflow at the James River at Jamestown streamgaging site was measured to be 6,330 cfs with a correlated stage of 16.94 feet. An estimated 960 homes, 65 businesses, and 15 public utilities were flooded. Total urban damages in the City of Jamestown were estimated at more than $1.5 million. Section 8-12.a.(1) contains a detailed description of the operation of Jamestown Reservoir during this event.

l. Flood of 1984. During late March, flooding from the Elm River occurred in the upper part of the Lake Plain Region in South Dakota. Elm River peak flows of 1,650 cfs were recorded at the Elm River at Westport, SD streamgaging site. Flooding downstream from the Lake Plain Region did not occur at the time because the downstream channel capacity was sufficient to carry the flows. Intense thunderstorms in June over the lower basin resulted in record James River and tributary flood discharges downstream from Mitchell, SD. While the 1984 flood affected both the Lake Plain Region and the lower James River, over 85 percent of the discharge volume was generated by tributaries downstream from Redfield, SD. A record peak discharge of 29,400 cfs occurred at the James River at Scotland, SD streamgaging site on June 23. This peak was nearly two times the previous record flood. Major flood damage occurred along the James River from Mitchell to its confluence with the Missouri River. In addition, extensive channel degradation occurred in the lower 5 miles in the form of channel widening and lowering. The resulting degradation forced the closing of one of the Highway 50 bridges east of Yankton because of the undercutting of a bridge pier. Approximately 27,100 acres of primarily agricultural land were inundated by floodwaters, which resulted in an estimated $6 million in agricultural damages. The flooding was particularly hard on bottomland farmers in the lower basin, as few were able to plant crops. Based on gage records at Scotland, flooding of bottomlands occurred at several different times during 1984.

m. Flood of 1986. During early 1986, rainstorms caused both the Elm River and the James River to flood large areas of the Lake Plain Region in Brown County, South Dakota. Snake Creek, Turtle Creek, and other tributaries discharged sufficient water to aggravate James River flooding in the reach from Redfield to Huron. Below Huron, heavy tributary discharges continued over several weeks. Peak discharges of 4,060 cfs occurred at Redfield on May 12, 5,010 cfs at Huron on March 23, and 12,200 cfs at Scotland on April 19. At Scotland, the river flow exceeded 4,000 cfs from March 29 to June 3. This prevented the planting of crops, caused swamping, and damaged normally flood-tolerant trees such as green ash and boxelder. In Brown County extensive areas of swamping were noted between Sand Lake and Stratford. Several thousand acres were not planted and swamping occurred when these lands were

invaded by cattails and other hydrophytic vegetation. High densities of crayfish were noted in old cropland stubble, which attracted large flocks of wading birds such as herons and egrets.

n. Flood of 1993. Flooding in the James River basin during 1993 resulted from above average spring rainfall and an intense July rainfall. Conditions shifted dramatically from dry to wet in late May. The basins above Jamestown and Pipestem Dams were part of the Midwest floods of July 1993, as heavy rains repeatedly struck the basin night after night by mid-July. Frequent rains lashed the basin throughout June, with more than 7 inches reported for that month at the City of Jamestown Airport. Storms across the lower basin on July 2 produced rainfall amounts in South Dakota from 5 to 7 inches. In the upper basin, a storm on July 15-16 produced rainfall totals from 4 to 7 inches in a 50-mile wide path from Bismarck to Fargo, ND. Torrential rain fell on wet soil the night of July 15, as an intense slow-moving thunderstorm tracked from west of Bismarck to Fargo, north of I-94. Over 8 inches of rain was reported unofficially around the City of Jamestown, which caused extensive street flooding. On July 15 the Pipestem pool rose 5.93 feet in one 24-hour period as a result of a peak daily inflow of 4,370 cfs. Another storm on July 23-25 produced 5 to 7 inches of rain over the upper James River basin. A period of heavy rain occurred in the upper basin near Fessenden, ND from July 25-27. That much heavy rain was unusual so late in the year and caused significant rises in both reservoirs. The James River at Jamestown streamgaging site reached a peak stage and flow of 13.58 feet and 1,300 cfs, respectively, on July 16. Section 8-12.a.(2) contains a detailed description of the operation of Jamestown and Pipestem Reservoirs during this event.

o. Flood of 1995. North Dakota experienced another very wet year in 1995. Late winter snowfalls, followed by a rapid warm-up in March, generated widespread flooding across east-central North Dakota. Heavy rainfall in May, in addition to the plains snowmelt runoff, resulted in very wet conditions throughout the basin. Conditions in North Dakota were so wet that a Presidential Disaster Declaration was issued for 32 of the 53 counties in North Dakota, including those counties in the James River basin. Section 8-12.a.(3) contains a detailed description of the operation of Jamestown and Pipestem Reservoirs during this event.

p. Flood of 1996. Precipitation remained above normal throughout the fall of 1995, and cold and wet conditions prevailed in the James River basin through the winter into 1996. Cold temperatures into January resulted in a deep frost layer. Multiple major winter storms resulted in snowpack depths that peaked at 15 to 25 inches by the end of January. In mid-April the snowpack melted quickly on frozen ground and resulted in above-normal inflows to both reservoirs. A new record pool of 1444.6 was set at Jamestown Reservoir on April 26, 0.5 feet above the previous 1969 record.

q. Flood of 1997. This year marked the fifth consecutive year of significant flooding along the James River in North and South Dakota. The wet cycle that began in 1993 caused long-duration flooding and significantly impacted landowners adjacent to the James River. The wet cycle also filled depression storage areas and increased the

effective contributing drainage area to flows in the river. A persistent moisture pattern became established in the Northern Plains as the winter of 1996-97 began. Referred to as the "Pineapple Connection", wind currents aloft brought moisture from the Pacific tropics into North Dakota. A nearly stationary low-pressure trough over eastern Canada provided the focus for frequent heavy snow and ice storms over the Dakotas in November and December. Despite a relatively dry summer of 1996, fall rains had recharged the soil moisture to a depth of more than 5 feet by late autumn. However, the early snowfalls resulted in little frost penetration. More blizzards struck North Dakota early in January. More than 60 inches of snow was recorded at the City of Jamestown Airport in the three months ending January 31, 1997. Following a drier February, winter returned with a vengeance in March and early April. Average basin SWE by mid-March was estimated at 3.9 inches above Scotland, SD and 3.5 inches above the City of Jamestown. The storms of early April had a significant impact on the floods that followed. A spring blizzard on April 5 dumped more than a foot of wet snow across parts of north central North Dakota. Additional snow fell April 7-11. Section 8-12.a.(4) contains a detailed description of the operation of Jamestown and Pipestem Reservoirs during this event. Flood damages prevented by Jamestown Dam totaled $16,872,500.

r. Flood of 2009. Heavy snowfall throughout the winter produced above-average SWE above Jamestown and Pipestem Reservoirs. As early as January, modeled SWE estimates showed 4 to 6 inches of accumulated SWE, prompting the Stutsman County Emergency Manager to request assistance from the State of North Dakota for snow removal to keep roads open and passable. With the heavy snowpack across the basin, the Corps issued a warning in February about the potential for very high runoff in the spring. Early forecasts indicated a medium to high runoff year and showed a possibility of record pool levels at both Jamestown and Pipestem Reservoirs. In early March, the Jamestown City Council declared a flood emergency in response to the Corps' prediction of high releases. On March 9-10, the City of Jamestown area received an additional 14 inches of snow, increasing SWE in some places above the reservoirs to over 6 inches. Additional rain and snow fell on March 29-31, bringing an additional 21 inches of snow to the City of Jamestown area. Updated forecasts indicated potential spillway flow at both dams, equivalent to a 3,400 cfs combined release. In early April, the Corps built advanced-measure levees in the City of Jamestown to handle a combined release of 4,000 cfs from the dams. Since the channel capacity through the City of Jamestown was stressed by the high releases, periodic reductions were made at the reservoirs when rain was expected over the City of Jamestown, providing additional space for local runoff in town. A peak pool at Jamestown Dam was reached on April 27 at an elevation of 1454.1 feet, 0.1 feet above the spillway crest. Section 8-12.a.(6) contains a detailed description of the operation of Jamestown and Pipestem Reservoirs during this event. Flood damages prevented by Jamestown Dam for this event were calculated to be $43,279,400.

s. Flood of 2010. Snow began to fall early in the year in the James River basin. By early January, 2.5 inches of SWE was reported at the Pipestem Dam Project Office. By the end of February, snow survey results upstream of the City of Jamestown, ND

showed almost 4 inches of SWE. Corps forecasts predicted a strong likelihood that high releases from Jamestown and Pipestem Dams would need to be made. A March 12 snow event resulted in an additional 0.5 to 1.5 inches of SWE. The mid-March survey showed a basin average SWE of 3.7 inches with an additional 2 inches of standing water below the snow and on top of the frozen soil. The NOAA National Operational Hydrologic Remote Sensing Center's (NOHRSC) snow model indicated an estimated 6 to 8 inches of SWE over the basin in mid-March. The Corps' March forecasts indicated similar pool peaks to 2009 and the forecast included the possibility of combined releases higher than 1,800 cfs. Ideal melt conditions were observed with rising temperatures in March. Thawing temperatures during the day and freezing temperatures at night spread the snowmelt over a few weeks. It was estimated that a large volume of snowmelt runoff infiltrated into the soil. This resulted in lower forecasted peak pool levels and construction of advanced-measure levees that began in early March to address combined releases higher than 1,800 cfs, was discontinued. Section 8-12.a.(7) contains a detailed description of the operation of Jamestown and Pipestem Reservoirs during this event. Flood damages prevented by Jamestown Dam for this event were calculated to be $17,079,400.

t. Flood of 2011. By January 1, 2011 NOHRSC-modeled SWE map indicated widespread areas of 3 to 4 inches, which were similar to 2009 and 2010. The Pipestem Dam Tender began taking weekly SWE measurements on January 24. On January 24, the measured SWE at the Pipestem office was about 4.0 inches. At a February meeting, Corps officials recommended local agencies prepare for a combined release of 1,800 cfs. By March 1, NOHRSC-modeled SWE above the reservoirs was 2 to 4 inches with pockets of 5 to 6 inches. The Corps' March runoff forecasts indicated high peak pool levels at Jamestown and Pipestem Reservoirs, but no spillway flows. Very little melt occurred in March, and by April 1, peak SWE values were between 6 to 8 inches over most of the upper basin. Inflows, primarily from snowmelt, resulted in pool elevation increases at both reservoirs.

Since the channel capacity through the City of Jamestown was stressed by the high releases, periodic reductions were made at the reservoirs when rain was expected over the City of Jamestown. This provided additional space in the channel for local runoff downstream of the dams. Starting in late June, the basin began to receive heavy rainfall. From June 18 to August 16, 13 to 30 inches of rain fell in some parts of the basin. Normal rainfall for the period is about 8 inches. Both reservoirs began to rise again after peaking in the spring. Section 8-12.a.(8) contains a detailed description of the operation of Jamestown and Pipestem Reservoirs during this event. Flood damages prevented by Jamestown Reservoir for FY 2011 were $56,899,500.

4-07. Runoff Characteristics. The majority of annual runoff and most of the floods of record in the City of Jamestown vicinity have occurred from the melting of the winter's snow cover and accompanying rainfall. Rainfall-only floods occur less frequently. The seasonal nature of flow on the James River basin and the average streamflow at selected stations in the James River basin are shown on Table 4-3. While the snowmelt runoff has produced the majority of the annual flood peaks, spring snowmelt runoff is

not the only flood hazard. Floods from rainfall may occur since 75 percent of the annual precipitation occurs as rainfall during the April-September period.

4-08. Water Quality. The State of North Dakota has designated Jamestown Reservoir as a Class III lake in the state's water quality standards. The beneficial uses designated for Class I streams are also applicable to all classified lakes in North Dakota. Water quality is also to be suitable for municipal or domestic use after appropriate treatment. Low dissolved oxygen levels have been observed at Jamestown Reservoir in the winter due to the breakdown of organic matter and little mixing because of steady ice cover. See paragraph 8-04 for more information. Some water quality issues occur in the James River downstream of the City of Jamestown water treatment plant during low flows. Because of this concern, the water control plan calls for a small release from Pipestem during the drier months of June, July and August targeting a pool elevation of 1442.5 feet PD by September 1. During dry years this may not be feasible. For more information regarding water quality, see Reclamation's SOP for Jamestown Dam and Reservoir.

4-09. Channel and Floodway Characteristics. The WCP outlines combined flood control releases of 450, 750, 1,200 and 1,800 cfs, depending on reservoir elevations, from the Pipestem and Jamestown Dams. These combined releases are based primarily on the downstream channel capacity. See Section 3-05.e. for a detailed explanation of the James River downstream channel capacity. Generally, the 450 cfs value represents the minimum downstream rural area channel capacity of non-damaging flow. The 750 cfs and 1,200 cfs rates represent intermediate values. The 1,800 cfs value represents the approximate channel capacity within the City of Jamestown at the time of construction of Jamestown Dam (1952). The 1,800 cfs discharge approximately corresponds to the flood stage established by the National Weather Service (NWS) at the James River at Jamestown streamgaging site. As of 2015, streamflow in excess of 1,200 cfs will cause minor damage that requires some action by the City of Jamestown. James River flows in excess of 1,600 cfs will cause significant damage within the City of Jamestown. The estimated channel capacities at various streamgaging locations at and below the City of Jamestown, North Dakota are listed in Table 4-4. Recent observations indicate that streamflows up to 500 cfs do not cause appreciable damages in the low channel capacity reaches. The Pipestem Creek channel capacity in the 6-mile reach between the Pipestem Dam and the confluence with the James River ranges from 1,000 cfs to 2,000 cfs.

Table 4-3
Monthly Mean Streamflow for the James River Basin
(Gage period of record USGS statistics through Sep 2014 except reservoir inflows)

Stream/ Station	Drainage Area (Sq. Mi.) Total	Drainage Area (Sq. Mi.) Non-Contrib [1,2]	Yrs of Rd.	Monthly Mean Daily Discharge (cfs) J	F	M	A	M	J	J	A	S	O	N	D	Ave	Max	Max Date
James/ Grace City	1,060	650	46	1	3	136	376	129	56	64	40	14	9	10	3	70	8,140	4/11/11
James/ Kensal	1,200	750	29	3	3	186	544	194	89	99	78	26	16	19	7	105	8,470	4/18/09
James/ Jamestown Dam[3]	1,760	735	62	3	4	115	427	155	72	70	69	22	20	17	7	82	14,283	4/15/11
Pipestem/ Pingree[4]	700	440	41	2	5	131	236	74	44	64	44	15	12	10	4	53	9,200	4/14/09
Pipestem/ Buchanan[5]	758	460	28	0	1	48	135	53	27	11	5	4	3	2	1	24	6,080	4/10/69
Pipestem/ Pipestem Dam[3]	1,010	416	42	6	12	192	297	106	78	98	66	30	27	20	10	79	9,232	4/14/09
James/ Jamestown	2,820	1,650	76	7	13	108	316	309	244	176	132	111	92	41	13	130	6,390	5/13/50
James/ LaMoure	4,390	2,600	64	21	26	225	553	466	398	308	205	166	149	83	33	219	12,200	4/15/09
James/ Columbia	5,687	726	40	20	16	48	588	625	405	388	251	166	158	127	62	238	9,620	4/24/09
James/ Stratford	8,773	1,126	36	49	31	145	844	909	627	628	450	295	243	192	109	377	9,910	4/26/09
James/ Ashton	9,705	1,379	69	48	31	170	864	923	631	566	434	278	221	193	114	373	9,520	5/2/11
James/ Redfield	13,876	2,007	56	58	40	394	1,104	1,037	712	623	453	281	233	209	127	439	17,000	4/3/97
James/ Huron	15,793	2,050	71	71	62	689	1,565	1,317	911	716	519	326	259	228	142	567	23,400	4/6/97
James/ Forestburg	17,600	2,051	64	88	84	871	1,913	1,588	1,170	849	606	373	298	269	172	690	28,400	3/25/11
James/ Scotland	20,657	2,056	87	103	146	1,057	2,166	1,700	1,461	983	616	354	275	257	180	775	29,400	6/23/84

[1] North Dakota calculated from manual delineation from 1:24,000-scale USGS topographic maps published prior to 1980.
[2] South Dakota calculated from manual delineation of drainage basin to intersection with SD Watershed Boundary Dataset (WBD), based on contours from county-mosaic digital raster graphics (DRGs). WBD dated June 9, 2010, projection: NAD 1983, UTM Zone 14N.
[3] Calculated from peak daily reservoir inflows from Jamestown Reclamation data through September 2014 and Pipestem Corps data through September 2014.
[4] Started in October 1973.
[5] The Pipestem Creek near Buchanan gaging station was established in 1950 and was discontinued in September 1973 because of potential backwater effects from Pipestem Lake. A gaging station was established in 1973 upstream from the old Buchanan gage site and near Pingree, which now serves as the reservoir inflow guide.

A unique channel capacity condition exists along the James River. Normally channel capacity increases as the flow moves downstream and the drainage area increases. However, the James River channel capacity decreases significantly in the river reach between Columbia and Ashton, SD. Flooding in this reach has historically been a common annual occurrence. This reach is commonly referred to as the Lake Plain Region. In this reach the river slope is flat and there are many river oxbows and obstructions. The remoteness of this reach from the City of Jamestown, ND makes it impracticable to meet target flows for this area from releases from Pipestem and Jamestown Dams. Some factors that identify the remoteness are: (1) the two dams together control only about 26 percent of the drainage area above a point just below the mouth of the Elm River near Columbia, (2) the long distance and travel time of 18 to 21 days between the City of Jamestown and Columbia and from anywhere between 10 days to 4 weeks between Columbia and Ashton is excessive, and (3) the lakes of the wildlife refuges located between the City of Jamestown and Columbia have major influence on the streamflow.

Table 4-4
James River Channel Capacities

Streamgage Location	NWS Flood Stage (ft)	Channel Capacity* (cfs)
North Dakota		
Jamestown	12.0	1,920
LaMoure	14.0	2,400**
South Dakota		
Columbia	13.0	959
Stratford	14.0	1,080
Ashton	13.0	2,020
Redfield	20.0	6,190
Huron	11.0	2,390
Forestburg	12.0	2,820
Mitchell	17.0	2,750
Scotland	13.0	4,830
Yankton	12.0	6,140

*Channel capacity flows are based on the NWS Flood Stage value and its correlated flow from the most recent USGS rating curves as of October 2015.
**The LaMoure streamgage flow value is based on the LaMoure County Emergency Management Office assessment of capacity over several years of flooding.

In South Dakota, the James River channel capacity is again limited in the approximate 130 river mile reach between the Sand Lake Refuge and Ashton. A 1977 Reclamation study indicated that about 25 miles of this reach had a bankfull capacity of 200 to 400 cfs. In 1978 and 1979, the James River Water Development District (JRWDD), an organization that represents the interests of the people along this reach, estimated that the channel capacity in this reach at 500 cfs. This reach of the river contains many oxbows and natural and man-made river obstructions that trap sediment and impede streamflow. Most of the man-made obstructions are diversion dams and road crossings that were apparently installed during drought periods, such as the mid to late 1950s and during dry years such as 1961 and 1977. Federal funding was obtained in the 1990s in partnership with the JRWDD for removal of dead trees and logs from the channel and floodplain. Over 28,000 tons were removed, primarily in 1998-1999, and some replacement trees were planted, mostly above the floodplain. While the purpose of the channel cleaning was to increase local channel conveyance, it had negligible impact to the regulation of Jamestown and Pipestem Reservoirs. Updated bankfull capacities are estimated using the NWS flood stage values and applying a rating curve to obtain a flow at that stage, as shown in Table 4-4.

Approximate river flow travel times in the James River basin are shown on Plate 4-11. Rating curves for key gaging stations along the James River and Pipestem Creek are shown in Plates 4-12 through 4-16. The stage-discharge relationships shift over time and are kept current with discharge measurements made by the USGS. Shifted ratings for these stations are stored in the Omaha District WCWQS database.

4-10. Upstream Structures. Arrowwood NWR is located on the James River upstream of Jamestown Reservoir. Shown on Plate 4-17, Arrowwood NWR consists of four main control structures: Depuy Dam, Jim Dam, Mud Dam, and Arrowwood Dam (see Plate 4-18). The refuge has a major impact on the regulation of the Jamestown and Pipestem Dams during flood control periods. Elevations and locations of the control structures relative to Jamestown Dam are shown in Plate 4-19.

4-11. Downstream Structures.

a. The "Ice House Dam." The Ice House Dam is located on the James River just downstream of the James River-Pipestem Creek confluence and Klaus Park in the City of Jamestown (see Plate 4-4). This low head dam is an open concrete weir that was built in the late 1890s and rebuilt in the 1930s to provide refrigeration ice and power for a flour mill. The concrete weir provides regulated flows and pool levels. There is one gate on the small weir and it is normally in the closed position. It is opened only when a drawdown of the pool is desired. The weir creates a small backwater pool on Pipestem Creek just upstream of the James River confluence and also on the James River up to Jamestown Dam. Its operation has been a source of concern since 1993 when high releases from Jamestown Dam impacted houses adjacent to the James River. Some river residents upstream want the gate closed to keep enough water in the river, while others want the gate opened to keep water off the edges of their lawns. To date, no homes have been affected by the operation of the weir. Operation of the gate is decided by the city council vote. Studies indicate that when combined reservoir releases reach 1,800 cfs, there is minimal impact to river stages due to the Ice House Dam.

b. The Oxbow Closure Structure. In the 1970s a cutoff channel was constructed on the James River channel in the southeast part of the City of Jamestown. This created a man-made oxbow on the James River. A plan view of the oxbow dike project can be seen in Plate 4-20. The purpose of the cutoff channel was to convey high flows and protect neighborhoods adjacent to the channel from high stages. When it was constructed, both ends of the oxbow were left open so that water continued to flow through the natural channel to avoid water quality problems. This worked for many years because discharges from the two dams did not exceed 450 cfs. In fact, further development occurred and many new houses were built close to the oxbow channel. This became a problem in 1993 when the combined release from Jamestown and Pipestem Dams exceeded 450 cfs. A number of the houses were impacted by high stages within the oxbow lake. This problem was corrected in 1999 with the installation of gated channel blocks on both the upstream and downstream ends of the oxbow and a permanent pumping station on the downstream structure. Gates on both the upstream and downstream structure are left open until flows on the James River reach 450 cfs, at which point the upstream gate is closed. Once the James River streamflow reaches 650 cfs, the downstream gate is also closed and the pumps are operated automatically. When the water levels in the oxbow reach a certain level due to interior drainage, the pumps automatically turn on and pump water from the oxbow into the James River.

c. Structures below Jamestown Reservoir. A pumping plant is located near Oakes, ND. This pumping plant is part of the Oakes Test Area (OTA) of the GDU. The purpose of this pumping plant is to divert water for irrigation purposes. This pumping plant is not authorized for flood control purposes. Sand Lake NWR near Columbia, SD (see Plate 4-21), which consists of the Sand Lake and the Mud Lake areas, is a major structure downstream from the Jamestown and Pipestem Dams. Sand Lake has two control structures, Columbia Dam and Houghton Dam, which control the flow through the Sand Lake NWR. These structures are not authorized for flood control purposes, but are used to assist the refuge manager in achieving the authorized purposes of the NWR.

4-12. Economic Data.

a. Population. The population trend in towns located along the James River below Jamestown Dam in North Dakota is shown in Table 4-5.

Table 4-5
Population Along the James River below Jamestown Dam

	Population							
ND City	**1940**	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**
Jamestown	8,790	10,697	15,163	15,385	16,280	15,571	15,527	15,427
Montpelier	133	105	97	116	96	82	103	87
Dickey	203	165	143	118	74	53	57	42
LaMoure	990	1,010	1,068	951	1,077	970	944	889
Oakes	1,665	1,774	1,650	1,742	2,112	1,775	1,979	1,856

b. Agriculture. The James River basin is primarily an agricultural area. Soils are generally fertile and a great variety of crops are grown, including corn, soybeans, wheat, which are the principal crops in the basin, and oats, flax, barley, potatoes, hay and forage crops. Based upon the United States Department of Agriculture (USDA) Agricultural Census of 2012, individual farms are large, averaging about 990 acres, and farms of more than 1300 acres are common. Small holdings of livestock are maintained on most farms, including cattle, hogs, and sheep. Some stock feeding is practiced in the southern part of the basin where corn is the principal crop.

c. Industry. There is no mining of commercial importance and little manufacturing in the basin. The area is well served by highway, railroad, and air transportation facilities.

d. Flood Damages. Curves for estimating the magnitude of flood damages at the City of Jamestown and the reach on the James River between the City of Jamestown and LaMoure are shown on Plates 4-22 and 4-23. Damages in the City of Jamestown up to 1,750 cfs are due to basement seepage only, not overbank flows. See Table 4-6 for flood damages prevented by Jamestown Dam.

Table 4-6
Damages Prevented by Jamestown Dam and Reservoir, 1950 to 2015 (in $1,000)

Year	Unadjusted $	Adjusted to 2015 $
1950		
1951		
1952		
1953		
1954		
1955		
1956		
1957		
1958		
1959		
1960		
1961		
1962		
1963		
1964		
1965	130	1,149
1966	1,025	8,738
1967	23	189
1968	0	0
1969	1,303	9,139
1970	0	0
1971	0	0
1972	0	0
1973	0	0
1974	1,010	4,644
1975	1,412	5,991
1976	0	0
1977	0	0
1978	382	1,280
1979	5,406	15,608
1980	0	0
1981	0	0
1982	0	0
1983	1,266	2,943
1984	0	0
1985	0	0
1986	0	0
1987	6,287	13,711
1988	0	0
1989	0	0
1990	0	0
1991	0	0
1992	0	0
1993	7,690	14,159
1994	10,022	17,821
1995	9,557	16,968
1996	12,137	20,718
1997	16,873	27,620
1998	600	980
1999	4,452	7,040
2000	172	269
2001	6,927	10,646
2002	0	0
2003	0	0
2004	129	175
2005	6	8
2006	0	0
2007	0	0
2008	0	0
2009	43,279	50,334
2010	17,079	19,273
2011	56,899	61,847
2012	0	0
2013	4,446	4,662
2014	0	0
2015	0	0
TOTAL	**208,512**	**315,912**

V – DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. Hydrometeorological Stations.

a. Facilities. Within the states of North Dakota and South Dakota, various state and federal agencies have established a system of stream, reservoir, and precipitation gages. The United States Geological Survey (USGS), the NWS, Reclamation, the Natural Resources Conservation Service, the states of North Dakota and South Dakota and the Corps contribute personnel and/or funding to the support the system. Stream and reservoir gage stations pertinent to the regulation of the Jamestown and Pipestem projects are listed in Table 5-1. Precipitation stations are listed in Table 5-2. Stream and reservoir gage locations are shown on Plates 4-1 and 4-2.

All of the stream and reservoir gaging stations are equipped with automatic data collection equipment that allows for near real-time monitoring of the reservoir and stream levels. The USGS makes periodic streamflow measurements at the river gage locations and reports them to the Omaha District WCWQS. These measurements are used to update stage-discharge rating curves. Periodic streamflow measurements are also made by the USGS on the James River below Jamestown Dam and on Pipestem Creek below Pipestem Dam. These streamflow measurements are used to verify the discharge of the dams' outlet works. Historically, reservoir elevations were obtained and recorded by a conventional "bubbler type" water level recorder. Since 1981, Data Collection Platforms (DCPs) have been installed at both the Pipestem and Jamestown projects to automatically collect elevation and precipitation data. A staff gage is also attached to each service spillway intake structure to verify the DCP pool level readings.

The NWS station at the Jamestown State Hospital reports daily snow depths through the winter season. The NWS stations at Fargo, ND and Bismarck, ND also report daily snow depth and water content data through the winter season. The NWS disseminates the snow depth and precipitation data via their website.

The NWS provides current weather conditions, 1- to 5-day forecasts, precipitation reports, river level data and special hydrologic forecasts such as flood warnings. There are many websites that provide a variety of weather products. Available products range from raw data (i.e., precipitation, temperature) to detailed meteorological summaries. In addition to DCP data, other data streams have been added to the Omaha District's database to provide redundant and supplemental information.

Table 5-1
Stream and Reservoir Gage Stations
(Pertinent to Jamestown and Pipestem Reservoir Regulation)

Stream	Station	Drainage Area (Sq. Mi.)[1]	Operating Agency-Type
North Dakota			
James River	near Grace City	1,060 (410)	USGS-DCP
James River	near Kensal	1,200 (450)	USGS-DCP
James River	Arrowwood Lake	-	Corps-DCP, FWS-Staff Gage
James River	Jim Lake	-	FWS-Reference[2]
James River	Depuy Marsh	-	FWS-Staff Gage
James River	Jamestown Dam	1,760 (1,025)	Reclamation-DCP, Staff Gage
Pipestem Creek	near Pingree	700 (260)	USGS-DCP
Pipestem Creek	Pipestem Dam	1,010 (400)	Corps-DCP, Staff Gage
James River	at Jamestown	2,820 (1,170)	USGS-DCP, Staff Gage
James River	at LaMoure	4,390 (1,790)	USGS-DCP
Bear Creek	near Oakes	357 (102)	USGS-DCP
Pilot Drain	at Oakes	5.1	USGS-Recorder
James River	at ND-SD State Line	5,480 (2,180)	USGS-DCP
South Dakota			
James River	Mud Lake Bridge (Houghton Res.)	-	Corps-DCP, FWS Staff Gage
James River	Columbia Dam	-	FWS-Staff Gage
James River	at Columbia	5,687 (4,961)	USGS-DCP
Maple River	at ND-SD State Line	750 (480)	USGS-DCP
Elm River	near Frederick	283 (261)	USGS-DCP
Elm River	at Westport	1,680 (1,170)	USGS-DCP
Elm River	near Ordway	1,504 (1,229)	USGS-DCP
Foot Creek	near Aberdeen	173 (151)	USGS-DCP
Moccasin Creek	at Aberdeen	57.5 (57.5)	USGS-DCP
James River	near Stratford	8,773 (7,647)	USGS-DCP
James River	at Ashton	9,705 (8,326)	USGS-DCP
James River	near Redfield	13,876 (11,869)	USGS-DCP
James River	at Huron	15,793 (13,743)	USGS-DCP
James River	near Forestburg	17,600 (15,549)	USGS-DCP
Firesteel Creek	near Mt. Vernon	587 (587)	USGS-DCP
James River	near Mitchell	19,074 (17,023)	USGS-DCP
James River	near Scotland	20,657 (18,601)	USGS-DCP
James River	near Yankton	20,947 (18,891)	USGS-DCP

[1] Contributing area in parenthesis. Contributing areas are calculated differently by the state USGS offices and may not match with the upstream gage.
[2] Readings of lake levels are made by hand from a reference measuring point.

Table 5-2
Precipitation Stations – National Weather Service[1]
Near the James River Basin in North Dakota

North Dakota (year began)	
Carrington (1929)	Litchville (1951)
Courtenay (1930)	McHenry (1948)
Edgeley (1901)	Montpelier (1948)
Ellendale (1892)	Oakes (1922)
Fullerton (1897)	Pipestem Dam[2] (1985)
Harvey (1948)	Sykeston (1951)
Jamestown Municipal Airport (1948)	Tuttle (1998)
Jamestown State Hospital (1881)	Verona (1948)
LaMoure (1948)	

[1] Data can be obtained from the National Climatic Data Center website: http://www.ncdc.noaa.gov/.
[2] Corps station

b. Reporting. The automated DCPs located throughout the basin transmit river stage, reservoir elevation and precipitation data via a Geostationary Operational Environmental Satellite (GOES) to the downlink at the NOAA National Environmental Satellite, Data, and Information Service. The Omaha District WCWQS maintains a computer server, which is located in Omaha, NE, that receives this data via the downlink and stores it in a water control database. This database provides accurate up-to-date information during critical periods of regulation.

The DCP gages at the projects will normally be used to obtain the pool levels, which are used to determine the daily change in storage. Inflows are computed on the basis of the storage change, releases, and estimated evaporation. Per ER 1110-2-240, the Omaha District WCWQS prepares a Monthly Reservoir Report (MRD Form 0168). Real-time readings of pool elevation and precipitation may be obtained at any time by dialing into and interrogating the DCP. Hourly data can be obtained from the Corps Water Management System (CWMS) database.

The NOAA NOHRSC models plains snow coverage, snow depth and SWE. The model is assimilated with airborne gamma radiation remote sensing and on-the-ground measurements. The Pipestem Dam Tender takes bi-weekly snow depth and SWE measurements near the Pipestem office in January, February and March. These measurements are shared with NOHRSC so they can assimilate these data into their model. If the snow cover is particularly heavy or the need exists, approximately 17 snow survey locations, including 2 downstream of the Jamestown Reservoir and 15 upstream of Jamestown and Pipestem Dams, have been established. Snow depth and SWE measurements are taken by the Pipestem Dam Tender, as requested by the Omaha District WCWQS.

c. Maintenance. A cooperative streamgaging program is maintained by the USGS and Corps. The Corps funds the USGS to maintain the DCPs and some of the associated equipment. Also, rating curves are maintained by the USGS and furnished

to the Corps as they are updated. The gaging station located at Jamestown Dam is maintained by Reclamation's Dakotas Area Office. Rating curves (e.g. stage-discharge relationships) for key streamgaging stations along Pipestem Creek and the James River are shown in Plates 4-12 through 4-16. Similar rating curves for other streamgaging stations are in the Omaha District WCWQS database. The stage-discharge relationships may shift over time and are updated with ongoing discharge measurements made by the USGS. The largest shifts from these stage-discharge relationships will occur when ice forms on the streams. Discharge measurements are made below Jamestown Dam, as needed, in order to verify the gate opening-discharge curve of the Jamestown Dam outlet works.

5-02. Water Quality Stations. For information regarding water quality, see Reclamation's SOP for Jamestown Dam and Reservoir.

5-03. Sediment Stations. No bed or suspended sediment sampling is conducted by the Corps at this project. For information on sediment, see Reclamation's SOP on Jamestown Dam and Reservoir. Reclamation conducted sediment surveys of Jamestown Reservoir 1965 and 2009. Reservoir area and capacity tables were issued based on these surveys. There is 10,000 af of storage in Jamestown Reservoir between the streambed and elevation 1429.8 feet that is designated for 250-year sediment deposition. Since the initial filling (February 1954) and the 2009 Sedimentation Survey, 1,664 af of sediment has accumulated in Jamestown Reservoir (see Table 4-1). Table 5-3 shows the area (in acres) of Jamestown Reservoir as related to elevation. Table 5-4 shows the capacity (storage in af) for Jamestown Reservoir as related to elevation. The detailed capacity table is shown in Exhibit 4 and an area and capacity curve is shown on Plate 5-1. Arrowwood NWR is a series of lakes and sub-impoundments, which are all located within the Jamestown Reservoir flood storage. The area and storage tables for these structures are shown in Exhibit 5.

Table 5-3
Jamestown Reservoir 2009 Survey (Area in acres)

ELEV	0	1	2	3	4	5	6	7	8	9
1390	0	0	0	2	3	11	23	38	63	91
1400	122	160	207	244	287	328	367	414	462	509
1410	552	604	657	706	757	809	869	949	1028	1109
1420	1200	1289	1376	1458	1529	1607	1685	1772	1875	1995
1430	2161	2342	2524	2705	2887	3068	3295	6917	7348	7719
1440	8090	8452	8813	9175	9536	9898	10260	10622	10983	11345
1450	11707	12084	12460	12837	13213	13590	13986	14382	14779	15175
1460	15571	15995	16418	16842	17265	17689	18143	18598	19052	19506
1470	19980									

Table 5-4
Jamestown Reservoir 2009 Survey (Capacity in af)

ELEV	0	1	2	3	4	5	6	7	8	9
1390	0	0	0	1	3	10	27	58	108	185
1400	292	433	616	842	1107	1414	1762	2152	2590	3076
1410	3606	4184	4815	5497	6228	7012	7851	8760	9749	10817
1420	11971	13216	14548	15966	17460	19028	20674	22403	24226	26181
1430	28237	30488	32921	35536	38332	41309	44491	49597	56729	64263
1440	72167	80438	89070	98064	107420	117137	127216	137657	148459	159623
1450	171150	183045	195317	207965	220990	234392	248180	262364	276945	291922
1460	307295	323077	339284	355914	372967	390445	408361	426731	445556	464835
1470	484578									

5-04. Communication Network. The Corps is responsible for the flood control regulation of Jamestown Reservoir. Because Pipestem and Jamestown Dams are operated as a parallel system, the Corps coordinates the regulation of flood storage in Jamestown Reservoir with flood storage in Pipestem Reservoir. The Corps also maintains periodic contact with the State Water Commission of North Dakota, the South Dakota Department of Natural Resources, the Jamestown City Engineer, Stutsman County Emergency Management, LaMoure County Emergency Management, Brown County Emergency Management, the FWS, and the JRWDD in matters relating to Pipestem and Jamestown Reservoir regulation. The Corps cooperates with the NWS and USGS relative to the collection and reporting of precipitation, streamflow and stages.

5-05. Communication with Project.

a. Corps of Engineers with Bureau of Reclamation. The regulation of Jamestown Reservoir is coordinated with various agencies interested in flood control, water supply, wildlife, recreation and related matters by Reclamation. The Corps is responsible for regulation of reservoir storage specifically allotted to flood control. A statement setting forth the specific responsibilities between the Corps and Reclamation as related to the regulation of flood control storage in Jamestown Reservoir and regulation of Jamestown Dam for flood control is included in Exhibit 2, Field Working Agreement. Data collected at the dam will be relayed to Reclamation and the Corps via automated DCPs. The Reclamation's office of the District Engineer via Reclamation's office of the Area Manager, Dakotas Area Office in Bismarck, North Dakota will verify data through field observations.

Telephone and email are used to communicate between Reclamation's Dakotas Area Office and the Omaha District personnel. While voice communications are preferred, email can be used for routine transmission of information. In the rare event of an emergency, as described in Paragraph C of the Standing Instructions to Dam Tender (Exhibit 3), it may be necessary to use vehicular travel between the Dakotas Area Office in Bismarck and the City of Jamestown area. This distance is about 100 miles. The distance between Pipestem Dam and Jamestown Dam is about four miles.

Prior to the issuance of regulation orders for the Jamestown project, Reclamation will normally be consulted and/or advised of the action to be taken. The Omaha District WCWQS will then issue regulation orders directly to Reclamation's Dakotas Area Office. All requests for regulation of project releases will be referred to the Omaha District WCWQS for approval and issuance of orders. All verbal orders will be confirmed in writing as soon as possible. A copy of all orders issued will be furnished to the Reclamation offices in Billings, MT and Bismarck, ND. The written order will contain a brief statement outlining the background and reason for the issuance of the order.

b. Coordination of Regulation with Other Reservoirs. The regulation of Jamestown Reservoir is closely coordinated with that of Pipestem Reservoir. No other reservoirs regulated for flood control purposes now exist on the James River, either upstream or downstream from Jamestown Dam. The FWS has constructed dams in the James River to form wildlife habitat. These dams include several at the Arrowwood Refuge (within the Jamestown Reservoir flood storage pool), the Dakota Lake Refuge in southern North Dakota, and the Sand Lake Refuge in northern South Dakota. In addition, numerous small dams have been constructed by municipalities, utilities or private individuals. Outflow from all the reservoirs formed by these small dams is uncontrolled, and release plans from Jamestown and Pipestem Dams could affect planned operations of the refuges.

5-06. Project Reporting Instructions. The Dam Tender shall keep a log of reservoir and hydrologic data (see Exhibit 3, Standing Instructions to the Dam Tender, for an example). The Dam Tender shall note on the log all regulation orders received, noting the date, time and gate setting. The Dam Tender shall also note on the log any significant event, activity, or complaint regarding regulation of the project, particularly during flood events, and the periodic checks on the accuracy of the DCP and related gaging equipment. The Dam Tender shall retain the log on permanent file in the Pipestem project office. If the Dam Tender is notified or has reason to believe that the pool level will rise suddenly and endanger campers in the Jamestown Reservoir area, all affected individuals shall be notified immediately.

5-07. Warnings. During severe flood periods a summary of hydrologic conditions and reservoir operations will be furnished on a daily basis to the Omaha District Readiness and Contingency Operations office for upward reporting as part of the flood report required by EM 1110-2-3600. The MRBWM office will be kept informed by telephone and email of hydrologic conditions in the James River basin during flood control regulation periods and will be furnished a copy of special directives to the Dam Tender.

VI – HYDROLOGIC FORECASTS

6-01. General. Historically, the majority of the annual inflow into Jamestown Reservoir occurs during March, April and May. As shown in Plate 6-1, the total inflow volume into Jamestown Reservoir for these three months averages 41,374 af, 71% of the average yearly inflow of 58,321 af. The daily inflow frequency curve is shown in Plate 6-2. The daily inflow volume frequency for 1-, 3-, 7-, 15-, 30-, 60-, 90- and 120-day increments is presented in Plate 6-3. Plate 6-4 shows flow frequencies for the James River directly downstream of Jamestown Dam, Pipestem Creek directly downstream of Pipestem Dam and for the James River downstream of the James River-Pipestem Creek confluence. These frequency curves were developed as part of the Corps' 2012 James River North Dakota feasibility study. Plate 6-5 displays the historical annual flow volume at the James River at Jamestown streamgaging site. Of particular note are the extreme wet cycles from 1993-2001 and 2009-11. With the exception of 1993 and 2011, the majority of the runoff for these years came from heavy snowpack. In 1993 a mid-July rainfall event produced some large inflows into the reservoir. In 2011, 20 inches of rainfall was recorded in parts of the Pipestem Creek and upper James River basin upstream of Jamestown Reservoir during a 60-day period from June 18 to August 16.

While Jamestown Reservoir has a large amount of storage available for flood control, it has a disproportionate small outlet capacity. This is a result of the regulation considerations made during the design of the reservoir of storing the runoff of the entire design storm while making little or no release (see Section 3-05.a.). Because of this design, the forecasting of inflows into the reservoir is focused primarily on the volume of runoff rather than the rate of runoff. Simply put, Jamestown Reservoir was designed such that peak inflows are of less concern than the volume of runoff over a period of time and the resultant peak pool elevation.

a. Role of the Corps. The Omaha District WCWQS has the responsibility of preparing a runoff volume forecast for Jamestown Reservoir. This forecast is used to prepare an annual regulation plan for the Jamestown project.

b. Role of Other Agencies. The NWS has the responsibility of issuing flood warnings and flood watches. As part of this responsibility the NWS prepares spring flood outlooks for the entire James River Basin and forecasts peak spring flows and stages for the entire James River at its major tributaries. Generally, the first narrative flood outlook is issued in mid-February and describes basin hydrologic considerations. This is followed by another narrative flood outlook two weeks later at the end of February. These are followed by numeric (deterministic estimate of peak flow and stage) flood outlooks which contain actual results from modeling, if there are flood possibilities. The first numeric outlook comes in mid-March and is again followed two weeks later with the final numeric outlook. In addition, the NWS Missouri Basin River Forecast Center (MBRFC) in Pleasant Hill, Missouri produces a monthly probabilistic forecast that provides the probability of exceeding flood stage any time in the following three months. The forecast can also be used in the production of a long-range reservoir

inflow volume as discussed in Section 6-02.b.(1). The MBRFC forecasts peak stages from rainfall events for many of the streamgaging sites on the James River.

The Reclamation offices in Billings and Bismarck also collaboratively prepare an inflow volume forecast for Jamestown Reservoir, when basin conditions warrant. Both the Reclamation forecast and the NWS forecast are used to corroborate the Corps' inflow volume forecast.

6-02. Flood Condition Forecasts.

a. Requirements. The Corps' annual spring snowmelt runoff forecast considers many factors. The primary ones, in order of importance, are 1) current observed SWE, 2) observed and forecasted spring rainfall, 3) temperatures during the time of the snowmelt and subsequent rate of melt, 4) antecedent moisture and flow conditions during the previous fall and the winter months indicating soil moisture, and 5) frost depth during the melt period. Data regarding these factors is gathered from a variety of sources.

1) Information on the snowpack can be obtained from NWS observers in the basin, special snow surveys conducted by the Corps, and remote airborne gamma surveys conducted by the NWS. Based on these sources of data, NOAA NOHRSC produces modeled SWE maps. In-house maps can be drawn that show the spatial extent of the snowpack for different depths and SWE.

2) Rainfall is also reported through the NWS network of observers and official meteorological stations. In addition, a number of automated tipping bucket and weighting bucket instruments exist at streamgaging sites that report automatically via a DCP. Plates 4-1 and 4-2 show the location of meteorological stations and streamgaging sites in and adjacent to the James River basin.

3) Temperature data during the melt period are obtained via the NWS websites and NWS data directly delivered to the Corps via the Local Data Manager.

4) Antecedent moisture can be obtained from NWS precipitation data and antecedent flow data can be obtained from observed flow at USGS streamgaging stations. In addition, the calculated inflow at Jamestown and Pipestem Reservoirs can be used as indicators of antecedent conditions.

5) Data regarding frost depth can be obtained from a variety of sources - local contractors who are doing trenching or excavation work in the basin, the North Dakota State University's North Dakota Agricultural Weather Network, and the NWS Climate Prediction Center.

b. Methods. In general, forecasting inflows into Jamestown Reservoir can be conducted on a long-range or short-range basis, at different times of the year, and for different reasons.

1) **Long-range forecast of seasonal or annual volume of runoff usually considering snowmelt.** The long-range forecast is completed at the beginning of the runoff season (on or about March 1) and is used to select a regulation plan for Jamestown Reservoir. The results of this forecast are presented at the annual spring James River Operations meeting. The long-range forecast is periodically updated throughout the year as hydrologic conditions change in the basin. These updates are required to ensure that the regulation plan is on track for meeting key target pool elevations. The spring snowmelt volume forecast considers all five factors listed in Section 6-02.a. The volume is estimated through a process of simple calculations and is heavily dependent on the experience and judgment of the forecaster to qualitatively assess all available data, as described below.

    a) What is the SWE and spatial extent of the snowpack? What is an "average" value over the basin of the snowpack? An isohyetal map of the snowpack can be developed and an average SWE for the basin can be determined. The NOHRSC-modeled SWE map is the easiest to be used, but if there are questions about the modeled data, a separate map can be developed based on field measurements.
    b) Is rainfall occurring at the time of the forecast and what are the temperatures? Rainfall and sudden warm temperatures can greatly accelerate the rate of snowmelt. The faster the melt occurs, the greater the percentage of snowpack that will end up as runoff into the reservoir. In addition, the quantity of rainfall can be added to the volume of runoff.
    c) What were the antecedent conditions (soil moisture) prior to the snowpack accumulation and melt period? Dry soil moisture in the late fall could reduce the amount of runoff from the snowmelt because the melted snow may infiltrate into the soil rather than run off.
    d) What is the frost depth? Little or no frost in the ground can reduce the amount of runoff because the melted snow may infiltrate into the soil rather than run off.
    e) What are the Climate Prediction Center's 30-day and 90-day temperature and precipitation outlooks indicating? Will trends in runoff that have occurred over the last few months persist or are conditions expected to change?

After considering all the above data, the percentage of current SWE that will end up as runoff into the reservoir is estimated. Typically, 50 to 75 percent of the SWE will result in runoff. A volume of inflow (af) can be calculated by multiplying this SWE value (feet) by the basin contributing area of 1,000 square miles (1 sq. mi. = 640 acres). Because non-contributing areas can become contributing areas, such as occurred in 1997, the forecaster will need to consider this when forecasting future runoff.

Following completion of the inflow volume forecast, an inflow hydrograph is estimated and used as input to a reservoir simulation (e.g. HEC-ResSim) model. Approximate monthly inflows can be estimated by spreading the inflow over the runoff season based partially on statistical monthly averages shown in Table 6-1 and forecaster experience and judgment. By coordinating the regulation of Jamestown Reservoir with Pipestem Reservoir, release scenarios from Jamestown Reservoir are specified in the model and resultant pool elevations are determined. As the snowmelt progresses and inflows into the reservoir crest, a more accurate forecast can be made. As inflows recede, the forecast can be further refined. As a guide, a recession coefficient of 0.92 has been found to give reasonable results when estimating the volume under the receding limb of the inflow hydrograph.

Forecasting methods have been outlined for several high flow years. See the Pipestem Dam write-up in Appendix B14 of the "Tributary Reservoir Regulation Activities Annual Report" for several of the high flow years, especially 1997, 2009, 2010, and 2011. The After Action Reports for these flooding events also contains additional information on how the forecasts were developed.

Table 6-1
Percent of the Annual Flow Volume Received by Month

	Jamestown Reservoir Inflow[1]	Pipestem Reservoir Inflow[1]	James River at Jamestown
January	0.3%	0.7%	0.7%
February	0.4%	1.3%	0.7%
March	11.5%	21.8%	4.8%
April	45.2%	31.6%	18.4%
May	14.4%	9.6%	19.5%
June	6.0%	7.6%	15.1%
July	7.5%	10.8%	11.9%
August	7.6%	7.3%	9.9%
September	2.6%	3.3%	8.3%
October	2.0%	2.9%	6.4%
November	1.7%	2.1%	3.1%
December	0.7%	1.1%	1.2%

[1]Percentages may not add up to 100.0% due to small rounding errors.

2) **Short-range forecast of a flood runoff hydrograph from rainfall.** Future model development plans include finalizing four models: an HEC-HMS model that will provide runoff hydrographs from rainfall and gridded snow, an HEC-ResSim model that will give more flexibility in exploring

alternative reservoir regulation simulations, an HEC-RAS model that will give inundation information, and an HEC-FIA model that will provide quantitative estimates of damages due to flooding. These models were developed to run individually, but in the future they will be calibrated and incorporated in the CWMS to be used in real-time modeling.

6-03. Conservation Purpose Forecasts. Jamestown Dam and Reservoir is a Reclamation project for which the Corps only has flood control responsibilities. The Corps does not prepare conservation purpose forecasts for Jamestown Reservoir.

6-04. Long-Range Forecasts. For a discussion of the long-range seasonal forecast, see Section 6-02.

6-05. Drought Forecast. Jamestown Dam and Reservoir is a Reclamation project for which the Corps only has flood control responsibilities. The Corps does not prepare drought forecasts for Jamestown Reservoir.

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VII – WATER CONTROL PLAN

7-01. General Objectives. Jamestown Dam's authorized purposes include flood control, irrigation, municipal water supply, stream pollution abatement, recreation and wildlife, and potential power generation.

Section 9 of the Flood Control Act of 1944 authorized the Jamestown Dam and Reservoir project as a Department of Interior project that is managed by Reclamation. Under Section 7 of this act, the Corps is directed to regulate all federally constructed projects when water is in the flood control zone. Since Jamestown and Pipestem Dams are regulated jointly as a system this water control plan focuses primarily on the regulation of both dams for flood control.

Flood control storage is provided in Jamestown Reservoir in part to reduce flood damages in the City of Jamestown. Based on past flood events, as shown in Plates 8-9 through 8-15, and a maintained river flood channel, the project, combined with the Pipestem project, provides considerable downstream flood reduction to the City of Jamestown. Regulation of the two projects when the pools are in their respective flood control zones will also be based on reducing flows to the safe discharge capacity of the river channel downstream from the City of Jamestown. However, regulation of the projects targeting specific stages on the James River below LaMoure, ND is not practical because of the long travel time as well as the significantly decreased non-damaging channel capacity. As represented in this WCP, hydrologic conditions over the entire James River drainage basin and flows on the entire James River are still a consideration in determining project releases.

7-02. Constraints. The Jamestown and Pipestem projects are regulated as a system during flood conditions. Both projects have constraints that affect how they are operated during flood events:

a. Physical Constraints at Jamestown Reservoir. The main gates at Jamestown Dam experience cavitation problems with low releases. Minimum releases through the gates are held to 40 cfs, which is equivalent to a 0.2-inch gate opening. Releases of 450 cfs or higher affect access to the low water crossing below the spillway. Spillway releases at or above 2,500 cfs affect the second and third downstream wingwall support timbers.

b. Reduced Channel Capacity through the City of Jamestown. See Chapter 3 for an historical detailing of channel capacity. The project was constructed during a time when the channel capacity through the city was 1,800 cfs. The early regulation plans were based on this channel capacity, and many of the current regulation problems are related to the fact that this level of channel capacity can be lost during low flow years due to channel aggradation and vegetation. In the channel through the City of Jamestown, flows of 450 cfs to 1,200 cfs cause isolated basement seepage in homes located directly along the river. Combined releases above 1,800 cfs start to inundate city streets, and a combined release above 2,000 cfs affects the City of Jamestown

infrastructure and requires dike construction. When the Corps plans to make combined releases exceeding 750 cfs, the Corps shall notify the City of Jamestown so city personnel can plug storm sewers. At river flows above 1,250 cfs, water backs into the storm drains and causes minor ponding in several streets. During extended periods of high releases, infiltration into the City of Jamestown sanitary sewer can potentially overload the system necessitating raw sewage to be pumped into the river. In 2009, James River flows of 3,200 cfs caused problems with the sanitary sewer.

c. Long Travel Time and Reduced Channel Capacity of the James River in northern South Dakota. The James River in South Dakota has the flattest gradient of any river its length in North America. The gradient is so flat that high flows take several weeks to travel through the entire basin (see Plate 4-11). Most of the tributaries have steeper gradients than the James River. High flows on the Elm River, one of the major tributaries, can cause James River flows to reverse direction and move upstream in the reach upstream of the Elm River-James River confluence. Another unique feature of the James River is the reduction in channel capacity as the river travels downstream through northern South Dakota. Channel capacity on sections of the James River in northern South Dakota has been estimated to be as low as 200 cfs. This constraint has led to a need for increased coordination with stakeholders downstream of the projects and influences the timing and magnitude of project releases.

d. Flooding at National Wildlife Refuges on the James River. Arrowwood NWR, constructed prior to the construction of Jamestown Dam, is located just upstream of the permanent pool at Jamestown Reservoir and within the Jamestown Reservoir flood control pool. When pool elevations in Jamestown Reservoir exceed 1431.0 feet, the ability to manage the water levels at Arrowwood NWR and meet habitat management objectives is adversely affected. A bypass channel was constructed to allow water to bypass NWR lakes or be moved from lake to lake within the refuge, but the ability to move water within the bypass channel is heavily impacted by Jamestown Reservoir pool levels. The headwaters of Jamestown Reservoir “touch” the furthest downstream NWR gate structures when the Jamestown Reservoir elevation is in the joint use pool. The downstream invert of the bypass channel is at 1428.0 feet and the bottom of the outlet structure for Depuy Dam is 1430.0 feet. When the elevation in Jamestown Reservoir exceeds 1436.4 feet, the refuge gate structures are inundated and the refuge completely loses its regulation capabilities. The refuge sustains substantial erosion to its earthen dikes when the Jamestown Reservoir pool is in the 1440.0 to 1442.0 feet range. When Jamestown Reservoir’s pool elevations rise above 1442.0 feet, the spillway at Arrowwood NWR, which houses the electronic fish barrier, overtops resulting in fish passing upstream of the barrier. Jamestown Reservoir pool levels above 1445.0 feet result in overtopping of county and township roads that cross the Arrowwood NWR. Due to the constraints at Arrowwood NWR, evacuating the flood control pool at Jamestown Reservoir is given a higher priority over other management objectives. Prolonged high releases from Jamestown and Pipestem Reservoirs can also affect both the downstream Dakota Lake and Sand Lake NWRs by interfering with the water management at these refuges, particularly during the growing season. Changes in water levels can impact over-water nesting birds during the nesting season.

High pool elevations in the refuges also limit the ability of the managers to draw down the pools before the winter season. This compounds the refuges' problems during the spring. Impacts to these refuges are considered when determining a release schedule. See Plate 4-17 through Plate 4-19 for detailed maps of the Arrowwood NWR and Plate 4-20 for a map of the Sand Lake NWR.

e. Inability to Pass the Probable Maximum Flood at Jamestown Reservoir. The Jamestown project was originally designed in 1951 to safely pass the Inflow Design Flood (IDF), a hypothetical flood event that the dam is designed to safely pass with adequate freeboard. In 1986 a revised IDF was developed using the same volume as the PMF, which has a considerably larger volume than the original IDF. The project is capable of safely passing 91 percent of the revised PMF but cannot safely pass the full PMF. The Pipestem project can safely pass its PMF. Refer to Section 8-02 for more details. The inability of the Jamestown project to pass its PMF requires scheduling higher releases from Jamestown Dam than from Pipestem Dam when both projects have water stored in their respective flood control pools.

f. Upstream Impacts from High Pool Levels. Pool levels in the flood control zone in Jamestown and Pipestem Reservoirs cover a large area upstream of the dams. Several roads and bridges are inundated, requiring detours of several miles primarily impacting local traffic. Some cabins along Jamestown Reservoir flood when the pool level reaches elevation 1454.0 feet. The high pool levels at Jamestown Reservoir in 2009 prompted some cabin owners to build emergency levees for temporary protection. See Plate 7-1a and Plate 7-1b for modeled flood inundation of Jamestown Reservoir at pool level 1431.0 feet. Flowage easements are in place upstream of Pipestem Dam to allow flooding of agricultural land outside of the Corps property boundary.

7-03. Overall Plan for Water Control.

a. Storage Allocations. The storage space in Jamestown Reservoir is allocated as shown in Plate 7-2 and described below.

1) **Surcharge Storage.** Surcharge storage capacity allocation shall include the storage capacity between elevations 1454.0 feet, which is the elevation of the uncontrolled spillway crest, and 1464.4 feet. The surcharge storage zone is provided in combination with spillway capacity to ensure safety of the structure. The storage in this zone, based on 2009 surveys, amounts to 158,917 af.

2) **Exclusive Flood Control Storage.** Flood control storage capacity allocation shall include the storage capacity between elevations 1431.0 and 1454.0 feet, for which suitable outlet works have been constructed to provide discharges as expressly indicated herein. Based on 2009 surveys, storage in this zone amounts to 190,502 af.

3) **Joint Use Storage.** Joint use storage capacity in Jamestown Reservoir shall include the storage capacity between elevations 1428.0 and 1431.0 feet. This storage is used for project purposes such as irrigation, municipal and industrial water supply, and recreation and wildlife conservation. In addition to these project purposes, the portion of the joint use zone between elevations 1429.8 and 1431.0 feet is also used for flood control storage. Based on 2009 surveys, this portion of the joint use storage includes 2,680 af of storage. The remaining portion of the joint use zone, between elevations 1428.0 and 1429.8 feet, includes 3,582 af of storage. The target pool levels in the overall joint use zone vary seasonally based on mutual agreement between agencies for conservation uses.

4) **Conservation Storage.** Conservation storage capacity allocation shall include the storage capacity between elevations 1400.0 and 1428.0 feet. Storage in this zone initially amounted to 28,088 af, of which 9,178 af was provided for the accumulation of sediment. This left a net planned conservation storage capacity allocation of 18,910 af. Current conservation storage based on 2009 surveys amounts to 23,934 af.

5) **Dead Storage.** Dead storage capacity shall include the storage capacity between the streambed elevation, which is approximately 1390.0 feet, and elevation 1400.0 feet, initially amounting to 822 af. This capacity is established by the elevation of the outlet works, and provides for the accumulation of sediment in addition to the 9,178 af provided in the conservation storage zone. Current dead pool storage based on 2009 surveys amounts to 292 af.

b. Normal Flood Control Regulation Plan. The Corps assumes regulation of the Jamestown project when pool levels are in the flood control pool. When this occurs, the Jamestown project is regulated jointly with Pipestem Dam to achieve the primary objective of downstream flood control. The WCP for flood control operations for the Pipestem and Jamestown projects is flexible. It is designed to allow the water control managers to make release adjustments based on hydrologic conditions in the James River basin both upstream and downstream of the projects.

Two key elements of the WCP include:

1) forecasting the total runoff volume and
2) holding agency meetings to gather feedback regarding that year's regulation plan for the projects.

Specific objectives in close proximity to the dams and reservoirs include:

1) reducing flood damages in the City of Jamestown, ND,
2) minimizing impacts at the North Dakota Arrowwood NWR, and

3) maintaining dam safety at Jamestown and Pipestem Dams.

Downstream objectives include:

1) reducing agricultural damages downstream from the City of Jamestown and
2) reducing the adverse effects of high downstream flows in North Dakota and South Dakota and in the South Dakota NWRs of Dakota Lake and Sand Lake.

Achieving these objectives is accomplished by evaluating conditions both upstream and downstream from the reservoirs, determining a total release rate from the two projects, and giving priority to releasing water from one reservoir or the other, depending on this evaluation.

7-04. Standing Instructions to Dam Tender. The Omaha District WCWQS will issue the regulation orders through Reclamation's Dakota Area Office. Since Reclamation does not have a Dam Tender permanently onsite at the Jamestown project, actual gate changes can be made by several different individuals in Reclamation's behest, most notably the Corps' Pipestem Dam Tender. Due to the close proximity of the Pipestem Project Office and close coordination of Jamestown Dam with Pipestem Dam, gate changes may be made by the Pipestem Dam Tender. All requests for regulation of project flood control releases will be referred to the Omaha District WCWQS for approval and issuance of orders. A copy of all orders issued by the Omaha District WCWQS will be furnished to the Reclamation's Area Manager, Dakota Area Office. The order will contain a brief statement outlining the background and the reason(s) for its issuance. Exhibit 3 contains the detailed Standing Instructions to the Dam Tender.

7-05. Flood Control Operations. A flood control plan for the joint regulation of Pipestem and Jamestown Reservoirs was developed according to Flexible Plan B, which was the preferred regulation plan as outlined in the 2000 WCP Review. A summary of the range of releases that can be expected for flood control regulation are shown on Table 7-2. The flexible release plan, which is developed on an annual basis, is dependent on changing hydrologic conditions and varying agency objectives. Each spring the Corps and Reclamation will independently evaluate basin and reservoir conditions. An agency meeting will be conducted where that year's regulation plan is determined. The selected regulation plan will primarily be dependent on the amount of the forecasted runoff volume into the reservoirs and on the stated objectives of the agencies. As the year progresses, the selected regulation plan may be modified if basin and hydrologic conditions change in order to meet the management objectives and considerations described in Section 7-01.

a. Flood Control Regulation of the Joint Use Pool.

1) **History of changes to the joint use pool.** The first flood control agreement between the Corps and Reclamation developed in 1957 defined the base of

the flood control pool at elevation 1429.8 feet. No joint use pool was defined. The reservoir first filled to elevation 1429.8 feet in 1965. Following this initial fill, interest from recreationists at Jamestown Reservoir resulted in a new water control agreement in 1968 that included the establishment of a seasonal joint use pool between elevations 1429.8 and 1432.0 feet. This new joint use pool allowed for a higher summer pool level of 1432 feet. In 1972, the 1968 agreement was modified to include a provision for a summer flow of 10-20 cfs to alleviate stagnant conditions in the James River through the City of Jamestown. To account for the additional flow needed during the summer, the top of the joint use pool was raised to 1432.67 feet, which provided enough additional storage to keep the pool at or above 1432.0 with the summer release. In 1997, Reclamation, the Corps, and FWS agreed to lower the bottom of exclusive flood control pool from 1432.67 feet to 1431.0 feet. This action reduced the joint use pool used for flood control from the range of 1429.8 – 1432.67 feet to 1429.8 – 1431.0 feet. The lowering of the top of the joint use pool to 1431.0 feet was done to improve water management capabilities at the Arrowwood NWR. In addition, Reclamation agreed to lower the base of the joint use zone from 1429.8 feet to 1428.0 feet to maintain about the same joint use volume as the historical joint use pool (between 1429.8 and 1432.67 feet). Maintaining the same joint use storage would allow Reclamation to continue to provide traditional joint use pool benefits, including providing a summer flow to alleviate stagnant conditions in the James River through the City of Jamestown, when necessary. See Plate 7-2 for current storage allocations in the Jamestown Reservoir.

2) **Flood Control Regulation of the joint use pool (1429.8 to 1431.0 feet).** With the current joint use pool levels there is additional flexibility in how low the pool will be drawn down in the summer and fall months. For purposes of water control regulation and authority of the Corps, the base of the flood control pool remains at 1429.8 feet. For flood control storage requirements, elevation 1429.8 feet remains the minimum required pool level that the reservoir will be drawn down prior to winter. Reclamation has the option of lowering the reservoir below elevation 1429.8 feet should it be desirable based on conservation needs, water quality concerns, basin hydrologic conditions, and other operation and maintenance needs. The decision to lower the pool below this level is not based on flood control requirements and is solely Reclamation's decision. Details of the flood control regulation of the joint use pool are described in Table 7-1.

Table 7-1
Flood Control Regulation of the Joint Use Pool

The overall joint use space between elevations 1428.0 and 1431.0 feet will be used for seasonal multipurpose regulation. For purposes of flood control storage the reservoir water elevation will be no higher than 1429.8 feet at the beginning of the spring runoff period. The flood control portion of the joint use pool (between elevations 1429.8 and 1431.0 feet) will be used for storage and regulation of the spring runoff and summer rainstorms. In addition, water stored in this zone may be used during the summer months for conservation purposes. Storage remaining in the joint use pool above elevation 1429.8 feet after September 1 will be evacuated as directed by the Corps.

Reclamation has the option of lowering the reservoir below elevation 1429.8 feet should it be desirable based on water supply needs.

SEASON: BEGINNING OF SPRING RUNOFF TO SEPTEMBER 1

Elevation 1429.8 feet (base of flood control zone) to 1431.0 feet (top of joint use pool)

Release greater of:

a. conservation releases
b. based on inflows occurring at the time and the existing potential for further inflows, releases will be maintained as necessary according to the WCP.

SEASON: SEPTEMBER 1 to NOVEMBER 1

Make releases necessary to evacuate storage in Jamestown Reservoir to elevation 1429.8 feet prior to November 1.

SEASON: NOVEMBER 1 TO BEGINNING OF SPRING RUNOFF

Make releases necessary to maintain elevation 1429.8 feet.

b. Types of Flow Years. In order to meet the management objectives and considerations, regulation guidelines have been developed for the type of flow year (calendar year) that is forecast to assist in preparing an annual regulation plan. The type of flow year is classified into one of three categories: low flow year, medium flow year, or high flow year. The flow category is based on the total combined forecasted annual inflow volume for both Jamestown and Pipestem Reservoirs for the calendar year. The forecasted annual inflow volume is normally prepared in the late February to late March timeframe just prior to when the snowmelt begins in the Northern Great Plains. This forecast represents the spring snowmelt volume plus average rainfall runoff volume for the remainder of the year. A plot of historic flow volumes for the James River at Jamestown, ND streamgaging site is shown in Plate 6-5.

1) **Low Flow Year (Combined inflow of less than 90,000 af).** A low flow year is defined as a year when the combined inflow volume for the calendar year is less

than 90,000 af. A low flow year has occurred in 32 of the 45 years of record-keeping (1954-1998, 2000 WCP Review). In low flow years, plains snow is very limited, and thus little snowmelt runoff is realized. At the upper end of the low flow year record, enough runoff occurs from snowmelt and rainfall to result in the pool level at Jamestown Reservoir rising 2-3 feet above the base of the joint use pool of 1429.8 feet and the pool level at Pipestem Reservoir rising up to 20 feet above the base of its flood control pool of 1442.5 feet PD. The low flow years are generally very dry years and downstream flow augmentation, especially during the summer months of June, July, and August, is desirable for environmental, water quality and water supply purposes. During drought years, the regulation of Jamestown Reservoir focuses on water conservation to meet recreation and water quality needs. Impacts to Arrowwood NWR are minimal.

During low flow years:

a) water management in drought years has a direct impact on fish populations in both reservoirs and downstream of the dams and
b) downstream flow support helps the James River fish and wildlife, but can be at the expense of the reservoir's fishery and wildlife use.

There was limited analysis of the benefits or impacts to the reservoir's fisheries from following these release criteria.

2) **Medium Flow Year (Combined inflow of 90,000 – 160,000 af).** Medium flow years, where the combined inflow volume for the calendar year ranges from 90,000 to 160,000 af, occurred in 8 of 45 years of record-keeping (1954-1998, 2000 WCP Review). Typical maximum pool levels at Jamestown Reservoir range from 3 to 10 feet (elevation 1434.0 to 1441.0 feet) into the exclusive flood control zone. Peak Pipestem reservoir pool levels range from 20 to 40 feet (elevation 1462.5 to 1482.5 feet PD) into the flood control zone. In medium flow years, downstream low flow augmentation is not a goal. Typically, the main objective during medium flow years is to evacuate stored flood waters in Jamestown Reservoir early in the year while storing flood waters in the Pipestem Reservoir flood control pool.

During medium flow years, priority is shifted to:

a) holding flood waters at Pipestem Reservoir to minimize impacts to downstream farming interests and
b) releasing water early from the Jamestown Reservoir flood control pool to reduce flooding at the Arrowwood NWR.

3) **High Flow Year (Combined inflow exceeds 160,000 af).** High flow years, where the combined inflow volume for the calendar year exceeds 160,000 af, occurred in 5 of 45 years of record-keeping (1954-1998, 2000 WCP Review). In the 16 years (1999-2014) since completion of the 2000 WCP Review, seven of these years have fallen in the "High Flow Year" category. This would suggest that "High Flow Years" might occur more frequently than the 2000 WCP Review would indicate. During

high flow years, the maximum pool level at Jamestown Reservoir generally exceeds elevation 1441.0 feet and the maximum pool level at Pipestem Reservoir exceeds elevation 1470.0 feet PD.

In high flow years, priority is shifted to:

a) safely evacuating accumulated storage,
b) avoiding combined releases greater than 1,200 cfs,
c) preventing uncontrolled spillway flow at either project, and
d) maintaining dam safety.

During high flow years:

a) there is much less flexibility in setting releases from the reservoirs,
b) the water control structures at Arrowwood NWR are completely inundated by the backwater affect of Jamestown Reservoir and the refuge's primary habitat management objectives cannot be met, and
c) reducing flooding in the Arrowwood NWR is NOT a consideration in determining project release rates.

c. Periods of the Regulation Year. The regulation goals for Jamestown and Pipestem Reservoirs change during the periods of each year. For these projects, the regulation year can be divided into four periods.

1) **Ice-out to June 1.** Ice-out is defined as the date the downstream channel between the dams and LaMoure is open enough to allow releases from the two projects. June 1 is a general target date that serves as a "goal" for Jamestown Reservoir to reach elevation 1431.0 feet, the base of the exclusive flood pool. By evacuating the flood storage down to this level by or near this date, Arrowwood NWR personnel can then normally manage the refuge pools during the upcoming growing season.

2) **June 1 to September 1.** Generally, the June 1 through September 1 period is when releases are made to evacuate exclusive flood control storage. In addition, releases are made from the conservation storage zone at Jamestown Reservoir to meet downstream authorized purposes.

3) **September 1 to November 1.** September 1 is typically the end of the recreation season and is the date that releases are initiated or adjusted, if necessary, to meet the fall drawdown elevation for the given year. The reservoirs are drawn down in the fall to provide additional flood storage for the coming spring. Fall drawdown will depend on conservation needs, moisture conditions in the James River basin and projected drawdowns of pools in Arrowwood NWR. Reclamation is responsible for determining releases from Jamestown Reservoir when the pool level is below elevation 1431.0 feet. The only flood control requirement is that the flood control pool at

Jamestown Reservoir be drawn down to elevation 1429.8 feet by November 1. Fall drawdown for non-flood control purposes will typically be to a level below 1429.8 feet, the base of the joint use flood control pool. November 1 is the end of the regulation season and the flood control pools at both reservoirs should be evacuated. The fall drawdown target date used in historic water control plans was November 15. This was changed to November 1 in the 2008 water control plan update to provide a two-week margin of safety for offsetting unexpected runoff and forecast error.

4) **November 1 to Ice-out of the following year.** During this period combined releases from Jamestown and Pipestem Dams will normally be held to a maximum of 100 cfs to maintain Pipestem and Jamestown Reservoir levels at a relatively constant level until spring snowmelt inflows begin. Flood control zone releases are generally not initiated or increased until ice-out as defined in paragraph 7-05.c.1. During this period Jamestown Reservoir releases will be made only when winter inflows result in water accumulating substantially in the flood control zone. Pipestem Reservoir will be self-regulating with any winter inflows passing over the service spillway into the downstream channel. If winter releases are required, the release rate should be held constant throughout the winter as much as possible to lessen the chance of ice jams forming downstream.

d. Release Schedule for Flood Control. Table 7-2 shows a summary of the range of releases that can be expected from Jamestown and Pipestem Reservoirs during flood control operations. Table 7-2 is a guide and should not be used to strictly determine releases for any given type of flow year or reservoir elevations. Rather, Table 7-2 presents the normal range of estimated releases when the regulation of the two reservoirs was simulated for 45 years of inflow record-keeping (1954-1998, 2000 WCP Review). Additional guidance for each type of flow year is presented Section 7-05. Releases for any given year and reservoir elevations could fall outside the ranges specified in Table 7-2. Releases during these periods will be based on the objectives described in this chapter and coordination with other agencies.

Table 7-2
Summary of the Range of Releases for Each Type of Flow Year

This table is not to be used as the final guide in determining releases under real-time conditions. For additional guidance in determining releases, refer to the detailed discussion in this chapter and the footnotes following this table.

Footnote	Type of Flow Year	Forecast Calendar Year Inflow Volume (af)	Typical Peak Annual Reservoir Levels		Normal Maximum Release		Normal Maximum Combined Release (cfs)
			Jamestown Pool Level (feet)	Pipestem Pool Level (feet PD)	Jamestown Reservoir (cfs)	Pipestem Reservoir (cfs)	
1.	High	more than 160,000	above 1445.4	above 1489.0	1,200-1,800	1,200-1,800	1,800
2.	High	more than 160,000	1440.0-1445.4	1478.2-1489.0	750-1,200	750-1,200	750-1,800
3.	High	more than 160,000	below 1440.0	1478.2-1489.0	450-750	750-1,200	750-1,200
4.	Medium	90,000 - 160,000 –	below 1440.0	below 1478.2	450	450	450-750
5.	Low	less than 90,000	below 1433.0	below 1460.0	200	120	200

Footnotes:

1. Combined release of 1,800 cfs. Release proportion from Jamestown and Pipestem Reservoir is based primarily on the percentage of flood control storage occupied at each reservoir.
2. Combined release ranges from 750 to 1,800 cfs. Jamestown Reservoir release will range from 750 cfs at the low end (elevation of 1440.0 feet) increasing to 1,200 cfs at the high end (elevation of 1445.4 feet). The release from Pipestem Dam will depend on the release from Jamestown Dam and also on the pool level at Pipestem Dam. For example, if both Jamestown Dam and Pipestem Dam are near the upper end of the pool ranges specified, Jamestown Dam release would be near 1,200 cfs and Pipestem Dam would be near 600 cfs for a combined 1,800 cfs release. If both pools are near the low end of the specified pool range, the combined release would be near 750 cfs. If Pipestem Dam is near the upper end (1489.0 feet PD) and Jamestown Dam is near the low end (1440.0 feet), the combined release would be closer to 1,200 cfs with the greater part of the release coming from Pipestem Dam.
3. Combined release ranges from 750 to 1,200 cfs. The combined release should be distributed between both projects until the pool level at Pipestem Dam is below 1478.2 feet PD. Then, either maintain the higher release (see “ADDITIONAL NOTES” below) or reduce the combined release to a lesser discharge until Jamestown Dam reaches 1431.0 feet and Pipestem Dam reaches 1450.0 feet PD. Evacuate the remainder of the stored flood waters from both projects by November 1.
4. Combined release ranges from 450 to 750 cfs. Release no more than 750 cfs until the Jamestown Dam target of 1431.0 feet is met and until Pipestem Dam reaches a pool level where a Pipestem Dam release of 50 cfs is sufficient to evacuate flood storage at Pipestem Dam to 1442.5 feet PD by September 1. Evacuate the remainder of the stored flood waters from Jamestown Dam to elevation 1429.8 feet by November 1.
5. Use constant release option. Alternate releases between the two projects. First, evacuate flood storage from Jamestown Dam to 1431.0 feet by June 1. Then, evacuate flood storage from Pipestem Dam to 1442.5 feet PD by September 1. Finally, evacuate flood storage from Jamestown Dam to 1429.8 feet by November 1.

ADDITIONAL NOTES:

- The forecast flow volume is the total combined forecast annual inflow for both Jamestown Dam and Pipestem Dam for the calendar year. The forecast inflow is derived from the spring snowmelt volume plus average rainfall runoff volume for the remainder of the year. If above-normal runoff from rainfall occurs, releases may change from what are shown in the table.
- Once the maximum release for the year has been reached, that release may be continued even as the pool drops through the different elevation zones indicated by Table 7-2.
- During the winter season (November to beginning of spring runoff) releases should not result in the James River flow to exceed 100 cfs at the James River at Jamestown streamgaging site.

e. Reservoir Regulation in Low Flow Years. The overall objectives for low flow years are 1) to meet target elevations at Jamestown Reservoir, 2) to store spring inflow at Pipestem for release during the months of June, July, and August, and 3) to maintain a reasonably constant combined low flow release. By meeting target pool levels at Jamestown Reservoir, water management at the Arrowwood NWR can be accomplished. Maintaining a constant low flow provides the lowest damage potential to downstream areas and also benefits downstream water users and environmental concerns.

1) **Details of Jamestown Reservoir Regulation during Low Flow Years.** Releases from Jamestown Reservoir shall be made with the following objectives:

a) Target elevation of 1431.0 feet or below on June 1
b) Maintain elevation at 1431.0 feet or below until September 1
c) Evacuate flood storage to elevation 1429.8 feet by November 1

The Jamestown Reservoir pool level is managed to be at or below 1431.0 feet on June 1 or as early as possible. In many of the low flow years there is not sufficient runoff to fill the pool to elevation 1431.0 feet. If the pool is below 1431.0 feet and it is before November 1, releases are determined by Reclamation. The only flood control requirement is that the flood control pool be completely evacuated down to elevation 1429.8 feet by November 1. By maintaining a pool level at or below elevation 1431.0 feet on June 1, Arrowwood NWR personnel have the ability to manage the four refuge pools at target levels and pass minor inflows through the refuge downstream to Jamestown Reservoir. FWS has indicated that reaching target levels on or before June 1 is critical to meet the refuge's habitat management objectives. The refuge is managed to produce sago pondweed and create moist soil moisture conditions to provide needed food sources and habitat conditions for ducks, geese, and a variety of other resident and migratory birds during the nesting season and migration. If the Jamestown Reservoir pool level is over five feet into the flood control pool of 1431.0 feet on June 1, FWS considers it a "lost" year in terms of refuge water management. For the 32 low flow years between 1954 and 1998 that were modeled, the actual required release never exceeded 200 cfs.

During low flow years, Jamestown Reservoir is managed at or below elevation 1431.0 feet through the summer until September 1. Historically, management of the pool level involved making releases to provide a steady pool elevation for recreation and meeting downstream project demands. Habitat manipulation or water level management implications were not considered during these early management efforts. Water management can be a part of the regulation scheme to provide for better recreational benefits to the system as well as to provide benefits to refuges such as the Arrowwood NWR. By maintaining the reservoir elevation at or below 1431.0 feet, the refuge also has a much better chance of passing inflows resulting from summer thunderstorms without greatly exceeding their refuge pool target elevations.

From September 1 to November 1, the primary management objective for Jamestown Reservoir is to make constant releases so that the Jamestown Reservoir pool elevation is drawn down to 1429.8 feet by November 1. This accomplishes the evacuation of the flood control pool for the following spring runoff. For extremely low flow years, no release was necessary due to low pool levels and evaporation. For the rest of the low flow years, the release ranged upwards to 100 cfs.

2) **Details of Pipestem Reservoir Regulation during Low Flow Years.**
The operation of Pipestem during a low flow year can be generally summarized as follows:

a) Little or no release during the spring snowmelt period up to a pool elevation of 1460.0 feet PD as long as Jamestown Reservoir elevation is above 1431.0 feet.
b) Constant release during the dry months of June, July, and August targeting a pool elevation of 1442.5 feet PD by September 1.
c) Evacuate the remainder of the storage in the flood pool from September 1 to November 1.

The Omaha District WCWQS coordinates Pipestem Reservoir releases with Reclamation so that combined releases are as constant as possible over the entire period from ice-out until November 1. Normally, when Reclamation is scheduling increases to Jamestown Reservoir releases, the Corps reduces Pipestem Reservoir releases. When Jamestown Reservoir releases are reduced, Pipestem Reservoir releases are increased. As much as possible, spring inflow is stored in Pipestem Reservoir to be released during the dry months of June, July, and August. Only small releases are made from Pipestem Reservoir during the spring snowmelt. Thus, inflows are stored at Pipestem Reservoir while Jamestown Reservoir is evacuating water. As a result, the pool level at Pipestem Reservoir may rise to as high as elevation 1460.0 feet PD. The overall effect of the system regulation of Jamestown Reservoir and Pipestem Reservoir is a constant low flow release from ice-out to November 1.

f. Reservoir Regulation in Medium Flow Years. Medium flow years have sufficiently high inflow that the regulation emphasis shifts from setting a constant minimum release to following a fairly rigid release schedule. The special focus for these years is to evacuate water in the Jamestown Reservoir flood control zone following the spring runoff. This is accomplished by reducing Pipestem Reservoir releases to a minimum and maximizing Jamestown releases. These are the critical “marginal” years for the Arrowwood NWR; management at the refuge has a chance of being salvaged.

1) **Details of Jamestown Regulation during Medium Flow Years.**
Releases from Jamestown Reservoir shall be made with the following objectives:

a) Begin a combined release from 450 cfs to 750 cfs as soon as possible, targeting a pool elevation of 1431.0 feet on June 1.
b) Maintain a pool elevation of 1431.0 feet until September 1.

c) Evacuate to a pool elevation of 1429.8 feet by November 1.

Meeting the target pool of 1431.0 feet by June 1 involves releasing a maximum 450 cfs from Jamestown Reservoir as soon as possible after ice-out and up to a combined release of 750 cfs. Even with a 450 cfs Jamestown Reservoir release, modeled peak pool levels at Jamestown Reservoir for the medium flow years range from 1433.9 to 1441.4 feet. In four of the eight modeled medium flow years the pool level does not meet the target pool of 1431.0 feet on June 1. However, by continuing to release 450 cfs from Jamestown Reservoir, the target elevation of 1431.0 feet is reached in one of those four years within a short time after June 1, allowing some pool management at Arrowwood NWR.

2) **Details of Pipestem Reservoir Regulation during Medium Flow Years.** The regulation of Pipestem Reservoir during a medium flow year can be generally summarized as follows:

a) Little or no release made during the spring snowmelt period up to a pool elevation of 1470 feet PD as long as Jamestown Reservoir pool elevation is above 1431.0 feet.
b) Once Jamestown pool elevation is below 1431.0 feet, increase the release rate from Pipestem Reservoir in order to maintain a combined release rate ranging from 450 to 750 cfs.
c) Maintain the release from Pipestem Reservoir until such time that the release may be reduced to a lower level, such as 50 cfs, and still arrive at the target Pipestem Reservoir pool elevation of 1442.5 feet PD by September 1.
d) Once the target Pipestem Reservoir pool elevation of 1442.5 feet PD is reached, releases will match inflows to maintain a pool level of 1442.5 feet PD.

As a consequence of prioritizing releases from Jamestown Reservoir, Pipestem Reservoir pool levels reach as high as elevation 1470.0 feet PD for some of these years.

g. Reservoir Regulation in High Flow Years. The primary objective for these years is 1) to evacuate both pools as quickly as possible following the spring runoff at a rate that will minimize the risk of uncontrolled spillway flow and 2) minimize downstream damages. While Pipestem Reservoir has sufficient storage capacity to manage its PMF without overtopping, Jamestown Reservoir is overtopped by the PMF. Jamestown Reservoir's emergency spillway has a maximum discharge of 2,900 cfs while Pipestem Reservoir's emergency spillway has a capacity of 56,000 cfs. During high flow years the Arrowwood NWR water control structures are completely flooded and the refuge is used to provide additional flood storage space for Jamestown Reservoir. The primary habitat management objectives of the refuge are sacrificed during periods of prolonged high pool elevations.

1) **Details of Jamestown Reservoir Regulation during High Flow Years.** The schedule of release rates from Jamestown Reservoir will depend on how the runoff event(s) unfolds. The Jamestown Reservoir release schedule will depend on 1) the respective pool levels at each project, 2) the rate of inflow into each project, 3) the release rate at Pipestem Reservoir, and 4) the target flow at the James River at Jamestown streamgaging site. The combined release rate will range from 750 to 1,800 cfs. The maximum non-damaging release rate from the Jamestown project is 1,200 cfs. Releases up to 1,600 cfs result in minimal downstream damages. A 1,800 cfs release from Jamestown Reservoir requires advanced preparation. The regulation of Jamestown Reservoir during high flow years can generally be summarized as follows:

a) As high spring inflows raise the pool level at Jamestown Reservoir, gradually step up releases to a maximum of 1,800 cfs.
b) Once the pool level begins to drop, gradually reduce releases to a non-damaging discharge
c) Set a release rate that will evacuate the flood pool by November 1.

2) **Details of Pipestem Reservoir Regulation during High Flow Years.** The regulation of Pipestem Reservoir during high flow years is similar to its regulation during medium flow years (Section7-05.f). There are impacts in the Pipestem Creek channel when Pipestem Reservoir releases exceed 500 cfs. These impacts include seepage into basements of houses near Pipestem Creek and into the City of Jamestown's sanitary sewer system.

7-06. Recreation. The Park Board administers recreational features at Jamestown Reservoir. Activities available at the reservoir include camping, boating, fishing, and hunting. At Jamestown Reservoir, pool elevations of 1454.0 feet or above make boat ramps inaccessible. Some restrooms and shelters are impacted when pool elevations are at or above elevation 1440.0 feet, but these structures were designed such that they become temporarily inaccessible during flooding periods and then fully functional after the pool elevation returns to normal levels. High pool elevations affect the recreation activities at the Arrowwood NWR. Jamestown Reservoir releases of 1,800 cfs result in adverse recreation effects downstream in the City of Jamestown and much further downstream at the Sand Lake and Dakota Lake NWRs.

7-07. Water Quality. Normally, there are no water quality issues during flood control regulation periods. Water quality issues could arise from emergency situations described in Section 7-14.a. For more information regarding water quality, see Sections 4-08, 8-04 and Reclamation's SOP for Jamestown Dam and Reservoir.

7-08. Fish and Wildlife.

a. Jamestown Reservoir Fishery. Jamestown Reservoir is a locally important sport fishery. Fish populations are typical of northern reservoirs with sport fish such as northern pike, walleye, yellow perch, crappie, and smallmouth bass. Abundant non-sport species include black bullhead, white sucker, carp, and bigmouth buffalo. Natural

reproduction of game fish is limited due to the lack of suitable habitat that includes the quantity and quality of spawning substrates, littoral zone complexity and water levels. Water level has a direct influence on these factors for Jamestown and Pipestem Reservoirs. In addition, nursery areas are a function of water levels over suitable habitats in both reservoirs. A stocking program of primarily walleye and northern pike has been implemented. Natural reproduction of walleye and northern pike has been found in the reservoir. Spottail shiners were last stocked in 1986 and fathead minnows in 1992. Fathead minnows are a native component of the upper James River fish community. The effects of forage introduction have not been well documented.

b. North Dakota Game and Fish Department. The mission statement of the North Dakota Game and Fish Department (NDGFD) is to "protect, conserve and enhance fish and wildlife populations and their habitats on lands and waters within North Dakota". Since the 1910s it has been the NDGFD's responsibility to develop plans that work toward accomplishing this mission. This would include providing input during their coordination with other agencies regarding regulation plans for reservoirs.

c. U.S. Fish and Wildlife Service. The FWS has established refuges for production of waterfowl within specific sites, which can provide benefits to other wildlife. The Arrowwood NWR was established in 1935. It was established as a refuge and breeding ground for migrating birds and other wildlife. It provides, protects, and manages habitat for resident bird species, waterfowl, and other migratory species, as well as federally listed endangered and threatened species. The refuge contains four low head structures and lakes, all of which lie within the flood control pool of Jamestown Reservoir. Jamestown Dam was constructed by Reclamation in 1953 with the realization that the refuge would be flooded during high flow periods. All of the water detention structures on the NWR are located within the Jamestown Reservoir joint use pool. This is one of the reasons that preference is given to the evacuation of flood storage from Jamestown Reservoir prior to the evacuation of storage in the Pipestem Reservoir. Plate 4-19 is a profile of the James River above Jamestown Dam. The management of the Arrowwood NWR is affected at reservoir elevations above the top of the joint-use pool, elevation 1431.0 feet. The four low head structures are completely flooded when water is above pool elevation 1442.0 feet. In addition, the vegetative cover, which provides wildlife nesting habitat, is destroyed with prolonged inundation. When the Jamestown Reservoir pool elevation is between elevation 1440.0 and 1442.0 feet, severe erosion impacts the dike embankments and the refuge roads.

The Dakota Lake NWR, located on the James River just north of the North Dakota-South Dakota state line, and the Sand Lake NWR, located on the James River just south of the North Dakota-South Dakota state line, are also affected by the releases from Jamestown and Pipestem Reservoirs.

7-09. Water Supply. The Jamestown project was constructed by Reclamation as a multipurpose project with the primary authorized purposes being flood control and irrigation. Reclamation holds the storage water right for Jamestown Reservoir under North Dakota State Water Permit No. 434, dated July 2, 1956. The water right allows

for multiple uses including: flood control, irrigation, municipal water supply, stream pollution abatement, recreation and wildlife, and potential power generation. There are numerous other water rights vested in the James River Basin above the North Dakota-South Dakota state line. During flood control regulation, water rights issues are coordinated through Reclamation.

7-10. Hydroelectric Power. While authorized for power generation, there are no hydropower facilities at the Jamestown project.

7-11. Navigation. The Jamestown project is not authorized for, or regulated for, navigation.

7-12. Drought Contingency Plan. This water control plan is prepared for occurrences when the pool is in the flood control zone. The Corps is responsible for regulating the reservoir when the pool is in the flood control zone. Drought contingency planning for Jamestown Dam, under the Corps' regulations, is not within the Corps' area of responsibility. Project regulation to assist in drought contingency planning is conducted by Reclamation.

7-13. Flood Emergency Action Plans. Normal flood control regulation of Jamestown Reservoir is accomplished by specific regulation orders to the Dam Tender from the Omaha District WCWQS. It is conceivable, though unlikely, that communication may be disrupted between these offices at times when events may require changes in existing regulation. The Emergency Regulation part of the Standing Instructions to the Dam Tender, presented in Exhibit 3, has been developed for this contingency. These instructions are also contained in Reclamation's SOP for Jamestown Dam and Reservoir in Chapter IV, Reservoir Operations. These instructions should not to be confused with Reclamation's EAP which is also found in the SOP. During any such emergency, continuing efforts will be made to re-establish communications. As described in Exhibit 3, it may be necessary for the Pipestem Dam Tender to make gate changes at the Jamestown Dam. Exhibit 2 contains the FWA, which outlines how the Corps' Pipestem Dam Tender has authority for regulation of the Jamestown Dam during emergency conditions.

7-14. Deviation from Normal Regulation. Temporary deviations from the normal flood control regulation plan may be made if conditions warrant. Except as noted under the following paragraph, "a. Emergencies", deviations require prior approval from the MRBWM office. Requests to deviate from normal regulation of the project fall into one of the categories described below. All deviation requests to the MRBWM office should follow the guidelines outlined in the NWD deviation regulation, NWDR 1110-2-6 – Deviation Requests for Approved Water Control Manuals, May 2015.

a. Emergencies. Occasional non-flood emergencies can occur where deviation from the normal operating procedures would assist other interests in managing the emergency. Examples of these types of emergencies include dam safety emergencies, downstream chemical spills, drowning, and facility failures. The Corps will assist by

deviating from normal regulation whenever possible, unless the action taken would create an equal or worse condition. During an emergency activity, the Omaha District will inform the MRBWM office 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 water control manager.

b. Unplanned Minor Deviations. In some instances, activities of other interests create the potential need for unplanned deviations from normal regulation. These activities usually require deviations 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. In evaluating requests for these types of deviations, the Omaha District will consider upstream watershed conditions, potential flood threats, the amount of water in storage at Pipestem and Jamestown Reservoirs, and whether any alternative measures could be taken that would not require a deviation. Any deviation requires the approval of the MRBWM office.

c. Planned Deviations. Examples of planned deviations include actions taken to avoid exceeding the channel capacity through the City of Jamestown, scheduled dam safety work, or to move flow through South Dakota as quickly as possible before winter. Water level fluctuations for fish spawning management or vegetative habitat improvement are an option that will be considered each year both at the annual spring James River operations meeting and throughout the regulation year. All planned deviations will be thoroughly evaluated and coordinated with the affected state, local and other federal interests.

d. Periodic Channel Flush. Jamestown Dam began regulating flows on the James River in 1953. Pipestem Dam began regulating flows on Pipestem Creek in 1974. From 1953 to 1992 the maximum release from Jamestown Dam was 489 cfs in 1983. From 1974 to 1992, the maximum release from the Pipestem Dam was 310 cfs in 1975. Although the maximum combined release from 1973 to 1992 was 489 cfs in 1983, in many of these years the actual release was much less than 400 cfs and in some years was as low as 0 cfs.

The James River channel through the City of Jamestown had a maximum non-damaging capacity estimated at 1,800 cfs prior to the construction of Jamestown Dam. Due to the almost complete control of flows in the upper James River basin afforded by the dams and the very small releases, the design channel capacity of 1,800 cfs had dwindled down to an estimated 450 cfs by 1992. This reduction in non-damaging channel capacity was a result of many things including tree growth in the channel, new home construction adjacent to the river, leveling backyards near the river channel, and aging basement and sanitary sewer systems. While the channel could pass more than the 450 cfs estimated capacity, it could not be done without causing damages.

From 1993 through 2001, and again from 2009 to 2011, a series of exceptionally wet years resulted in very high discharges from the reservoirs including a maximum

combined discharge of 3,229 cfs in 2009. As a result of these high discharges, the capacity of the channel has increased to the point that a release of 1,800 cfs requires only a small amount of preparation in the downstream channel.

If there are several consecutive years of low and medium flow years, the maximum release would likely be no more than 450 cfs. Without high releases there is a strong likelihood that the channel capacity through the City of Jamestown will once again begin to degrade. This reduction in channel capacity is undesirable as it restricts the intended regulation of the projects and creates additional damages to downstream landowners.

For this reason, it is advisable to schedule a higher release periodically in order to maintain the channel capacity. A long-term goal will be to make a release of 1,200 cfs at least once every 5 years. Each year, depending on conditions, the possibility of making a higher release will be explored with other agencies and will be discussed at the annual spring “James River Operations Meeting”. The duration and the magnitude of the release will be determined following consultation with outside agencies. The release will be made as long as there are no major downstream impacts to agricultural areas or communities.

7-15. Rate of Release Change. Areas of concern regarding rate of release changes include potential safety problems in the downstream channel when releases are being increased. Safety is a concern primarily within the City of Jamestown. Another area of concern is bank sloughing or erosion problems in the downstream channel. This is a concern when releases are being reduced and the streambank is saturated. Problem areas in the downstream channel related to bank sloughing include areas within the City of Jamestown and sensitive archeological sites located in the reach between the City of Jamestown and LaMoure. As a result of these concerns changes in releases have been limited to 200 cfs per day whenever possible during ramp downs. This represents a James River stage change of approximately one foot through the City of Jamestown. This is especially true when releases are reduced from a high flow rate down to a lower flow rate due to the potential for bank sloughing.

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VIII – EFFECT OF WATER CONTROL PLAN

8-01. General. The primary project purpose for the flood control storage in Jamestown Reservoir is to prevent upper James River flows from contributing to flood damages within the City of Jamestown. In addition, this storage will be used to mitigate flood risk in reaches below the City of Jamestown.

8-02. Flood Control.

a. Reservoir Design Flood. The flood control capacity for Jamestown Reservoir was established primarily as the amount of storage necessary to store the greatest runoff of record at the site while no releases from the reservoir are made during the progression of the flood. The Reservoir Design Flood (RDF) did not consider the not-yet-constructed Pipestem Dam. The RDF was developed based on the 1950 snowmelt event over western North Dakota. The amount of storage required to control the RDF was 207,000 af, which was rounded to 200,000 af for storage allocations. Significant rainfall floods were also examined but proved to be less critical than the snowmelt events.

The RDF was simulated by transposing the 1950 snowmelt flood runoff volume for the Cannonball River near New Liepzig, ND to the James River basin above Jamestown Reservoir. The 1950 snow accumulation and resultant runoff above the Cannonball River basin was the greatest known in this general area, amounting to about 3.3 inches of runoff at New Liepzig during April. Assuming losses amounting to about 1.5 inches, the total SWE available prior to melt would have been 4.8 inches. After subtracting losses that were expected to occur over the James River basin (1.6 inches), the runoff resulting from the 4.8 inches of SWE was 3.2 inches. This volume was used as the RDF runoff prior to May 1 above Jamestown Reservoir. For runoff after May 1, observed 1950 James River flows were used and the runoff volume was computed to be 1.8 inches. Thus, the total runoff volume above Jamestown Reservoir for the RDF was 5 inches (3.2 + 1.8). The RDF hydrographs were developed by means of unit hydrographs and an assumed snowmelt sequence. The resulting unregulated peak discharge at the James River at Jamestown streamgaging site was computed to be 14,500 cfs. The computed flood was routed through Jamestown Reservoir according to the proposed regulation plan. The resulting inflow, outflow, and pool elevation hydrographs are shown in Figures 1 and 2 on Plate 8-1. Routed James River hydrographs for the James River at Jamestown streamgaging site and LaMoure indicate flows with and without the regulation effects of Jamestown Dam and are shown in Figures 3 and 4 on Plate 8-2.

b. Original Inflow Design Flood. The IDF is a hypothetical flood event that the dam is designed to safely pass with adequate free board, considering antecedent conditions, water control plans, and regulating outlet capabilities. The original Jamestown Reservoir IDF was approved by the Corps' Chief of the Hydrology Branch, Project Planning Division, by letter dated November 8, 1951. The approved IDF, which could occur any time during the June-October period, included a peak inflow of 63,300

cfs and a 12-day volume of 325,000 af, as shown on Plate 8-3. This IDF study assumed a rainstorm averaging 10.9 inches over a 12-hour period falling on 1,017 square miles of fully contributing area and 228 square miles of partially contributing "pothole" area above Jamestown Reservoir. The IDF was routed through the reservoir following a previous flood event. The previous flood event resulted in only 96,000 af of flood control space available at the beginning of the IDF. In routing the IDF, the outlet works release was limited to 1,500 cfs until the flood control pool was filled. Once the flood control pool was filled, the Jamestown Reservoir release was the full capacity of the outlet works and spillway. The maximum release through the outlet works and spillway are 2,990 cfs and 2,930 cfs, respectively, for a total discharge of 5,920 cfs. During the routing of the IDF, the maximum reservoir elevation was 1464.4 feet, which is 10.4 feet above the spillway crest and 6.6 feet below the top of the dam. The volume amounted to 158,860 af of storage above the spillway crest.

c. Updated Inflow Design Flood. In 1986, as part of Reclamation's Safety of Dams Program, the IDF for Jamestown Dam was updated to meet current standards. These new standards require the use of a PMF in place of the original IDF to determine the dam's ability to safely pass a design flood. The approved PMF hydrograph includes a peak discharge of 243,900 cfs and a 15-day volume of 574,000 af. A study was prepared to route the PMF through Jamestown Dam and Reservoir. The initial reservoir water surface elevation for routing the PMF was set at 1429.8 feet. For pool levels above 1454.0 feet, releases from the outlet works were increased 100 cfs per hour until the outlet works were fully open. A discharge coefficient of 2.7 was used for flows over the dam crest. Reclamation's PMF routing study determined that Jamestown Dam is not capable of passing the full PMF. The results of this flood routing study are summarized in Table 8-1.

Table 8-1
Summary of PMF Routing Results

Flood	Maximum W.S. Elevation (feet)	Freeboard (+ft) Or Overtop (-ft)	Total Discharge (cfs)	Outlet Works Discharge (cfs)	Spillway Discharge (cfs)	Discharge Over Dam (cfs)
PMF	1472.8	-1.80	15,200	3,150	3,050	9,000
91% PMF	1471.0*	0.00	6,200	3,130	3,070	-
90% PMF	1470.7	0.30	6,150	3,110	3,040	-
80% PMF	1467.9	3.10	6,070	3,070	3,000	-

*Top of Dam

8-03. Recreation. Minor effects on recreation begin when the flood control pool is about half full. At Jamestown Reservoir, pool elevations above 1440.0 feet impact picnic shelters and fish cleaning stations. Pool elevations above 1445.0 feet affect the septic system at a campground, necessitating campground evacuation. See Section 7-06 for more details on recreational effects.

8-04. Water Quality. There are normally no water quality issues during flood control regulation. Water quality issues could arise from emergency situations as described in paragraph 7-14.a. Water quality upstream from Jamestown Reservoir depends on the flushing and hydrology of the watershed. Snowmelt and large rainfall events flush the watershed. Periods with little or no flow are frequent, and the river may dry up entirely during a drought. High pool elevations and high releases will have short-term, unavoidable adverse effects on water quality in the reservoir and in downstream reaches.

During snowmelt or large rainfall events, nutrients and organic matter are transported from the watershed into the reservoir. The influent concentrations of phosphorus and nitrogen can lead to nuisance algal growth and subsequent algal decomposition within the reservoir. Algal decomposition, decomposition of influent organic matter, and decomposition processes occurring in the sediment all exert an “in-reservoir” oxygen demand. When this demand surpasses the natural processes that replenish dissolved oxygen (i.e. wind mixing, algal production, influent dissolved oxygen), it depletes concentrations to hypoxic or even anoxic levels, which can lead to fish kill events.

During the winter under snow and ice cover, there is little mixing and limited light for photosynthesis. The reservoir is inversely stratified - water near the bottom of the reservoir is at a temperature of near 4 degrees Centigrade (°C) and the surface water is slightly colder. Though occurring at a slower rate in cold temperatures, decomposition reactions can still surpass the dissolved oxygen supply. During the winter inflow to the reservoir is minimal; however, some pockets of refugia exist in the upper reaches of the reservoir where there are dissolved oxygen conditions suitable for fish survival. Any releases through the gates during the late winter months could potentially send hypoxic nutrient-laden water downstream while “pulling” some of the oxygenated influent water towards the dam. The hypoxic water would then be quickly oxygenated as it passes over the release structure.

During the spring, there is substantial mixing due to higher inflows and light for photosynthetic oxygen production; however inflow conditions during the spring are variable. Thermal stratification of the reservoir sets up in the summer and decomposition occurs in the calm, colder, bottom layer known as the hypolimnion. Decomposition of accumulated organic matter depletes the hypolimnion of dissolved oxygen and creates an expanding hypoxic zone in the reservoir below the mixed, oxygenated upper layer known as the epilimnion. The actual volume of the hypolimnion will vary with pool elevation and weather conditions. In late summer during thermal stratification, gated releases, which pull water from the bottom of the reservoir, could be opened to send hypoxic nutrient-laden water downstream; however, a dynamic water quality model should first be used to assess how much flow could be passed downstream without disrupting the thermal structure of the reservoir, and assess the ability of the outlet structure to oxygenate released water at warmer temperatures.

For more information regarding water quality, see Reclamation's SOP for Jamestown Dam and Reservoir.

8-05. Fish and Wildlife. Pipestem and Jamestown Dams store peak flood flows and release them later in the year. During medium and high flow years, this creates unavoidable, short-term effects on the management of the Arrowwood, Dakota Lake and Sand Lake NWRs. Flooding conditions diminish management options and productivity at the refuges, as described in detail in Section 7-08.

8-06. Water Supply. Reclamation has, and under specific conditions will, continue to issue temporary (1-year) water service contracts to furnish water for irrigation of up to 5,000 acres of lands in the OTA near Oakes, North Dakota. Water sources available for irrigation in the OTA, in priority order for use, include: 1) recaptured drain flows from the OTA, 2) surplus groundwater, 3) surplus James River flows, and 4) Jamestown Reservoir conservation storage. Use of James River water for irrigation in the OTA is governed by an agreement entitled "Operating Principles Between the United States of America, Bureau of Reclamation, U.S. Fish and Wildlife Service, Garrison Diversion Conservancy District, and Dickey-Sargent Irrigation District for the OTA Water Supply from the James River," dated July 6, 1998. The release of water stored in Jamestown Reservoir for the OTA does not affect the regulation of the project for flood control.

8-07. Hydroelectric Power. Not applicable.

8-08. Navigation. Not applicable.

8-09. Drought Contingency Plan. Reservoir regulation and planning for drought conditions will be coordinated through Reclamation.

8-10. Flood Emergency Action Plans. It is unlikely that communications between the Corps' Pipestem Dam Tender and the Corps district offices will be disrupted, however, a plan for such a contingency is presented in Exhibit 3.

8-11. Frequencies.

a. Inflow Volume Frequency. The inflow volume frequency curve for several durations is presented in Plate 6-3. The runoff volume for a 90-day duration can account for much of the total annual runoff, demonstrating the significance of the plains snowpack in total runoff. This also points out the importance of forecasting plains snow runoff.

b. Pool Elevation Duration and Frequency. A pool elevation duration curve is shown on Plate 8-4. The peak pool elevation frequency relationship is shown on Plate 8-5. Reservoir pool elevations and releases for the period of record are shown on Plate 8-6. Plates 8-7a to 8-7g present 10-year periods of reservoir pool elevations, monthly inflows and outflows and maximum annual daily inflows and outflows. Table 8-2 presents the total flow at the James River at Jamestown streamgaging site, water year

peak pool elevation, maximum percent of flood pool occupied, peak discharge and combined discharge for Jamestown and Pipestem Reservoirs for the period of record.

Table 8-2
Pipestem and Jamestown Reservoir Water Year Data

Year	Total Flow at Jamestown (af)	Pipestem Reservoir[1]			Jamestown Reservoir[1]				Combined Peak Discharge (cfs)
		Max. Pool (ft PD)	Max. % of FC Pool Occupied	Peak Discharge (cfs)	Max. Pool (ft)	Max. % of FC Pool Occupied	Above June 1 Target (feet)	Peak Discharge (cfs)	
1954	13,890				1409.8	0.0%	-29.0	5	
1955	13,174				1416.8	0.0%	-16.8	15	
1956	18,350				1422.1	0.0%	-11.7	0	
1957	9,210				1423.6	0.0%	-10.0	0	
1958	20,238				1428.0	0.0%	-3.1	13	
1959	3,979				1425.9	0.0%	-5.9	101	
1960	26,030				1429.5	0.0%	-2.2	0	
1961	3,250				1427.9	0.0%	-3.3	2	
1962	34,064				1428.6	0.0%	-4.3	0	
1963	5,464				1427.9	0.0%	-3.3	76	
1964	16,471				1426.7	0.0%	-4.9	2	
1965	68,706				1432.5	1.7%	1.1	260	
1966	147,895				1439.9	20.6%	6.2	400	
1967	59,052				1437.9	12.7%	5.9	250	
1968	9,391				1430.4	0.0%	-0.9	30	
1969	158,319				1443.8	38.8%	10.8	400	
1970	12,629				1430.5	0.0%	-0.8	0	
1971	45,158				1434.4	4.7%	1.2	150	
1972	37,751				1434.2	4.3%	2.9	173	
1973	5,422				1430.3	0.0%	-1.2	15	
1974	39,851	1444.0	1.0%	125	1436.1	7.4%	3.8	350	475
1975	131,161	1466.1	26.5%	310	1439.6	19.2%	7.1	350	488
1976	30,614	1447.4	3.6%	250	1433.0	2.5%	1.6	200	300
1977	3,073	1442.1	0.0%	0	1429.5	0.0%	-1.9	0	0
1978	41,512	1454.9	11.2%	150	1433.3	3.0%	1.7	300	300
1979	136,002	1468.3	30.3%	200	1440.6	23.6%	8.4	350	450
1980	20,695	1443.5	0.8%	84	1431.1	0.1%	-1.0	100	116
1981	16,264	1443.5	0.8%	98	1433.3	2.9%	2.3	75	98
1982	92,993	1457.4	14.5%	100	1438.1	13.6%	6.7	200	300
1983	136,352	1459.9	17.8%	182	1440.9	24.9%	7.0	489	489
1984	84,166	1456.9	13.8%	200	1436.1	7.5%	4.4	195	327
1985	15,459	1444.3	1.4%	100	1431.5	0.6%	0.4	53	100
1986	50,418	1447.9	4.2%	100	1434.5	4.8%	3.2	208	308
1987	144,847	1466.3	27.1%	140	1442.1	30.2%	7.9	359	470
1988	17,302	1445.2	2.0%	200	1431.9	1.1%	0.8	43	200
1989	4,299	1443.9	1.1%	40	1428.3	0.0%	-2.9	0	40
1990	1,954	1443.0	0.4%	0	1426.4	0.0%	-4.9	0	0
1991	2,558	1442.3	0.0%	0	1424.4	0.0%	-6.8	0	0
1992	6,704	1443.4	0.7%	117	1423.0	0.0%	-8.7	0	117
1993	203,569	1472.6	38.2%	568	1442.8	33.9%	-0.7	718	1,002
1994	197,198	1463.5	22.8%	303	1440.6	23.5%	3.4	712	712
1995	328,184	1479.5	52.5%	616	1442.8	34.0%	8.3	878	1,057
1996	276,823	1475.9	44.6%	610	1444.9	43.2%	6.7	1,169	1,269
1997	420,610	1487.0	71.9%	769	1445.7	49.9%	10.0	1,702	1,770
1998	127,743	1457.8	14.8%	357	1439.3	18.7%	4.7	399	510
1999	304,756	1479.3	52.0%	659	1441.6	28.3%	9.1	742	812

Table 8-2
Pipestem and Jamestown Reservoir Water Year Data

Year	Total Flow at Jamestown (af)	Pipestem Reservoir[1]			Jamestown Reservoir[1]				Combined Peak Discharge (cfs)
		Max. Pool (ft PD)	Max. % of FC Pool Occupied	Peak Discharge (cfs)	Max. Pool (ft)	Max. % of FC Pool Occupied	Above June 1 Target (feet)	Peak Discharge (cfs)	
2000	185,530	1464.2	23.8%	512	1438.7	15.7%	0.4	558	624
2001	280,930	1474.2	41.1%	797	1442.8	34.0%	5.6	1,152	1,275
2002	26,590	1445.3	2.0%	66	1431.9	1.1%	0.0	102	156
2003	48,160	1449.5	5.6%	128	1432.5	1.9%	1.1	200	277
2004	132,990	1456.1	12.8%	207	1437.5	11.4%	1.5	456	481
2005	61,470	1451.7	7.8%	174	1432.3	1.6%	-0.1	202	265
2006	16,838	1443.3	0.6%	104	1431.1	0.1%	-0.0	151	189
2007	92,086	1459.7	17.3%	235	1432.6	2.1%	0.3	104	338
2008	23,233	1447.0	3.4%	67	1431.5	0.6%	-1.0	84	98
2009	529,376	1492.2	86.5%	1,422	1454.1	100.8%	16.8	1,807	3,229
2010	346,622	1474.7	42.2%	614	1445.8	49.2%	8.4	1,220	1,758
2011	826,947	1488.7	76.0%	1,081	1451.2	81.3%	16.2	1,601	2,415
2012[2]	39,831	1472.5	37.8%	1,008	1442.1	0.6%	-0.4	1,405	185
2013	256,762	1474.1	40.9%	605	1441.0	25.8%	9.2	1,015	1,220
2014	78,777	1460.8	18.6%	308	1433.9	3.9%	1.0	502	513

[1]Pipestem Reservoir data is from the official Corps record through September 2014. Jamestown Reservoir data is from the official Reclamation record through September 2014.
[2]2012 peak pool elevation, storage and discharge were on Oct 1, 2011 for both reservoirs as the 2011 flood storage was being evacuated. The 2012 water year is from October 1, 2011 to September 30, 2012.

c. Key Control Points. The key control point for Jamestown and Pipestem Reservoir regulation is the James River at Jamestown streamgaging site (see Plate 4-4). Stage-discharge curves for key locations along the James River are shown on Plates 4-12 through 4-16.

8-12. Other Studies.

a. Examples of Regulation. Extensive analyses were conducted in revising the water control plans for the two projects. The results of these analyses are presented in detail in the 2000 WCP Review.

The 2000 WCP Review examined various alternative WCPs. Effects on downstream flood control, fish and wildlife (including management of the Arrowwood, Sand Lake and Dakota Lake NWRs), dam safety concerns at Jamestown Dam, cultural and archeological sites and erosion were all 2000 WCP Review criteria. Historic inflows and downstream incremental flows from 1954 to 1997 were modeled and the effects of the WCP alternatives were evaluated.

The analyses conducted during the review and update resulted in the development of a WCP that has considerable flexibility and requires extensive coordination. Table 8-3 presents the model results from the 2000 WCP Review for the “Flexible Plan B” alternative, which was selected as the new WCP. This WCP was modified in the later stages of the review to include only three types of flow years, instead of four. The “lower medium” and “upper medium” flow years were combined into one “medium” flow year. Details on the selected WCP can be found in Chapter 7.

The two most important evaluation criteria used in selecting the final WCP were 1) maintaining flow within the 1,800 cfs channel capacity through the City of Jamestown and 2) meeting the June 1 target elevation of 1431.0 feet at Jamestown Reservoir. As shown in Table 8-3, the 1,800 cfs combined release is not exceeded and the elevation in Jamestown Reservoir is at or below the target elevation of 1431.0 feet more than 80 percent of the time over the period of record. Table 8-2 indicates that implementation of the selected WCP from 2001 to 2014 resulted in the 1,800 cfs combined release being exceeded twice (2009 and 2011) and the June 1 target being exceeded 8 times (2003- 04, 2007, 2009-11, 2013-14).

Table 8-3
Summary of Calculated Annual Downstream Damages
Under "Flexible Plan B" Alternative
(Sheet is sorted in ascending order by combined water year total)

		Pipestem Reservoir			Jamestown Reservoir				Combined	Annual
	Total WY	Peak Pool	Max %	Peak	Peak Pool	Max %	Above	Peak	Peak	Downstream
Water	Inflow	Elevation	FC Pool	Release	Elevation	FC Pool	1-Jun	Release	Release	Damage
Year	(AF)	(feet PD)	Occupied	(cfs)	(feet)	Occupied	Target (ft)	(cfs)	(cfs)	$1,000
LOW FLOW YEARS										
1990	3,100	1443.3	0	30	1425.3	-3	-6.2	0	30	36
1991	3,500	1442.7	0	10	1423.2	-5	-7.8	0	10	1,099
1959	3,600	1442.6	0	10	1427.7	-1	-4.1	0	10	2
1961	5,000	1442.8	0	10	1428.1	-1	-3.0	0	10	142
1973	5,400	1443.0	0	20	1428.4	-1	-3.0	80	100	893
1963	5,500	1443.5	1	30	1427.8	-1	-3.5	0	30	146
1977	7,000	1442.8	0	40	1428.0	-1	-3.3	0	40	979
1968	9,100	1444.0	1	60	1428.6	0	-2.7	30	90	67
1989	9,500	1444.1	1	30	1427.5	-1	-3.7	0	30	3,174
1957	10,300	1442.7	0	50	1428.0	-1	-3.2	50	70	233
1992	10,900	1446.4	3	100	1422.0	-6	-9.7	0	100	203
1954	13,400	1445.5	2	30	1429.6	1	-3.0	20	40	389
1970	13,800	1446.7	3	20	1428.9	0	-2.2	50	50	562
1955	16,100	1446.9	3	30	1431.0	2	-1.2	40	40	267
1964	16,300	1446.4	3	50	1426.7	-2	-4.9	0	50	1,623
1988	16,900	1448.4	5	80	1429.7	1	-1.3	40	100	59
1985	18,800	1446.1	3	100	1429.8	1	-1.3	50	100	2,373
1956	20,900	1445.7	2	50	1431.0	2	-1.0	40	70	65
1980	25,800	1444.2	1	100	1429.2	0	-2.7	40	100	48
1962	27,100	1446.1	3	100	1428.8	0	-4.1	0	100	10,724
1958	29,800	1449.0	5	40	1431.0	2	0.0	100	100	151
1981	30,300	1444.0	1	100	1431.0	2	0.0	60	100	3
1960	32,600	1452.2	8	100	1431.0	2	-0.6	30	100	62,87
LOW FLOW AVERAGE DAMAGES										1,284
LOWER MEDIUM FLOW YEARS*										
1976	38,000	1453.9	10	100	1432.0	3	0.0	70	100	251
1972	42,000	1451.4	7	100	1431.0	2	0.0	100	100	4,833
1978	43,700	1456.2	13	100	1431.0	2	0.0	40	100	6,642
1971	47,200	1450.4	6	60	1431.3	3	0.0	100	100	489
1986	56,800	1456.4	13	100	1431.0	2	0.0	80	100	10,842
1967	60,000	1457.4	14	100	1433.0	5	-0.1	170	170	1,545
1974	61,500	1451.3	7	70	1432.8	4	0.1	120	120	105
1965	69,800	1455.5	12	110	1431.5	3	0.0	130	140	1,325
1984	89,500	1464.0	23	120	1431.5	3	0.0	190	190	13,409
LOWER MEDIUM FLOW AVERAGE DAMAGES										4,382

Table 8-3
Summary of Calculated Annual Downstream Damages
Under "Flexible Plan B" Alternative

(Sheet is sorted in ascending order by combined water year total)

		Pipestem Reservoir			Jamestown Reservoir				Combined	Annual
	Total WY	Peak Pool	Max %	Peak	Peak Pool	Max %	Above	Peak	Peak	Downstream
Water	Inflow	Elevation	FC Pool	Release	Elevation	FC Pool	1-Jun	Release	Release	Damage
Year	(AF)	(feet PD)	Occupied	(cfs)	(feet)	Occupied	Target (ft)	(cfs)	(cfs)	$1,000
UPPER MEDIUM FLOW YEARS*										
1982	90,500	1456.6	13	450	1433.9	6	0.0	450	450	3,014
1998	129,400	1466.9	28	450	1436.3	10	0.0	450	450	6,158
1975	138,600	1469.4	32	450	1437.9	15	5.1	450	450	3,989
1966	142,300	1466.1	27	450	1438.5	17	-0.1	450	450	4,128
1979	142,700	1470.1	33	450	1439.2	20	6.8	450	450	5,916
1983	144,700	1462.3	21	450	1438.7	18	0.0	450	450	2,782
1987	149,700	1467.5	29	450	1439.7	22	1.4	450	450	6,538
1969	159,000	1469.7	33	450	1441.4	29	6.8	750	750	17,037
UPPER MEDIUM FLOW AVERAGE DAMAGES										6,195
HIGH FLOW YEARS										
1994	189,600	1463.5	23	450	1439.3	20	3.1	450	450	7,483
1993	200,400	1470.5	34	450	1440.6	25	-1.5	750	860	12,306
1996	267,600	1478.7	51	450	1443.8	40	9.0	750	750	6,504
1995	338,700	1483.3	61	750	1441.7	30	8.3	750	750	19,095
1997	372,500	1491.4	84	1,800	1447.0	57	13.2	1,800	1,800	35,984
HIGH FLOW AVERAGE DAMAGES										14,943
TOTAL AVERAGE ANNUAL DAMAGES										4,442

Note: Upstream damages were not considered as part of this evaluation.
* Lower Medium and Upper Medium Flow Years were combined into "Medium Flow Years" with the selection of this plan

In 2012, the Omaha District conducted a study to determine the return period flow at the James River at Jamestown streamgaging site. The results of this study were used in a feasibility study to determine expected flow downstream of the Jamestown and Pipestem Dams (see Plate 8-8). The updated hydrology completed with this study found a change in the 100-year flow through the James River at Jamestown, ND streamgaging site from 1,800 cfs to 2,940 cfs.

Descriptions of actual regulation for high inflow years are provided below. The actual regulation will not match the modeled results shown in Table 8-3. Descriptions of the storms and flood damages can be found in Section 4-06 for the high inflow years discussed in the following sections as well as high flow years occurring before the construction of Jamestown Dam. Figure 8-1 below shows a summary of all peak stages at the James River at Jamestown streamgaging site for reference. Peaks occurring before 1954 are completely unregulated.

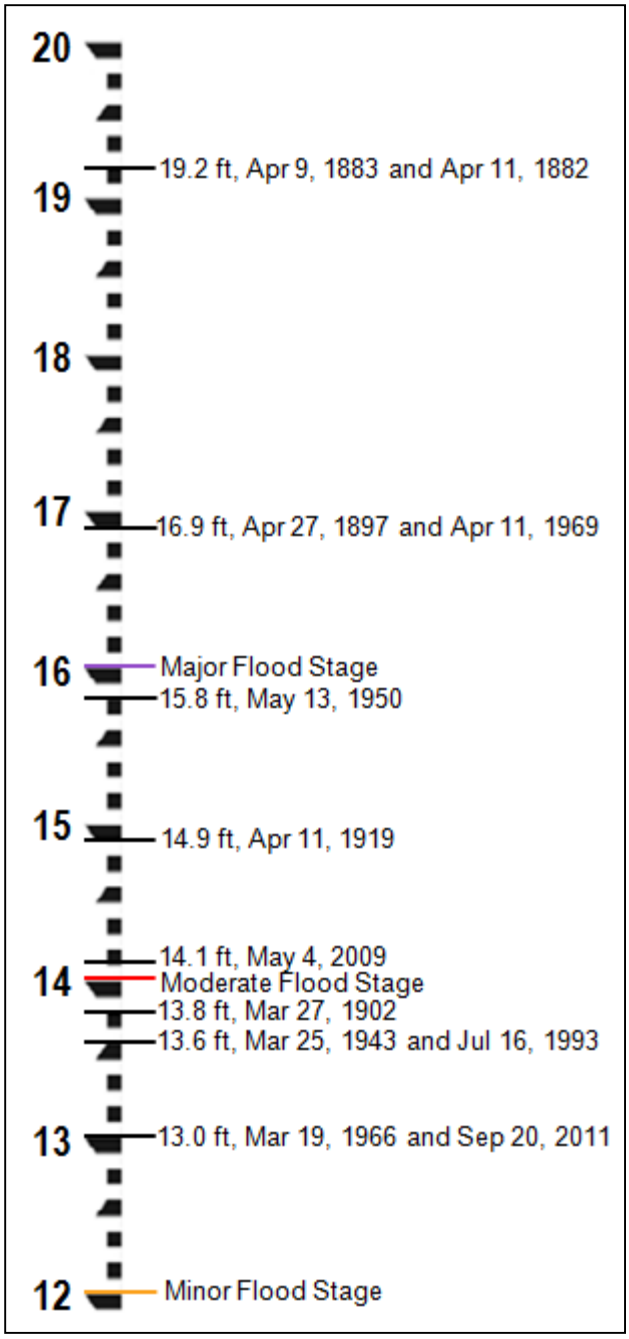


Figure 8-1. Historical Peak Stages on the James River at Jamestown, ND Streamgaging Site (Jamestown Reservoir was constructed in 1953, and Pipestem Reservoir was constructed in 1973)

1) **Flood of 1969.** Heavy snowstorms occurring during the winter of 1968-1969 resulted in heavy plains snow accumulation, ranging from 1.75 inches to more than 5 inches of SWE over the James River basin by mid-March. Snowmelt runoff began April 8. The peak stage and discharge at the James River at Jamestown streamgaging site was 16.94 feet and 6,330 cfs, respectively, on April 11. The peak flow at the James River at Jamestown streamgaging site was a direct result of Pipestem

Creek runoff. No releases were being made from Jamestown Reservoir during the time of downstream peaking. The Jamestown project stored all runoff until late April when releases from Jamestown Reservoir were initiated. A peak Jamestown Dam release of 400 cfs was reached in early May. The peak daily inflow into the Jamestown Reservoir was 7,220 cfs on April 18. The Jamestown Reservoir pool peaked on May 2 at 1443.8 feet. The peak stage and discharge at the James River at LaMoure streamgaging site was 16.17 feet and 6,800 cfs, respectively, on April 14. Emergency dikes were constructed along the James River at LaMoure, ND, Aberdeen, SD and Hecla, SD.

2) **Flood of 1993.** Flooding in the James River basin during 1993 resulted from above-average spring rainfall and an intense July rainfall. The July 15-16 storm produced a peak discharge of approximately 1,300 cfs at the James River at Jamestown streamgaging site and releases were completely shut off at both Jamestown and Pipestem Dams. Saturated soil conditions and the mid-July storm resulted in a slump in the Pipestem Dam embankment on July 28. Local repairs were necessary but no long-term dam safety issues were discovered. The July rainfall events raised the pool levels of Jamestown and Pipestem Reservoirs well into their respective flood control storage zones. This prompted record high releases from the projects in order to lower the pool levels of both projects before the winter freeze. A combined release of approximately 950 cfs lowered both reservoir pools. It is estimated that the combined effects of both reservoirs reduced the peak discharge at the James River at Jamestown streamgaging site from an estimated natural flow of approximately 7,500 cfs to 1,300 cfs. The natural flow would have been a new record discharge since the station record began in 1928. During 1993, Pipestem Reservoir experienced both the second lowest pool of record (in February) and a record high pool (in August), peaking at 1472.6 feet on August 15. The peak daily inflow into Pipestem Dam was 4,370 cfs on July 17. Peak daily inflow into Jamestown Reservoir was 4,110 cfs on August 3. The Jamestown Reservoir recorded its peak pool elevation of 1442.8 feet on August 16.

James River gaging locations in the lower part of the basin recorded significant peak stages and discharges in early July while the upper basin stations recorded significant discharges later in the month. A comparison of the size and timing of the peak discharges at Scotland, SD and Forestburg, SD indicates that the significantly high streamflows at the James River at Yankton, SD and Scotland, SD were a direct result of rainfall within the lower basin. This is further substantiated by an examination of the peak discharges recorded on the James River tributaries within this reach. These tributaries peaked during the July 5-6 period. This also corresponds closely with the reports of the July 2 rainfall amounts of 5 to 7 inches in an area from Mitchell to Madison, SD. Plate 8-9 shows reservoir routing for the flood of 1993.

3) **Flood of 1995.** Unusually high spring snowmelt runoff above the Pipestem and Jamestown projects resulted in inflows from snowmelt in March and April which were more than four times normal. Plains snow in the upper basin contained 3 to 4 inches of SWE that accumulated over the winter months. With frost depths up to 4 feet deep, depression storage areas filled from record runoff during the previous fall. With above-average baseflow in the river, nearly all of the water accumulated in the

snowpack resulted in runoff during a rapid warm-up, which began in mid-March. Plate 8-10 shows reservoir routing for the flood of 1995.

4) **Flood of 1997.** The unusually heavy snowpack, coupled with the wet antecedent soil conditions, resulted in record flood stages along the James River from the North Dakota-South Dakota state line to Mitchell, SD. Average basin SWE at mid-March was estimated at 3.9 inches above Scotland, SD and 3.5 inches above the City of Jamestown, ND. Additional snow accumulation occurred from mid-March through early April. Rapid melting began by April 14 and over a 3-day period up to 4 inches of SWE was released from the snowpack on saturated ground. Inflows remained high throughout the last half of April. Releases from the dams were restricted due to downstream flooding and emergency dike construction began in the City of Jamestown. Once releases were ramped up in late April, the release priority was given to Jamestown with Pipestem Reservoir releases being reduced to zero for a few days. A combined release of 1,800 cfs was sustained for most of May. Record pool elevations were set at both reservoirs, with Jamestown Reservoir cresting at 1445.7 feet on May 2 and Pipestem Reservoir cresting at 1487.0 feet PD on May 10. Total March through September inflow to Pipestem and Jamestown Dams from snowmelt and summer rainfall produced the highest volumes of inflow, 142,621 af and 211,563 af, respectively, since the dams were closed. It is estimated that the combined effects of both reservoirs reduced the peak discharge at the James River at Jamestown streamgaging site from a without-project peak of approximately 8,500 cfs to an observed peak of 1,770 cfs. The without-project flow would have been a new record discharge at this location.

In addition to record floods on the main stem of the James River, several tributaries including Snake Creek and Turtle Creek near Redfield, SD produced record floods. In South Dakota only 5 of 105 James River bridge crossings remained open throughout the flood. These crossings were Interstate 90 near Mitchell, Highway 12 near Aberdeen, Highway 37 north of Mitchell, and Highway 18 and Highway 50 near Yankton. Peak stages were more than 4 feet above the previous record flood from Ashton to near Forestburg. At Westport, the Elm River stage was within 0.4 feet of its previous record stage. At Scotland, the James River reached flood stage on March 12 and remained above flood stage until the end of June. At Columbia, the James River exceeded flood stage for about six months, beginning on March 24. Because of the flat gradient of the James River in the Lake Plain Region of northern South Dakota and the high tributary flows, the James River flowed backwards (reverse flows) in this reach. At Columbia and Ashton, reverse flows of record occurred, with -2,430 cfs at Columbia on March 30 and -8,450 cfs at Ashton on April 1. Plate 8-11 shows reservoir routing for the flood of 1997.

5) **Low Runoff Year 2003.** The runoff in 2003 was the second low runoff year since the wet years of 1993-2001 (see Plate 6-5). This was the first year where the newly developed WCP for Jamestown and Pipestem Reservoirs could be applied for a low flow year. During a low flow year the WCP calls for a “low constant release” in order to 1) minimize the potential for unexpected flooding in South Dakota and 2) provide environmental and water supply benefits from low flow augmentation.

Basin conditions during the fall of 2002 were very dry, a continuation of conditions prevalent in 2001. As fall turned to winter, dry conditions persisted and the winter snowfall was near record low levels. As a result, early spring forecasts indicated for very low runoff for 2003. All agencies in attendance at the spring James River Operations Meeting held in the City of Jamestown on April 10, 2003 concurred that the best plan of regulation would be to follow the "low constant release" criteria and also to meet the June 1 target elevation at Jamestown Reservoir of 1431.0 feet. Runoff was low at both projects until heavy rain upstream of both projects resulted in increased inflows in mid-May. The rainfall runoff caused Pipestem Reservoir to rise to elevation 1449.51 feet PD, almost 7 feet into its flood control zone and Jamestown Reservoir to rise to elevation 1432.47 feet, almost 1.5 feet into its flood control zone (see Plate 8-12).

As a result of the May rainfall, the highest combined release during 2003 was 270 cfs. That release was maintained for less than a month. Releases were gradually cut back during the summer as drought conditions returned to the region (see Plate 8-12). Releases for Pipestem were also adjusted to aid in the regulation of Jamestown Reservoir during renovation work at the Arrowwood NWR when inflows into Jamestown Reservoir were difficult to predict.

6) **Flood of 2009.** Heavy snowfall throughout the winter produced 5 to 6 inches of SWE across much of the Jamestown and Pipestem Reservoir drainage basins. This very high snowpack resulted in the Corps forecasting spillway flows at Jamestown and Pipestem Dams in early spring. Combined releases of 1,800 cfs were reached by April 14. As a result of the high pool forecasts, a deviation was approved by the MRBWM office in mid-April to allow combined releases up to 4,000 cfs on the condition that emergency levees were completed in the City of Jamestown. The emergency levees were designed to allow a combined release of 4,000 cfs without damaging infrastructure. A maximum combined release of 3,200 cfs (1,400 cfs from Pipestem Reservoir and 1,800 cfs from Jamestown Reservoir) was targeted from April 28 to May 19, and the actual maximum combined release was calculated to be slightly higher. The target releases were not increased above 3,200 cfs because field surveys indicated that higher releases would likely cause problems with groundwater seepage into the City of Jamestown's sanitary and storm sewer system.

Both reservoirs observed record daily inflows on April 15: 9,232 cfs at Pipestem Reservoir and 11,646 cfs at Jamestown Reservoir. Both reservoirs reached their peak pool of record during this event; however, peak pool levels did not reach as high as originally forecasted. Pipestem peaked at 1492.2 feet PD, 4.1 feet below the top of its flood pool. Jamestown Reservoir peaked at 1454.1 feet, 0.1 foot above the top of its flood pool. Small uncontrolled surcharge flows of less than 100 cfs were experienced through the Jamestown Reservoir spillway. In order to keep a constant total release from Jamestown Reservoir, gated releases were decreased as the uncontrolled spillway (surcharge release) increased. Since the channel capacity through the City of Jamestown was stressed by the high releases, periodic reductions were made at the reservoirs when rain was expected over the city. This provided additional channel capacity for local runoff downstream of the dams. The periodic reductions required 24-

hour monitoring by Omaha District WCWQS staff to order gate changes at the dams. The gate change was normally made at Jamestown Dam due to its shorter travel time to the city.

The peak flow and stage at the James River at Jamestown streamgaging site was 3,240 cfs and 14.05 feet, respectively, on May 4. It is estimated that the combined effects of both reservoirs reduced the peak discharge at the James River at Jamestown streamgaging site from a without-project peak of approximately 20,000 cfs to the observed peak of 3,240 cfs. The peak flow and stage at the James River at LaMoure streamgaging site was 12,200 cfs and 17.38 feet, respectively, on April 15. At the James River at Columbia streamgaging site, the peak flow was 9,620 cfs on April 24 and was over flood stage from mid-March until mid-September. The USGS installed Rapid Deployable Gages (RDGs) downstream and upstream of the dams to monitor runoff timing and provide early flood warning. The James River Annual Operations Meeting was delayed until it became apparent that large spillway flows would not occur. Reservoir drawdown options were discussed at the meeting to get a consensus about a ramp down schedule. See Section 4-06.r for a more detailed description of the event. See Plate 8-13 for a graphical representation of the 2009 reservoir routing.

7) **Flood of 2010.** The peak SWE estimates were about 4 inches in the basin above the dams and this led to a Corps forecast of high spring pool levels. Ideal melt conditions - daytime melting and nighttime freezing - spread the melt over a few weeks and resulted in a lower- than-expected runoff. Some of the modeled inflow scenarios indicated spillway flow, so a deviation to exceed the combined 1,800 cfs, in the event of imminent uncontrolled spillway flows, was prepared by the district and approved by the MRBWM office. As a result of these forecasts, partial emergency levees were constructed in the City of Jamestown to allow for combined releases of 1,800 cfs. The ideal melt conditions resulted in no spillway flows occurring and the deviation was not implemented. Maximum combined releases of 1,800 cfs were held for a few days before releases were gradually ramped down. During the peak combined releases, a release split of 1,200/600 cfs was maintained between Jamestown and Pipestem Reservoirs, respectively. Peak daily inflows were much lower than forecast - 2,070 cfs at Pipestem Reservoir and 4,802 cfs at Jamestown Reservoir. The peak pool level at Pipestem was 1474.7 feet PD, sixth highest on record. The peak pool at Jamestown Reservoir was 1445.8 feet, the second highest on record. See Plate 8-14 for a graphical representation of the 2010 reservoir routing.

8) **Flood of 2011.** Heavy winter snowpack resulted in high spring inflows, especially into Jamestown Reservoir. The Corps' model runs indicated that high pool levels, but no spillway flows, were expected. Therefore, no deviation was prepared and maximum releases were expected to be held to no more than 1,800 cfs. Pool forecasts indicated peak pool levels to be near the 1997 peaks. Initially, the release split between Jamestown and Pipestem Reservoirs was 1,600 cfs and 200 cfs, respectively. Pipestem releases were eventually increased up to 1,000 cfs as the spring runoff was evacuated from its flood control zone. Due to high combined releases being made in 2009 and 2010, the channel scouring had increased the James River channel capacity

through the City of Jamestown to about 1,800 cfs. The City of Jamestown opted to build their own levees instead of having the Corps construct them. The heaviest SWE in the upper Missouri River basin was in the James River basin. Jamestown Reservoir daily inflows peaked on April 16 at a record 14,300 cfs. Jamestown Reservoir's second highest pool level of 1451.2 feet was recorded on May 2.

From late June through mid-August the basins above the reservoirs received heavy rainfall. Fifteen to 20 inches above normal June-August rain fell in some parts of the basin and the flood storage filled back to the spring levels. Once the rainfall lessened and the flood storage began to be evacuated, concerns about getting the stored flood waters evacuated before the winter freeze spurred a deviation request to the MRBWM office to increase releases to evacuate the water more quickly. The City of Jamestown constructed levees to allow a combined release of 2,400 cfs. Target combined releases were increased to 2,400 cfs by September 2. The release split was 1,400 cfs from Jamestown Reservoir and 1,000 cfs from Pipestem Reservoir. Pipestem Reservoir recorded its second highest pool level of 1488.7 feet PD on August 21. Jamestown Reservoir peaked at 1450.1 feet on August 19 at 1450.1 feet, which was 1.1 feet lower than the spring peak.

The annual flow volume of 830,000 af at the James River at Jamestown streamgaging site set a new record for the 1928-2011 period. The peak flow at the James River at Jamestown streamgaging site was 2,470 cfs on September 20. It is estimated that the combined effects of both reservoirs reduced the peak discharge at the James River at Jamestown streamgaging site from a without-project peak of approximately 16,400 cfs to the observed peak of 2,740 cfs. The peak flows at the James River at LaMoure and James River at Columbia streamgaging sites were 4,600 cfs (July 1) and 6,200 cfs (July 17), respectively. The stage at the Columbia site was over flood stage from late March until mid-December. See Plate 8-15 for a graphical representation of the 2011 reservoir routing.

b. Channel and Floodway Improvement. Channel scouring caused by consecutive years (2009-2011) of high flows increased the channel capacity through the City of Jamestown. In 2011, the channel capacity through the City of Jamestown was estimated to be about 1,800 cfs. A flood risk management feasibility study of the James River basin was initiated in April 2012 and completed in September 2014. The purpose of the study was to determine the existence of any cost-effective solutions to basin flooding problems. Both structural and non-structural alternatives were assessed.

IX – WATER CONTROL MANAGEMENT

9-01. Responsibilities and Organization.

a. Corps of Engineers. When the Jamestown Reservoir pool is in the exclusive flood control zone, it is the responsibility of the Corps to determine the flood control regulation of Jamestown Reservoir. If the snow cover is particularly heavy or the need exists, intensive snow surveys are made by Corps personnel. Reports pertinent to the regulation of the Jamestown Reservoir are produced by either Reclamation or the Corps. An organization chart of the Omaha District is provided on Plate 9-1.

b. Other Federal Agencies.

1) **Bureau of Reclamation.** Reclamation is responsible for regulation of the project when the pool elevation is below the flood control pool or in the surcharge zone. Reclamation's regulation guidelines are contained in Reclamation's SOP for Jamestown Dam and Reservoir. Major design, dam safety reviews, structural behavior analyses, and development and update of SOP guidelines are the responsibility of Reclamation. Reclamation's Great Plains Regional Office in Billings, MT directs the Reclamation's Dakota Area Office regarding the operation, maintenance, and surveillance of the Jamestown project. The Regional office prepares the SOP and directs any special operation to the Area office associated with the regulation of Jamestown Reservoir. The Area office performs normal operation and maintenance of the Jamestown project. Refer to Plate 9-2 for a Reclamation organization chart.

2) **U.S. Fish and Wildlife Service.** The FWS is responsible for managing the Arrowwood, Dakota Lake and Sand Lake NWRs. Under a letter of understanding, the FWS and Reclamation coordinate releases from Jamestown Reservoir in order to facilitate efficient operations of the Dakota and Sand Lake NWRs when the pool at Jamestown Reservoir is below the flood control zone. The pool at Jamestown Reservoir significantly affects the FWS's management of the Arrowwood NWR. When the pool is in the flood control zone, the Corps, Reclamation, and the FWS coordinate regulation to retain some management flexibility at all three refuges.

3) **National Weather Service.** The NWS collects and transmits precipitation reports. The NWS station at the City of Jamestown reports daily snow depths through the winter season. The North Dakota NWS stations at Fargo, Devils Lake and Bismarck, which are adjacent to the James River basin, also report snow depth and water content data daily through the winter season. The NWS MBRFC forecasts river stages and flows along the James River during floods. The NOHRSC produces national modeled snow depth and SWE maps. This product is used for snowmelt

forecasting in conjunction with field measurements. Refer to Plate 9-3 for a NWS organization chart.

c. State and County Agencies. Stutsman County conducts routine surveillance of Jamestown Dam and may perform gate operations at the Dam as requested by Reclamation. The JRWDD communicates operational forecasts to the public in South Dakota.

9-02. Interagency Coordination. The WCP, presented in detail in Chapter 7 of this manual, allows for considerable flexibility in making flood control releases. This flexibility requires considerable coordination and communication among the affected interests. The plan includes two regularly scheduled coordination components and one unscheduled component for extreme flow events.

The first coordination component is the James River spring coordination meeting. This meeting will be conducted early each spring, preferably following the release of the NWS's first spring snowmelt flood outlook. The spring meeting is attended by representatives directly concerned with flows in the James River as well as any other interested parties. At this meeting, current hydrologic conditions in the watershed will be presented, and if considerable runoff is anticipated, the hydrologist from the NWS's Bismarck Weather Forecast Office will present their forecast. All other interested parties will be given the opportunity to present their proposed activities for the year. The Corps will present its initial reservoir volume forecasts and will consider the proposed activities of all other interests in identifying the regulation plan for the year. After this meeting the Corps will analyze potential regulation plans, select the plan of regulation, and notify all the agencies.

The second coordination component will occur when gate operations are scheduled, whether they are a planned change as part of the annual operating plan or unplanned in response to a changed hydrologic or other occurrence. Discussions shall take place between the Corps, Reclamation, FWS representatives from the Arrowwood and Sand Lake NWRs, manager of the JRWDD, and City of Jamestown. These discussions will be conducted either through phone calls or email.

The final communication component involving public meetings will be conducted only during extreme flow events when flooding is expected to occur or is occurring. Public meetings will be conducted as needed. These meetings will be open to all interests and will be used by the Corps to relay pertinent information about the projected flood event, the expected project regulation that will be necessary to control the event and the potential impacts of those releases on the various interests.

The following agencies coordinate as described below:

a. Local Press and Corps Press Releases. When the Corps is regulating the project for flood control purposes, the Corps' Public Affairs Office will issue news releases as necessary to inform the public of its activities. The Corps' daily bulletin,

which provides daily pool elevation, release and inflow, is disseminated via the Corps' public website. Reclamation also issues press releases as needed about their operations at Jamestown Reservoir. In general, the Corps will issue press releases about flood operations since they direct releases from both reservoirs during flood operations.

b. U.S. Bureau of Reclamation. Reclamation coordinates Jamestown Reservoir volume forecasts and reservoir operations with the Corps. The coordination is conducted on a more frequent basis during times of flooding. In the event that Jamestown Reservoir enters the flood pool, the Corps is responsible for determining Jamestown Reservoir operations and coordinates release decisions with Reclamation.

c. National Weather Service. The NWS attends the coordination meetings for the Jamestown and Pipestem projects to report on hydrologic conditions and meteorological forecasts. They also provide reservoir inflow forecasts upon request. Reclamation and the Corps communicate reservoir release forecasts with the MBRFC so they can incorporate those release forecasts into NWS river and flood forecasts.

d. U.S. Geological Survey. The USGS maintains most of the streamgaging sites in the James River basin. They make periodic streamflow measurements at the streamgaging sites to maintain the rating curves. The USGS will make flood measurements and install RDGs on request.

e. Power Marketing Agency. Not applicable.

f. Other Federal, State, or Local Agencies. Jamestown and Pipestem Reservoir releases are coordinated with the City of Jamestown, Stutsman County, LaMoure County, Arrowwood and Sand Lake NWRs, and the JRWDD. Each of these agencies is involved in the annual operations meeting. In addition, major release changes will be coordinated with these agencies throughout the year through email and phone calls. The JRWDD holds bi-monthly holds board meetings. A water control engineer from the Omaha District WCWQS is expected to participate in these meetings as needed to brief the board on reservoir regulations. Usually, the water control engineer will attend the March board meeting to share the Corps' annual forecast.

9-03. Interagency Agreements. Under Section 7 of the 1944 Flood Control Act, the Corps and Reclamation developed FWAs, which govern the regulation of reservoirs during flood operations. The current FWA was developed in 2015. The FWA is included in Exhibit 2.

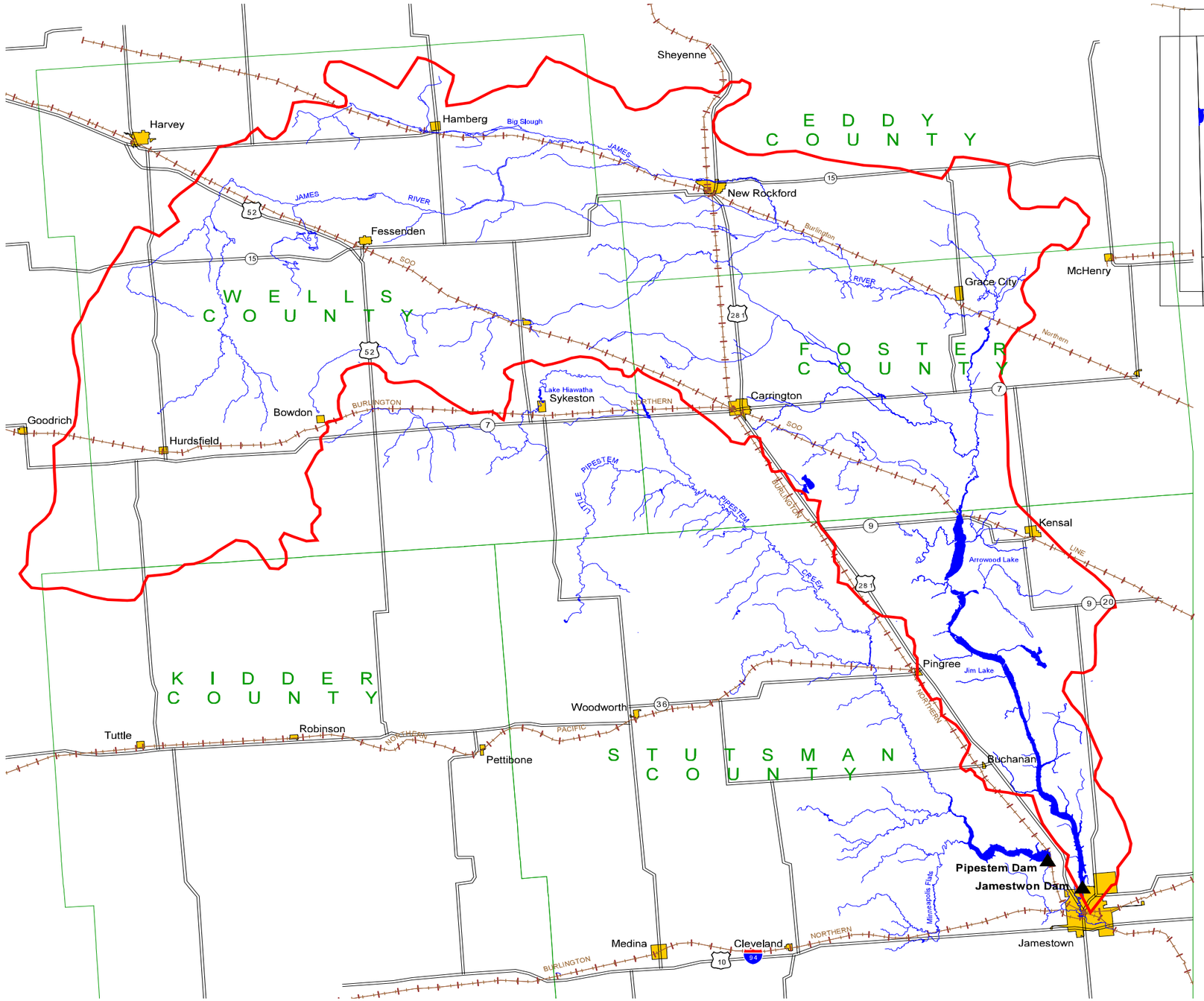
9-04. Commissions, River Authorities, Compacts, and Committees. Not applicable.

9-05. Non-Federal Hydropower. Not applicable.

9-06. Reports. Reports required when Jamestown Reservoir is in the flood control pool are shown in Table 9-1, along with the reports' governing regulation and required schedule.

Table 9-1
Report Requirements

Report Title	Regulation or Guidance	Schedule
Reservoir Regulation Orders	EM 1110-2-3600	Every release change
Monthly Reservoir Operations	EM 1110-2-3600 ER 1110-2-240	Monthly
Annual Report, Omaha District WCWQS	ER 1110-2-1400 ER 1110-2-240	Annual
Flood Emergency Reporting	EM 500-1-1	Per flood requirements
Omaha District Daily Reservoir Bulletin	EM 1110-2-3600	Daily
Annual Report of Flood Damages Prevented	EM 1110-2-3600	Annual



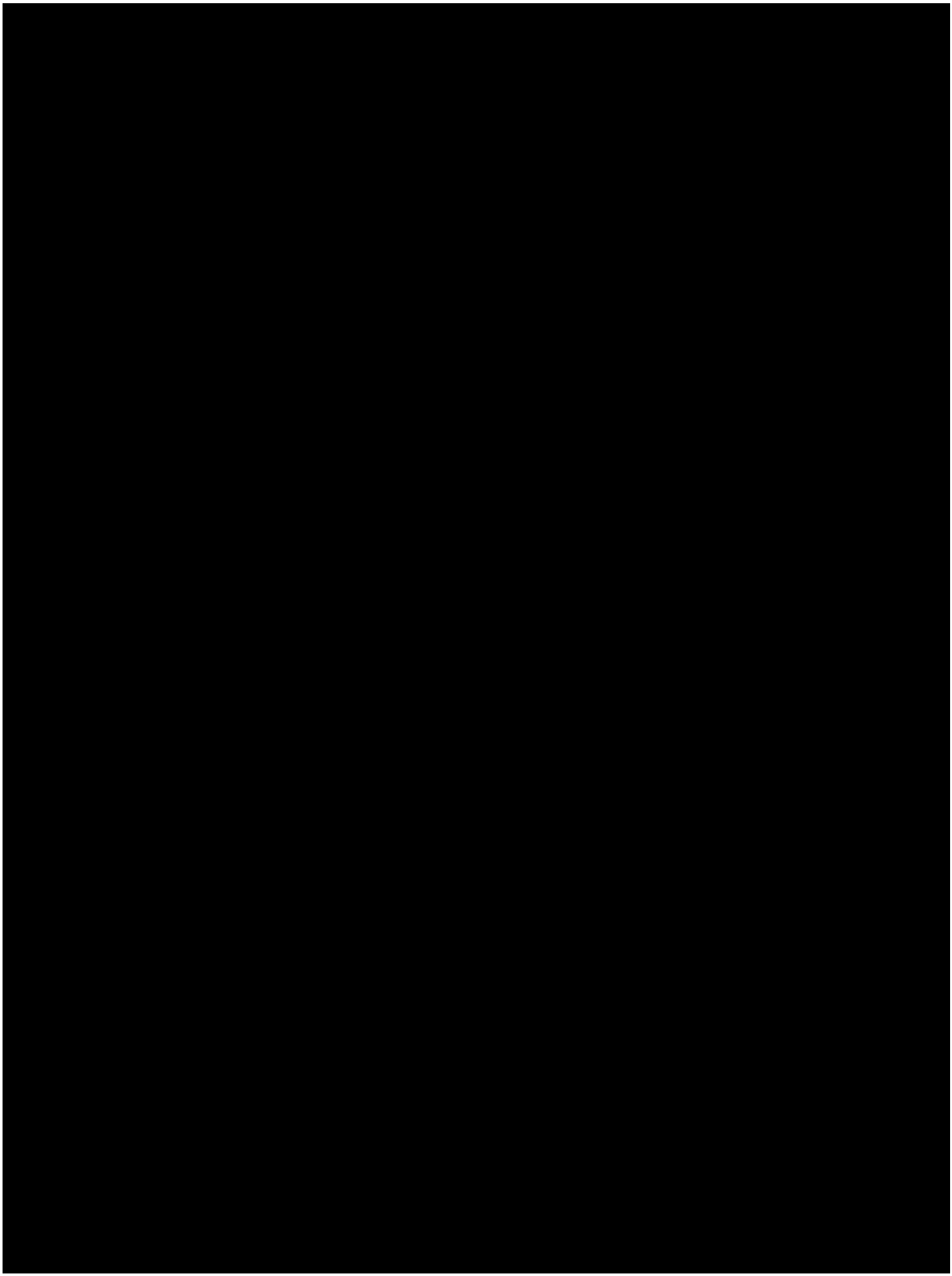
Prepared By: ES
Reviewed By: JL

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Jamestown Reservoir
Location Map

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 2-1



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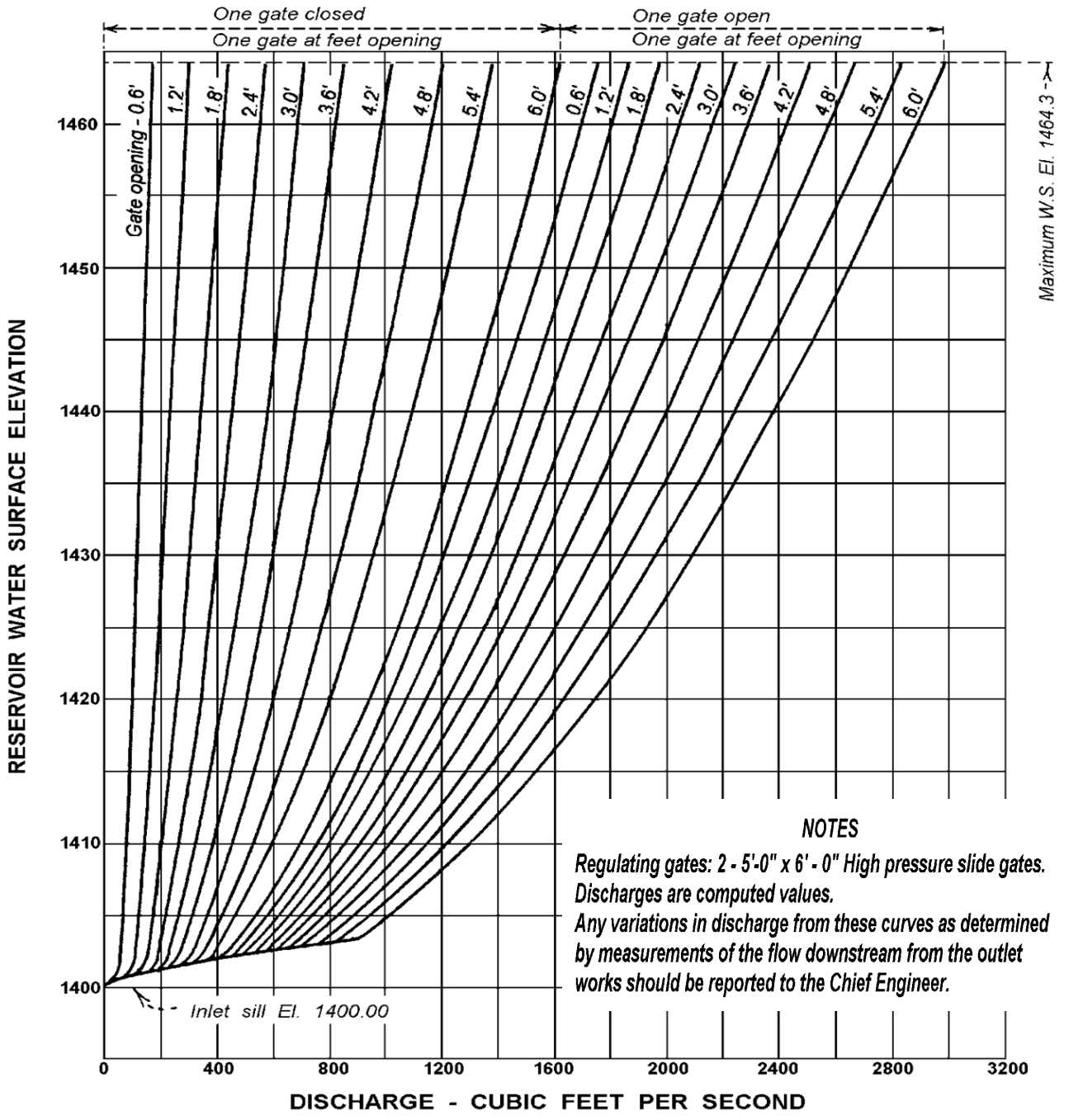


Source: Reclamation, Jamestown SOP

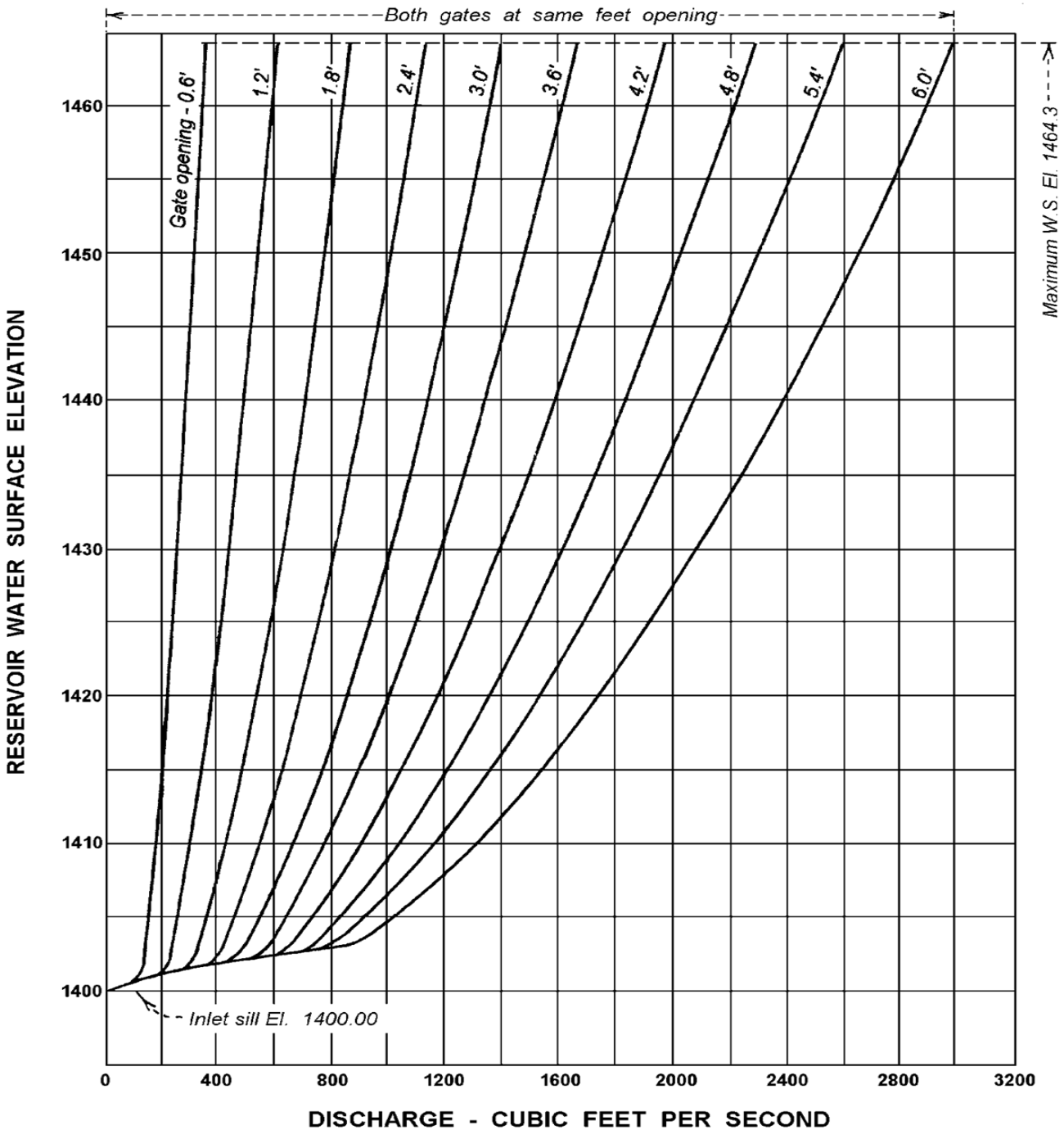
Prepared By: MB

Reviewed By: JL

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Outlet Works Discharge Curves
One Gate Open

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



Source: Reclamation, Jamestown SOP

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Outlet Works Discharge Curves
Both Gates Open Equal Amounts

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: MB
Reviewed By: JL

Plate 2-10

One Gate Open (cfs)

	Gate Setting (feet)										
Elevation	0.6	1.2	1.8	2.4	3	3.6	4.2	4.8	5.4	6	6.6
1410	80	147	233	273	333	387	460	540	600	700	700
1415	93	167	247	307	380	453	540	633	707	833	833
1420	100	180	260	353	427	513	600	713	813	953	953
1425	107	200	287	380	467	553	660	780	887	1060	1060
1430	113	207	300	400	507	607	727	840	967	1133	1133
1435	120	220	327	427	553	640	767	900	1027	1220	1220
1440	127	227	340	453	580	673	813	967	1100	1300	1300
1445	133	240	360	473	607	713	853	1020	1160	1360	1360
1450	140	260	380	507	653	753	900	1060	1227	1433	1433
1454	147	267	400	527	667	787	947	1113	1273	1500	1500
1458	160	287	420	553	673	820	980	1167	1327	1567	1567

Both Gates Open Equal Amounts (cfs)

	Gate Setting (feet)										
Elevation	0.6	1.2	1.8	2.4	3	3.6	4.2	4.8	5.4	6	6.6
1410	167	300	427	480	667	773	900	1033	1067	1313	1313
1415	200	340	460	627	737	887	1047	1207	1360	1500	1500
1420	220	380	540	693	853	1007	1167	1353	1593	1740	1740
1425	233	413	587	747	933	1100	1300	1487	1687	1920	1920
1430	260	447	633	813	1013	1187	1400	1613	1827	2080	2080
1435	273	473	667	867	1073	1267	1500	1727	1953	2240	2240
1440	287	500	713	913	1133	1340	1587	1833	2073	2387	2387
1445	300	520	753	967	1207	1420	1673	1940	2193	2527	2527
1450	313	533	780	1013	1253	1480	1767	2033	2300	2660	2660
1454	327	567	807	1060	1300	1540	1827	2113	2400	2767	2767
1458	340	587	833	1100	1353	1607	1913	2213	2500	2887	2887

Bypass Valve Releases (cfs)

	Gate Valve Setting (inches)									
Elevation	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
1420	1.2	2.5	3.7	4.8	5.9	7.0	7.9	8.7	9.3	9.7
1421	1.3	2.6	3.8	5.0	6.2	7.2	8.2	9.0	9.7	10.1
1422	1.3	2.7	3.9	5.2	6.4	7.5	8.5	9.3	10.0	10.4
1423	1.4	2.7	4.1	5.3	6.6	7.7	8.7	9.6	10.3	10.7
1424	1.4	2.8	4.2	5.5	6.8	7.9	9.0	9.9	10.7	11.1
1425	1.5	2.9	4.3	5.7	7.0	8.2	9.3	10.2	11.0	11.4
1426	1.5	3.0	4.4	5.8	7.1	8.4	9.5	10.5	11.3	11.7
1427	1.5	3.1	4.5	6.0	7.3	8.6	9.8	10.8	11.6	12.0
1428	1.6	3.1	4.6	6.1	7.5	8.8	10.0	11.0	11.8	12.3
1429	1.6	3.2	4.8	6.3	7.7	9.0	10.2	11.3	12.1	12.6
1430	1.6	3.3	4.9	6.4	7.9	9.2	10.5	11.5	12.4	12.9
1431	1.7	3.4	5.0	6.6	8.2	9.5	10.8	11.8	12.7	13.2

Note: The maximum gate opening for the main gates is 6.0 feet. An additional column is provided to allow for any slight error in the opening reported, so that calculations do not go above the maximum discharge.

Source: Reclamation, Jamestown SOP

Prepared By: MB

Reviewed By: JL

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Outlet Works
Discharge Tables

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

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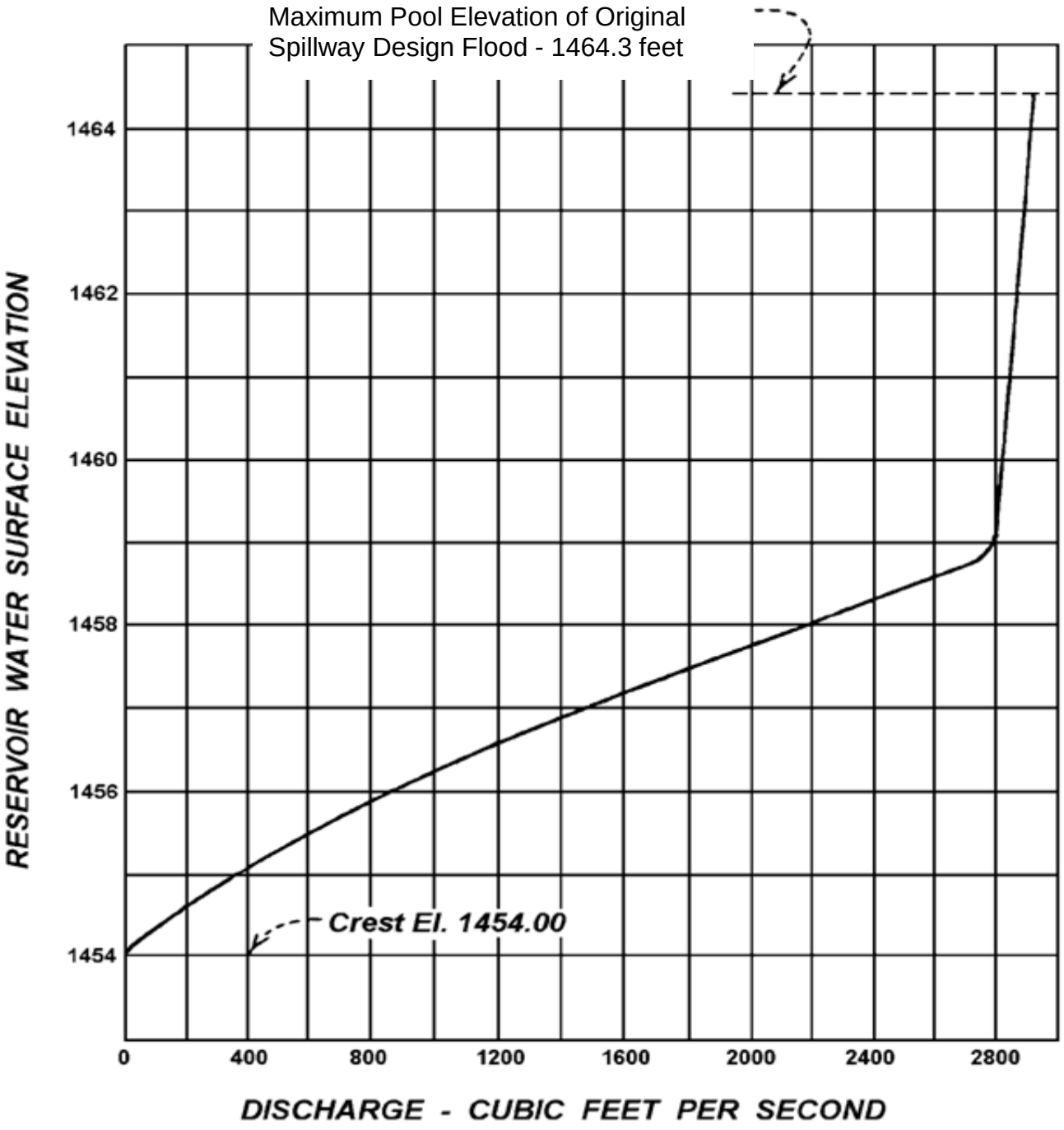


Source: Reclamation, Jamestown SOP

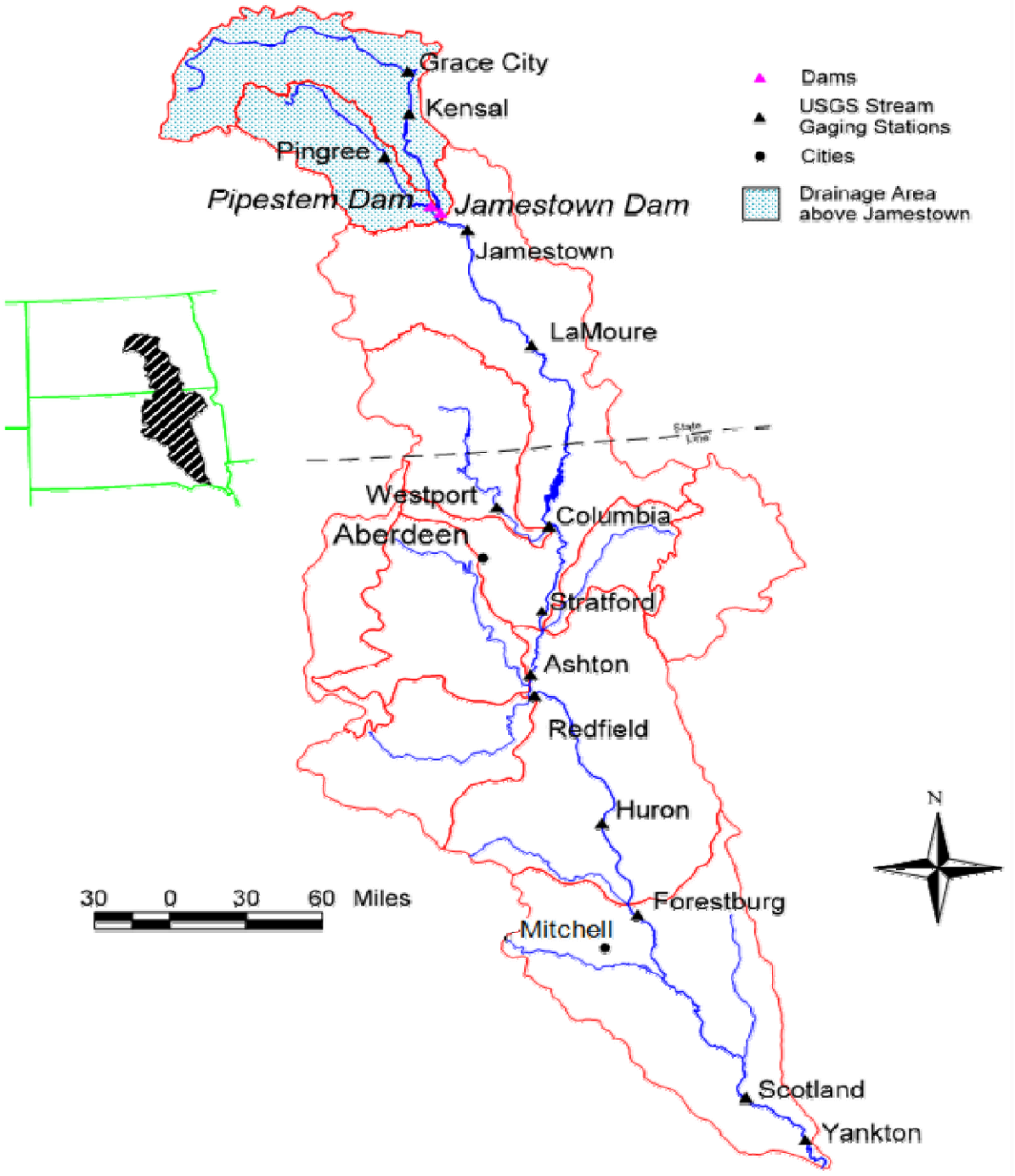
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Spillway Discharge Curve

Prepared By: MB
Reviewed By: JL

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 2-15



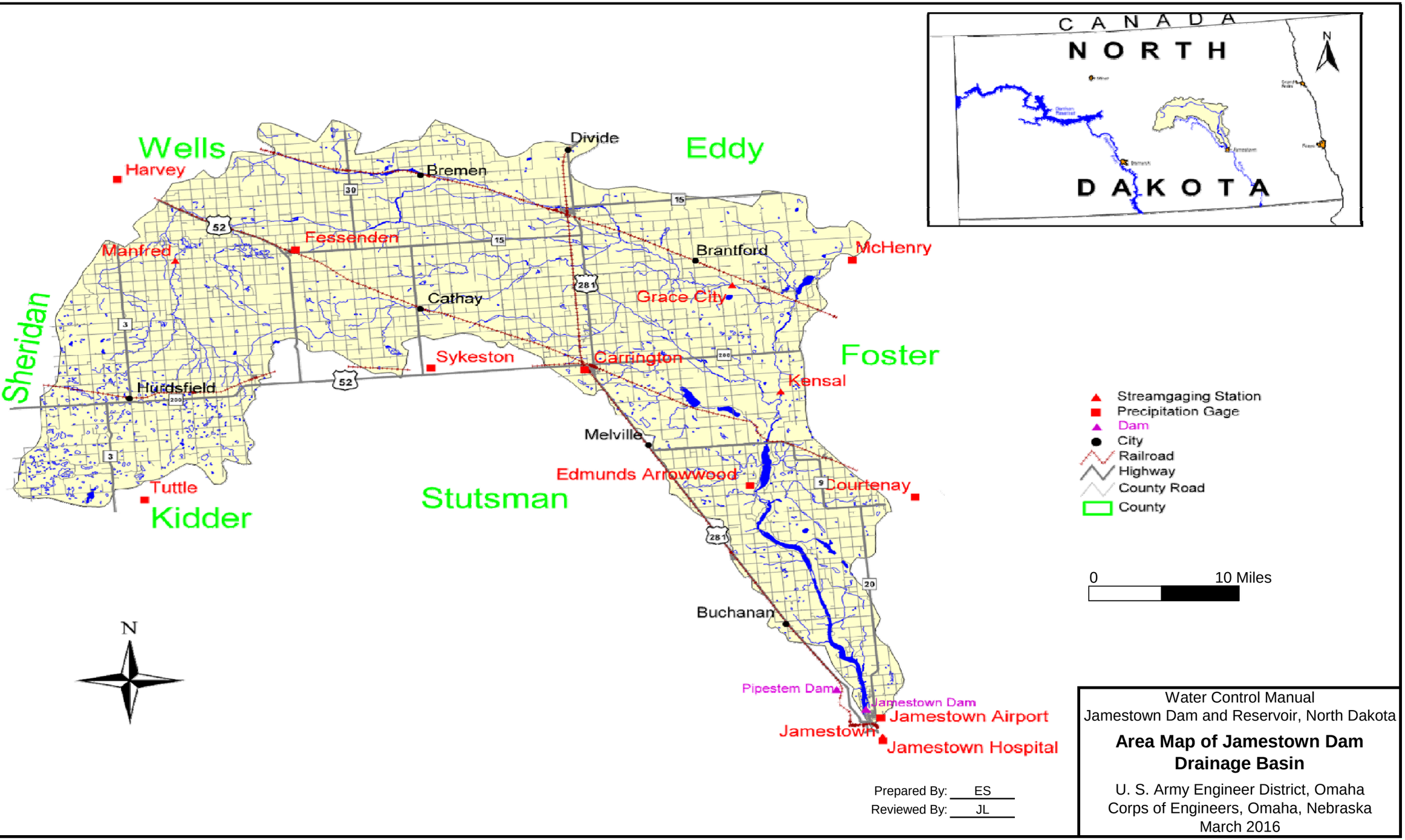
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

James River Basin Map

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: ES
Reviewed By: JL

Plate 4-1



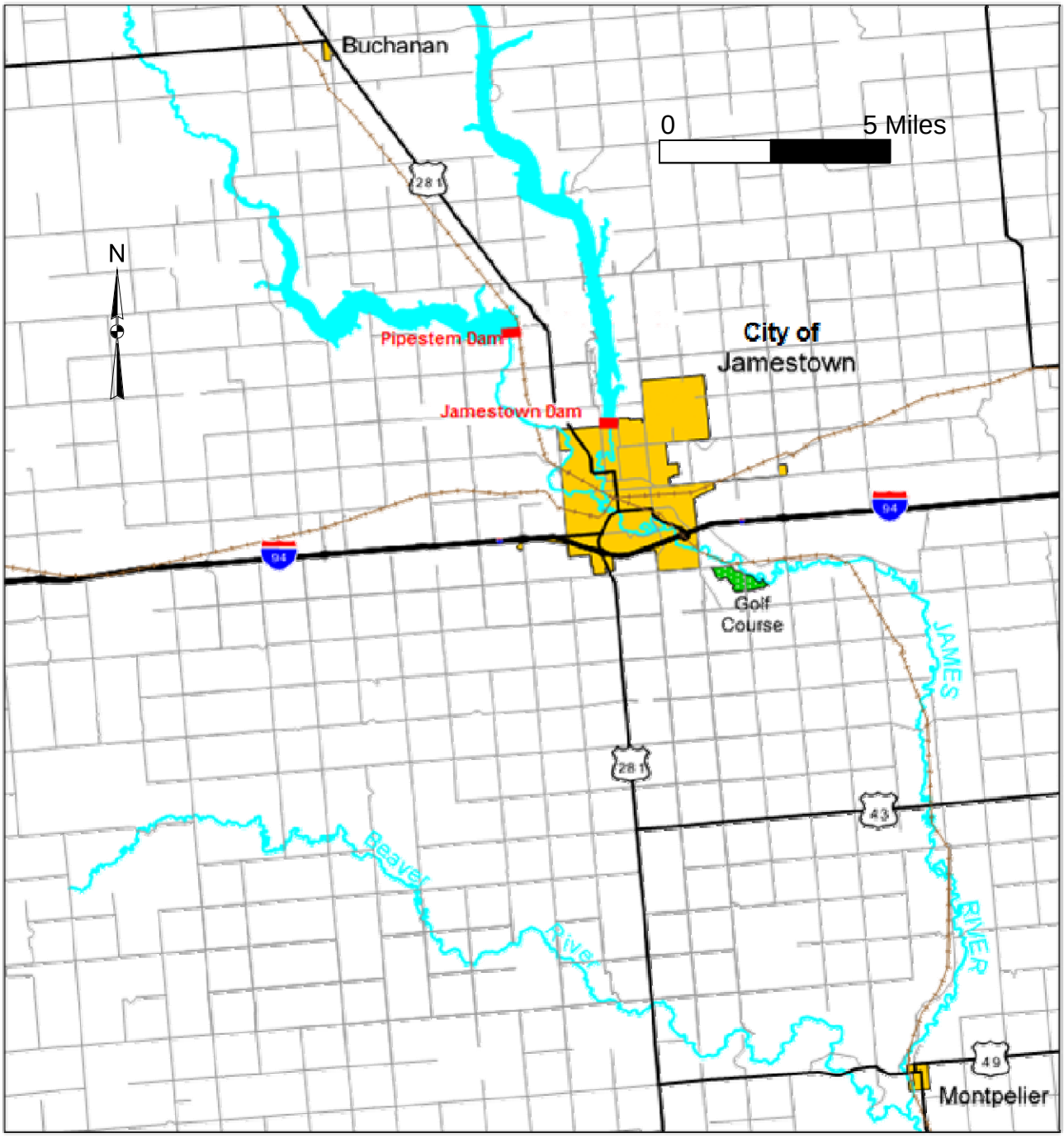
Prepared By: ES
Reviewed By: JL

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Area Map of Jamestown Dam Drainage Basin

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 4-2



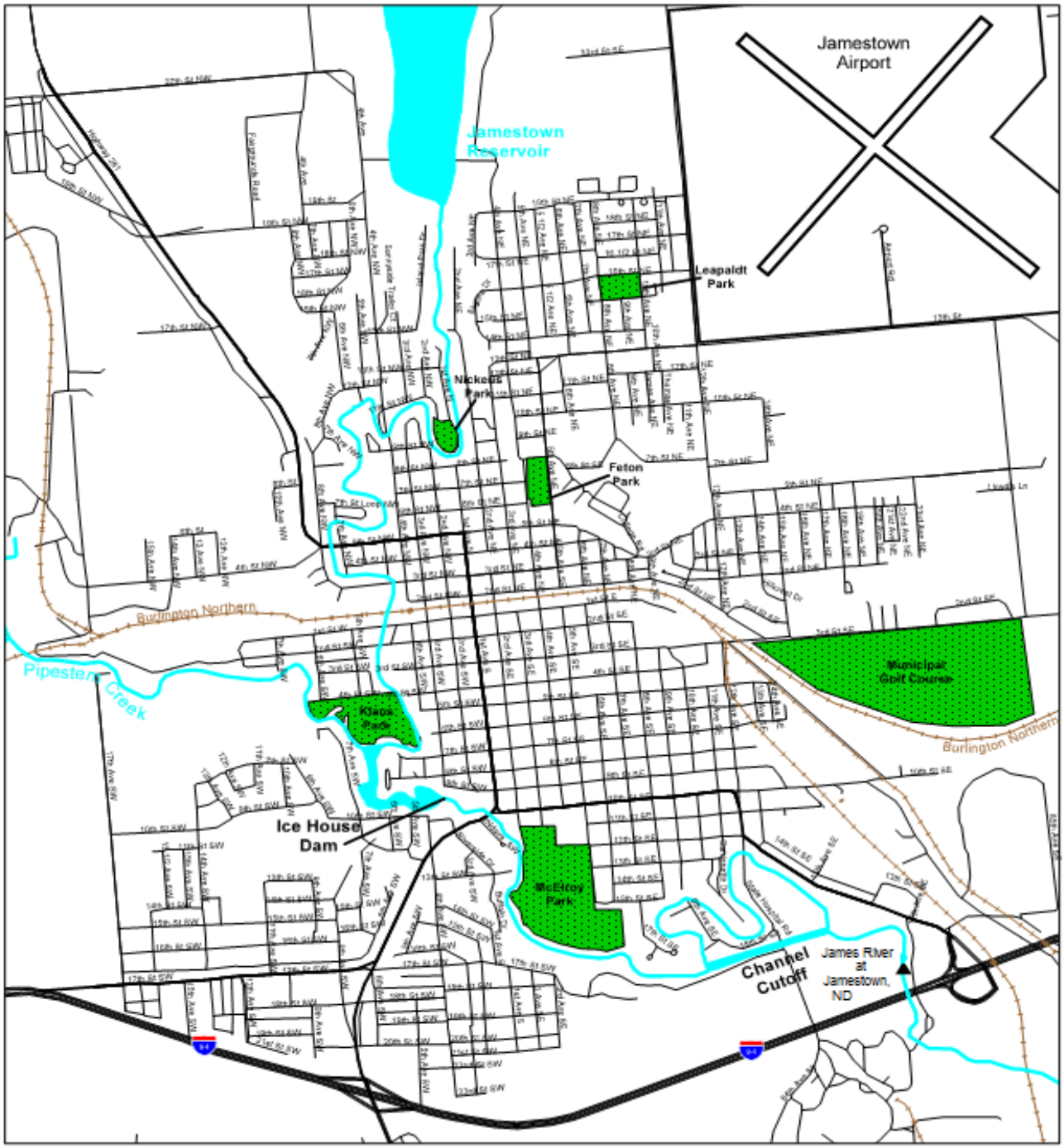
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Jamestown, ND and Vicinity Map

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: ES
Reviewed By: JL

Plate 4-3



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Prepared By: ES

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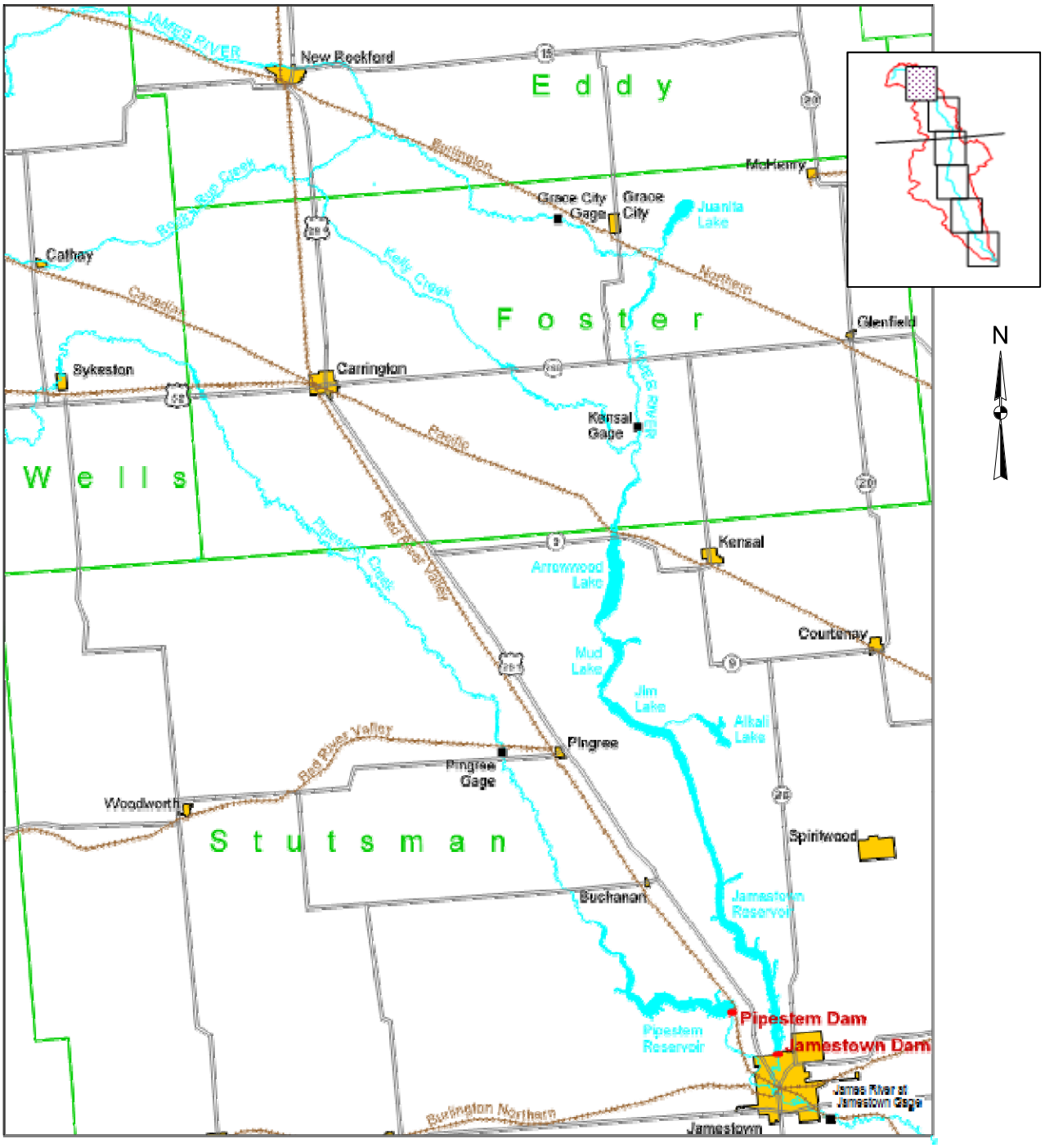
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

City of Jamestown, ND
Map

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 4-4



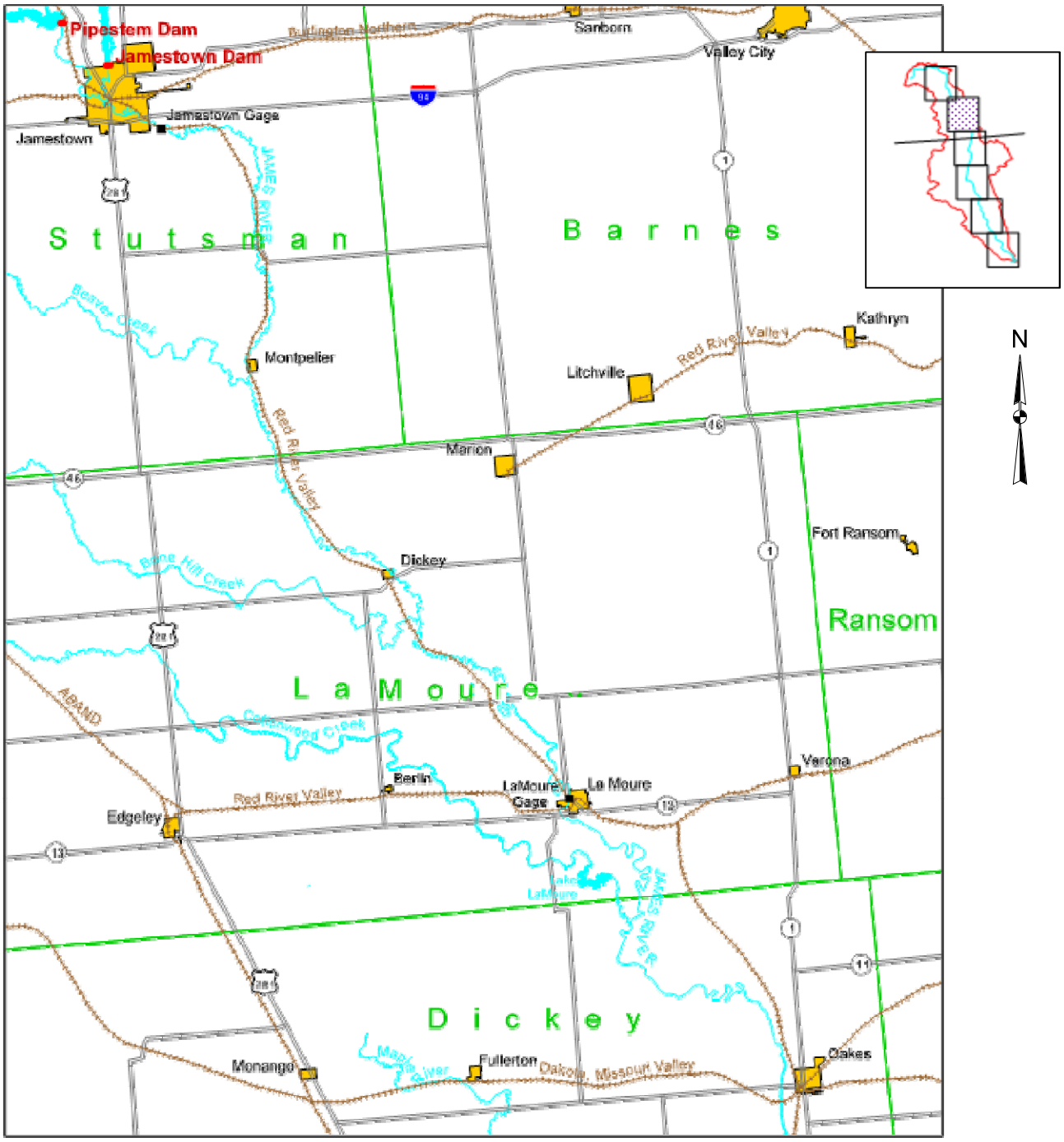
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

James River and Pipestem Creek Upstream of Jamestown, ND

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: ES
Reviewed By: JL

Plate 4-5



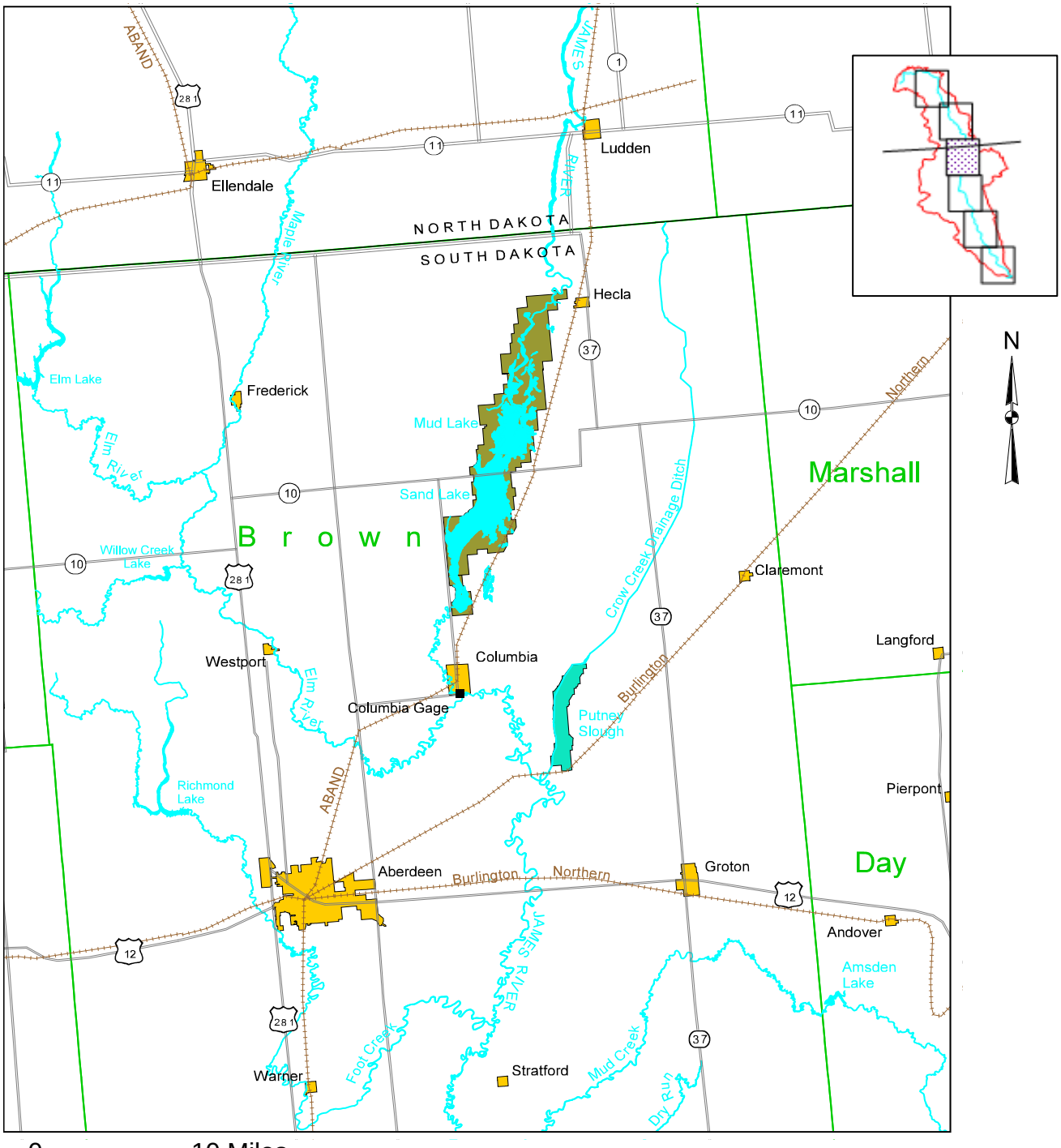
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

James River in Vicinity of LaMoure, ND

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: ES
Reviewed By: JL

Plate 4-6



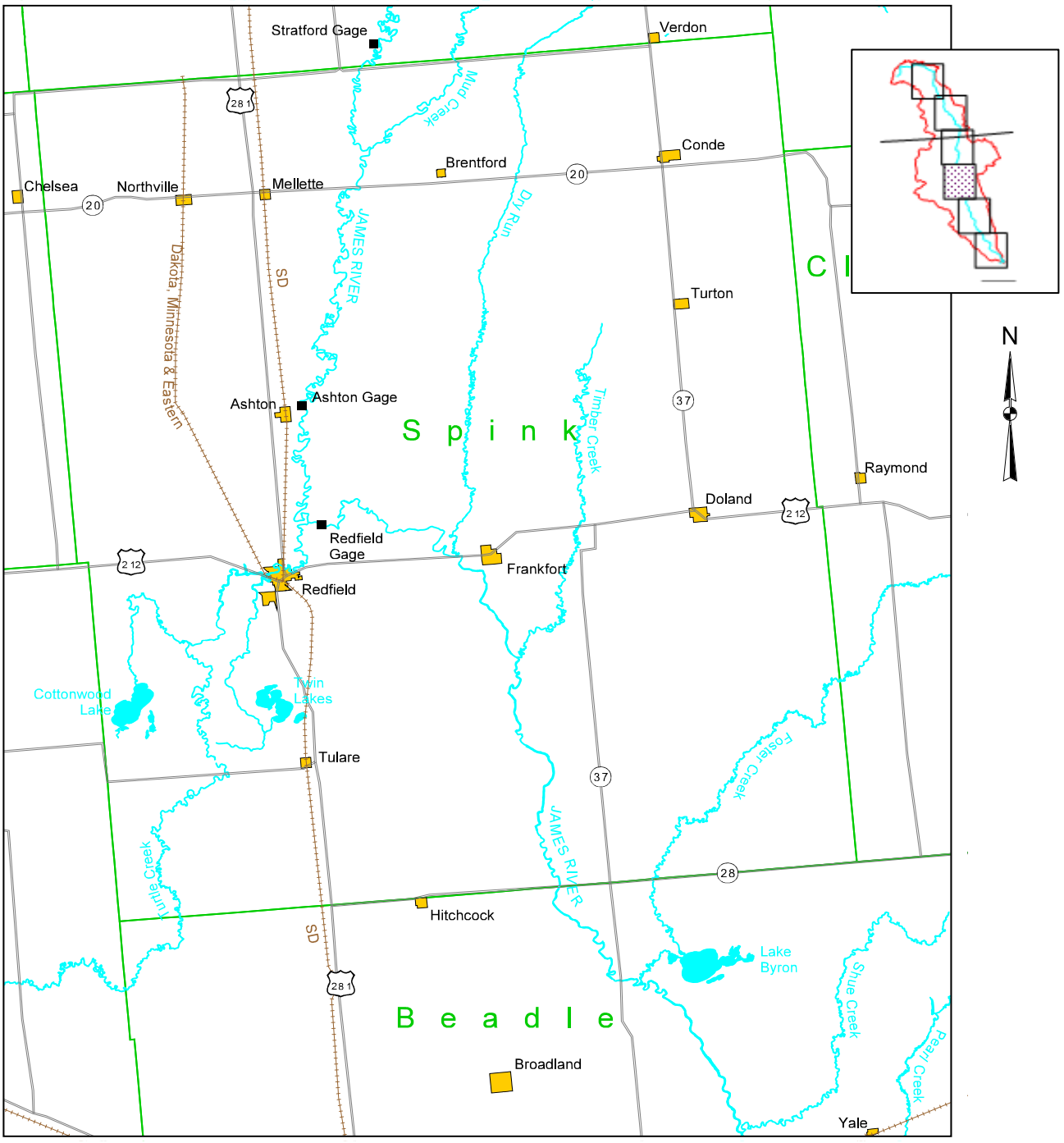
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

James River in Vicinity of Aberdeen, SD

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: ES
Reviewed By: JL

Plate 4-7



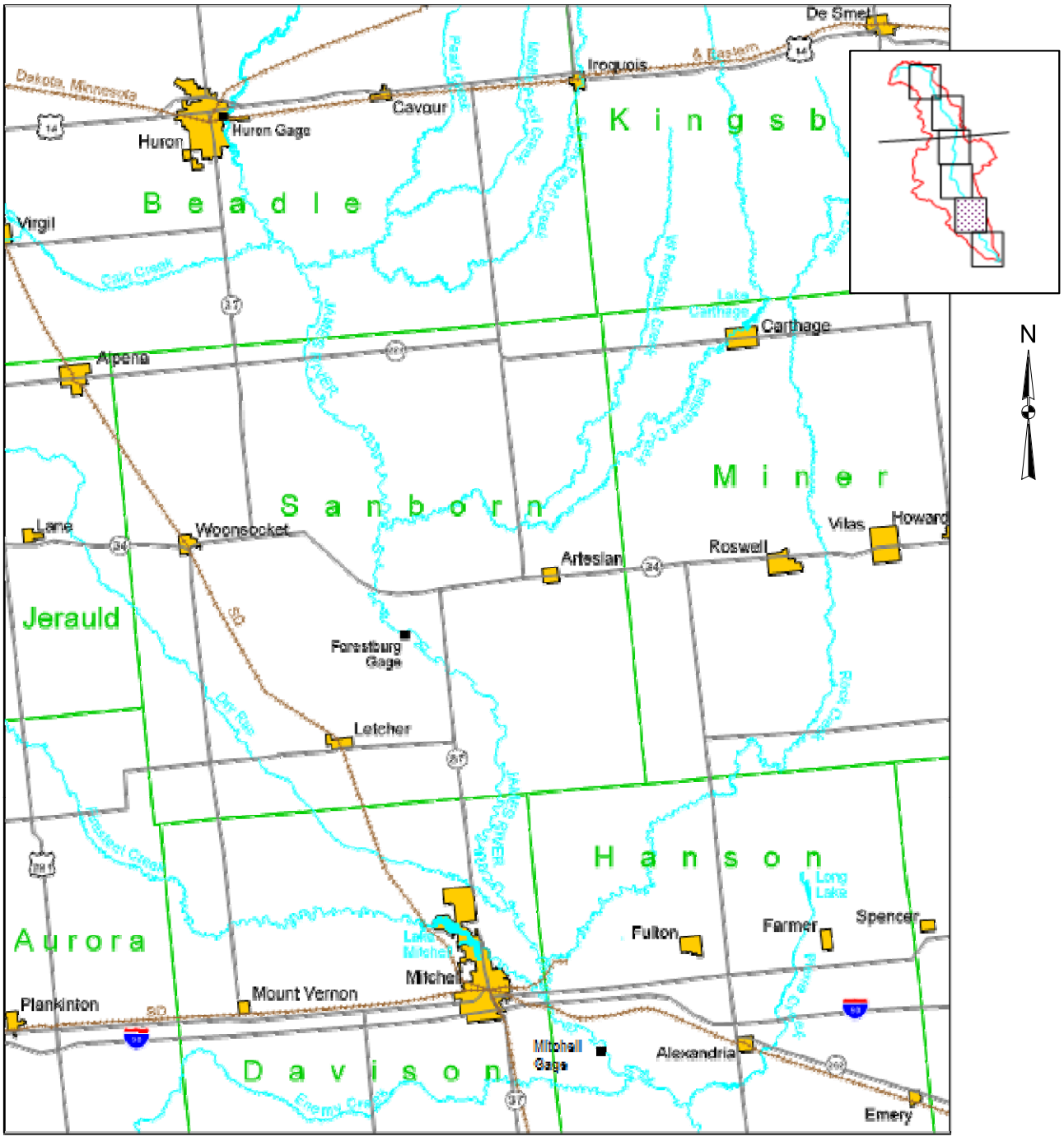
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

James River in Vicinity of Redfield, SD

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: ES
Reviewed By: JL

Plate 4-8



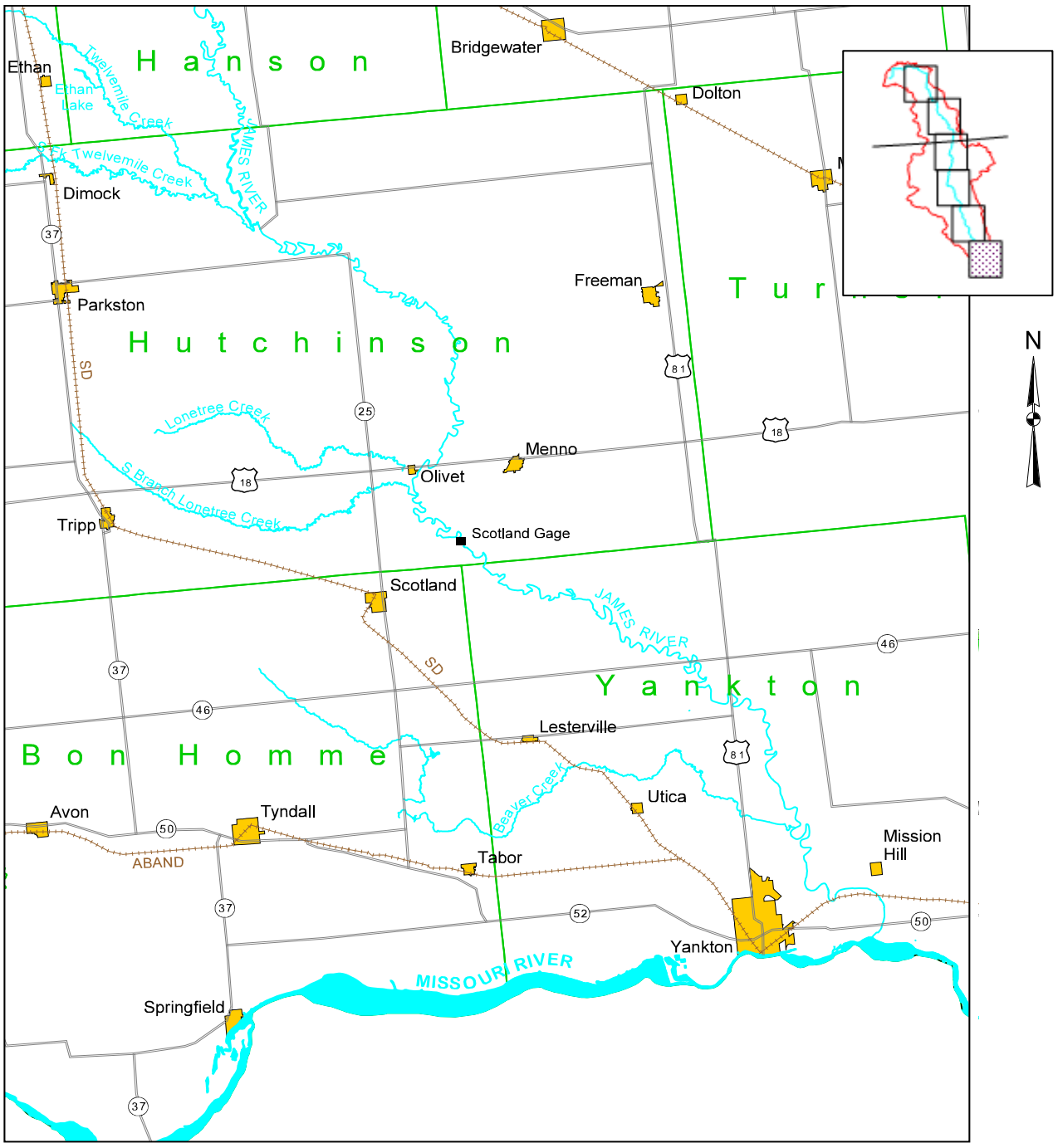
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

James River in Vicinity of Huron, SD and Mitchell, SD

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: ES
Reviewed By: JL

Plate 4-9



Water Control Manual
Jamestown Dam and Reservoir, North Dakota

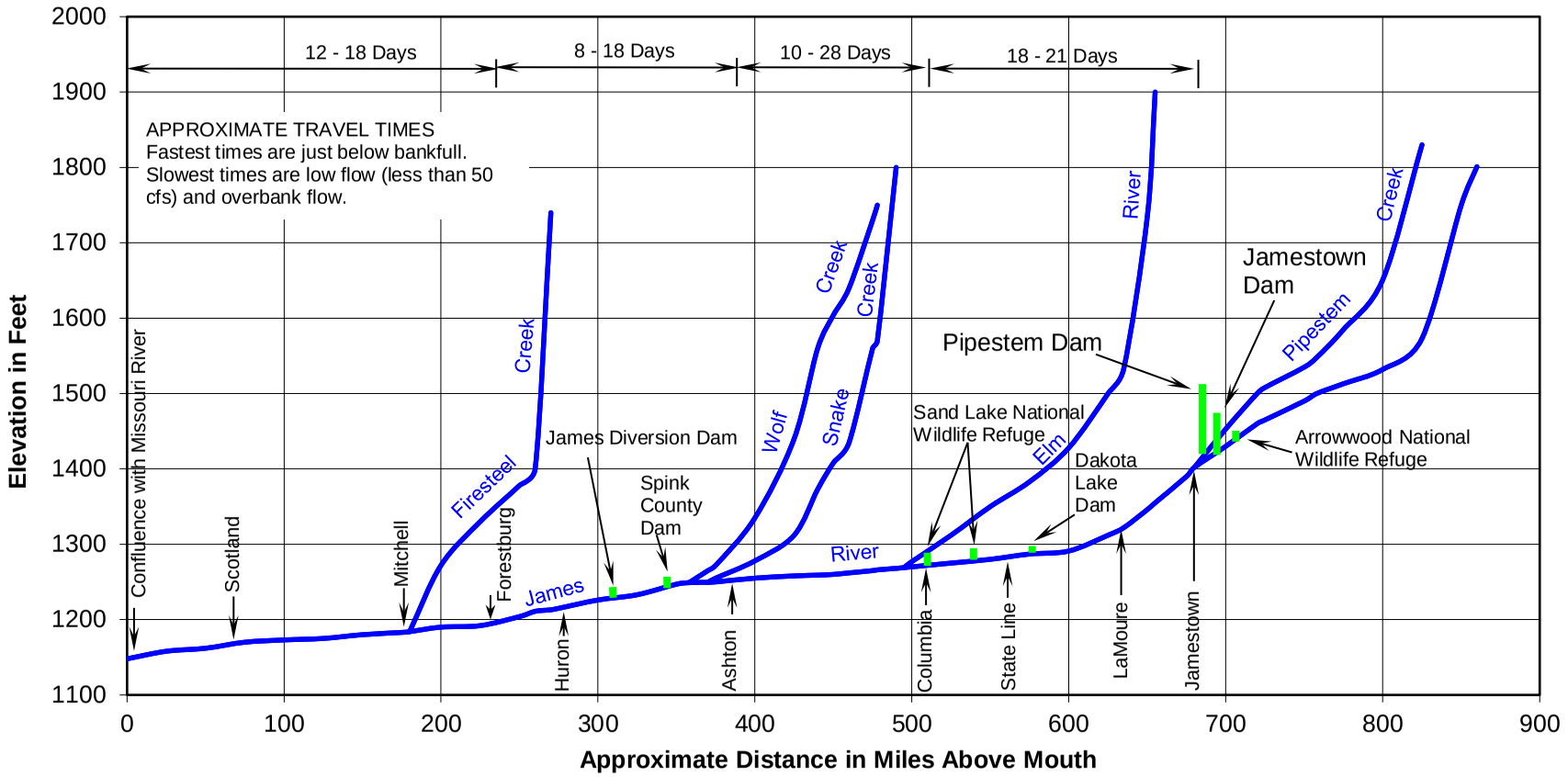
James River in Vicinity of Yankton, SD

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: ES
Reviewed By: JL

Plate 4-10

James River Profile



Source of data: Plate 2 Stream Profile, James River and Principle Tributaries. "Preliminary Reservoir Regulation Manual for Pipestem Dam and Lake, North Dakota" May 1975. Water Control Section Files.

See Section 4-09 in the Water Control Manual for further explanation on the variance of travel times within each reach of the James River.

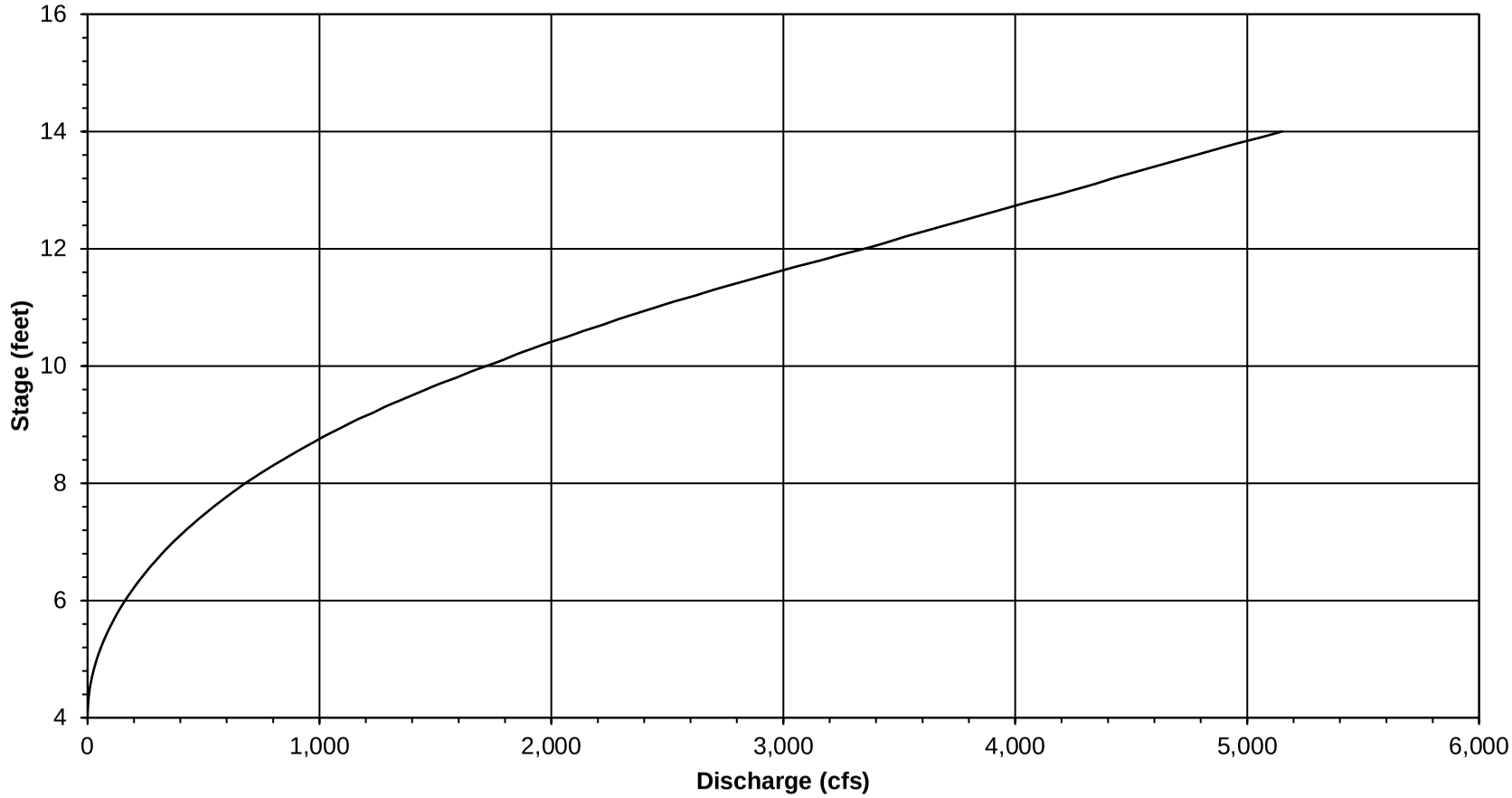
Prepared By: MB
Reviewed By: JL

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

James River Profile
Average Travel Times

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 4-11



Source: USGS
Rating ID: 7.0, July 2, 2002

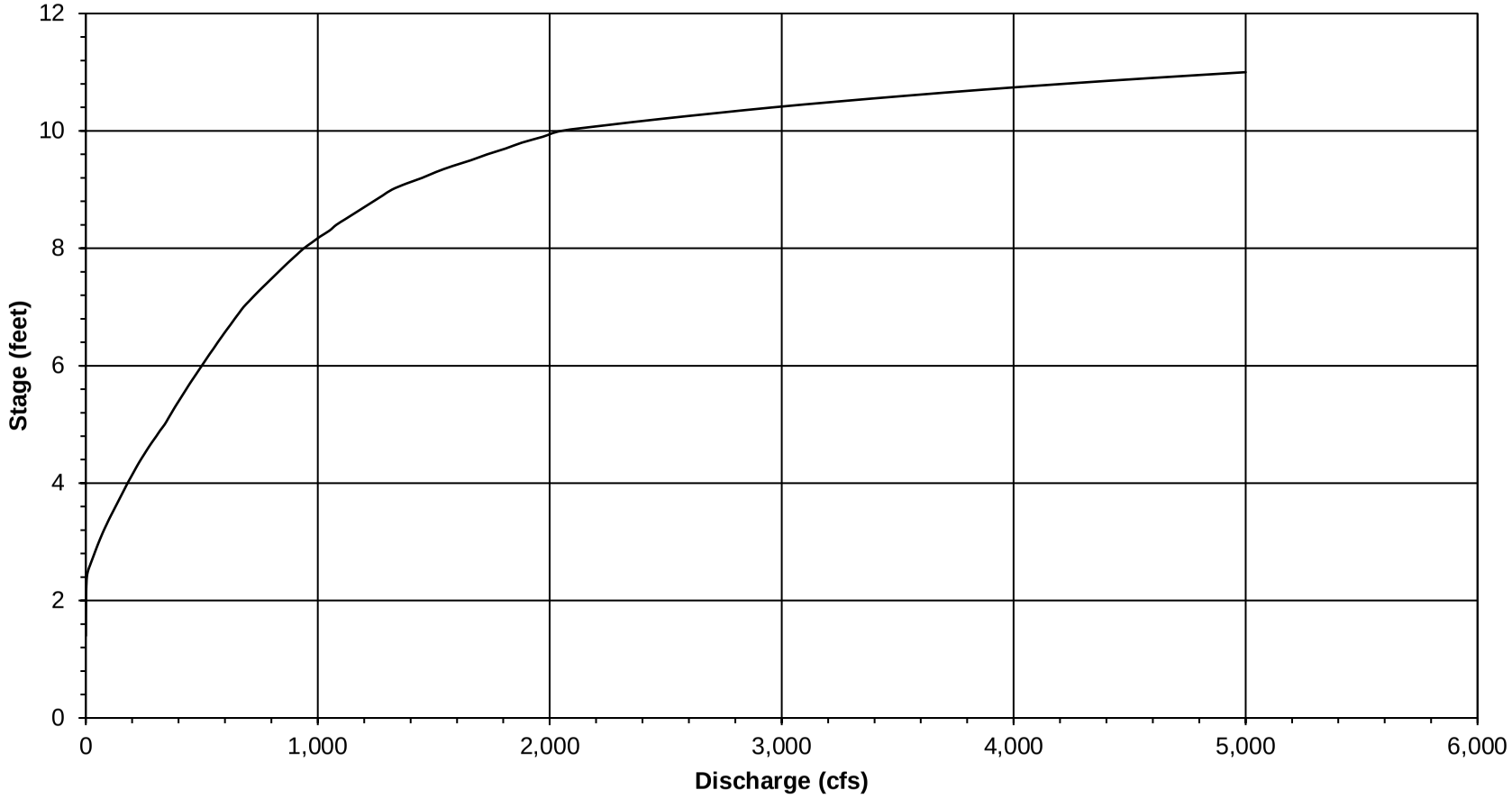
Prepared By: CC
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Rating Curve
James River at Grace City, ND

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 4-12



Source: USGS
Rating ID: 5.0, February 7, 2001

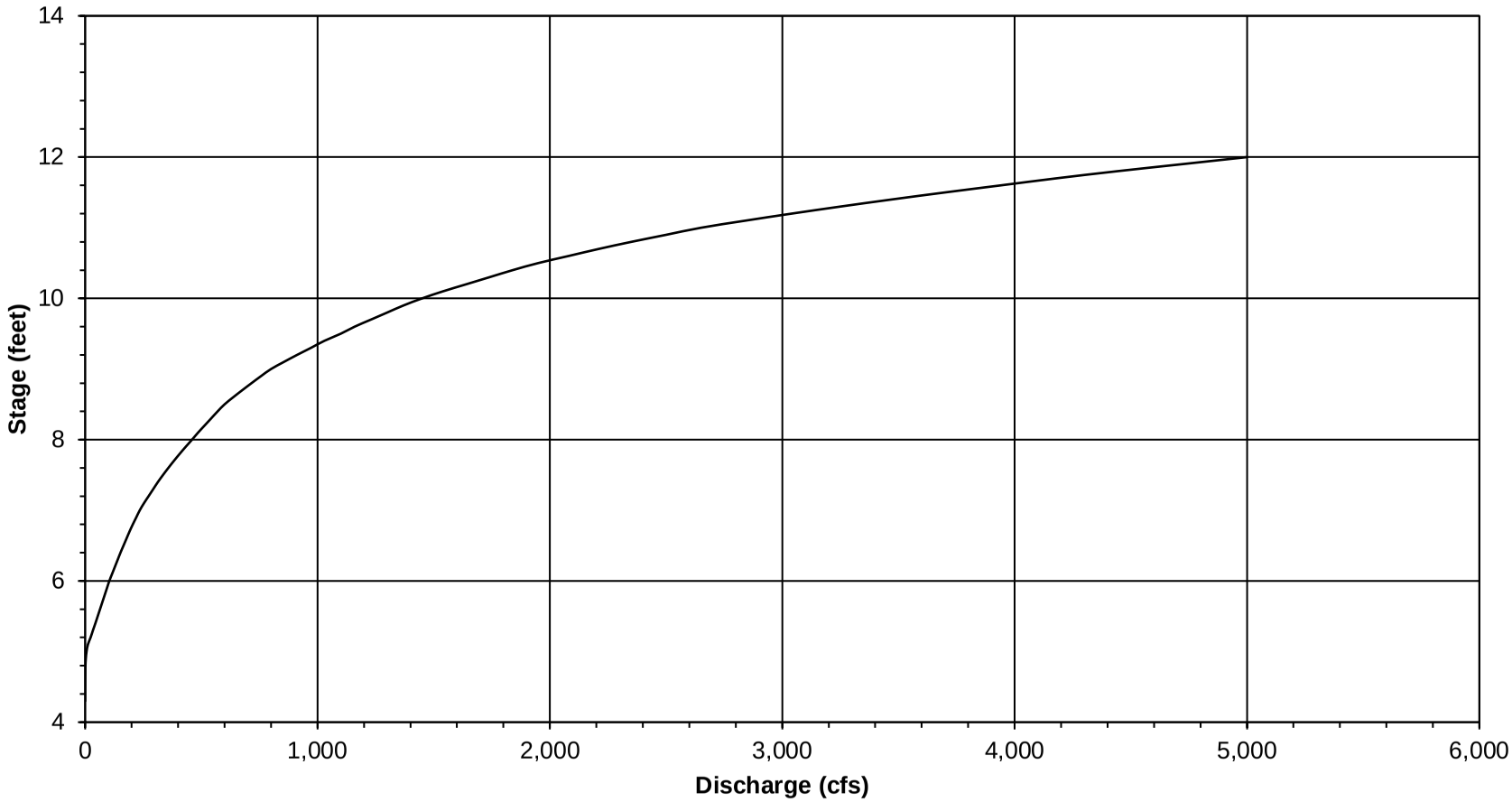
Prepared By: CC
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Rating Curve
James River at Kensal, ND

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 4-13



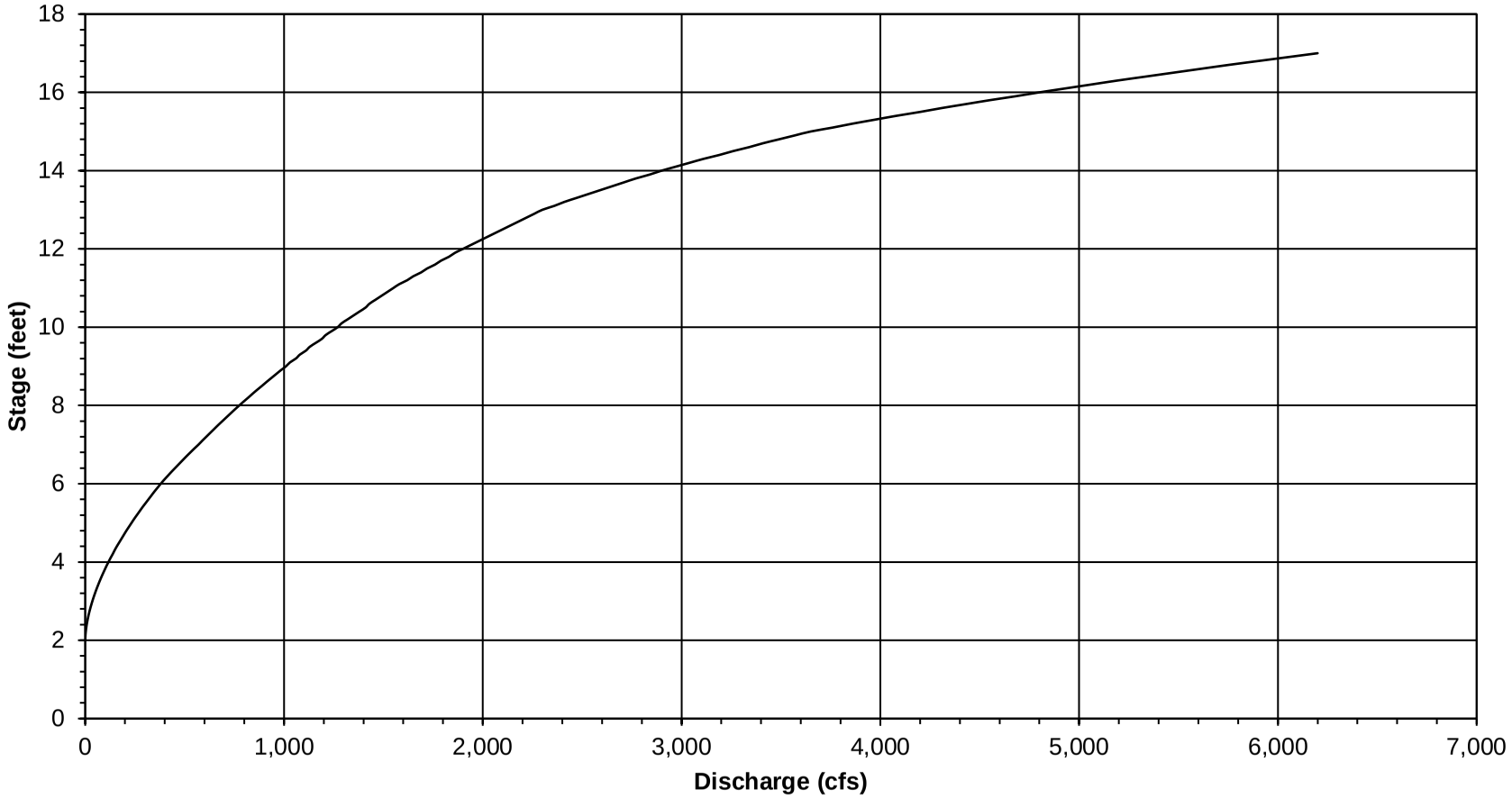
Source: USGS
Rating ID: 8.0, March 6, 1998

Prepared By: CC
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Rating Curve
Pipestem Creek at Pingree, ND

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



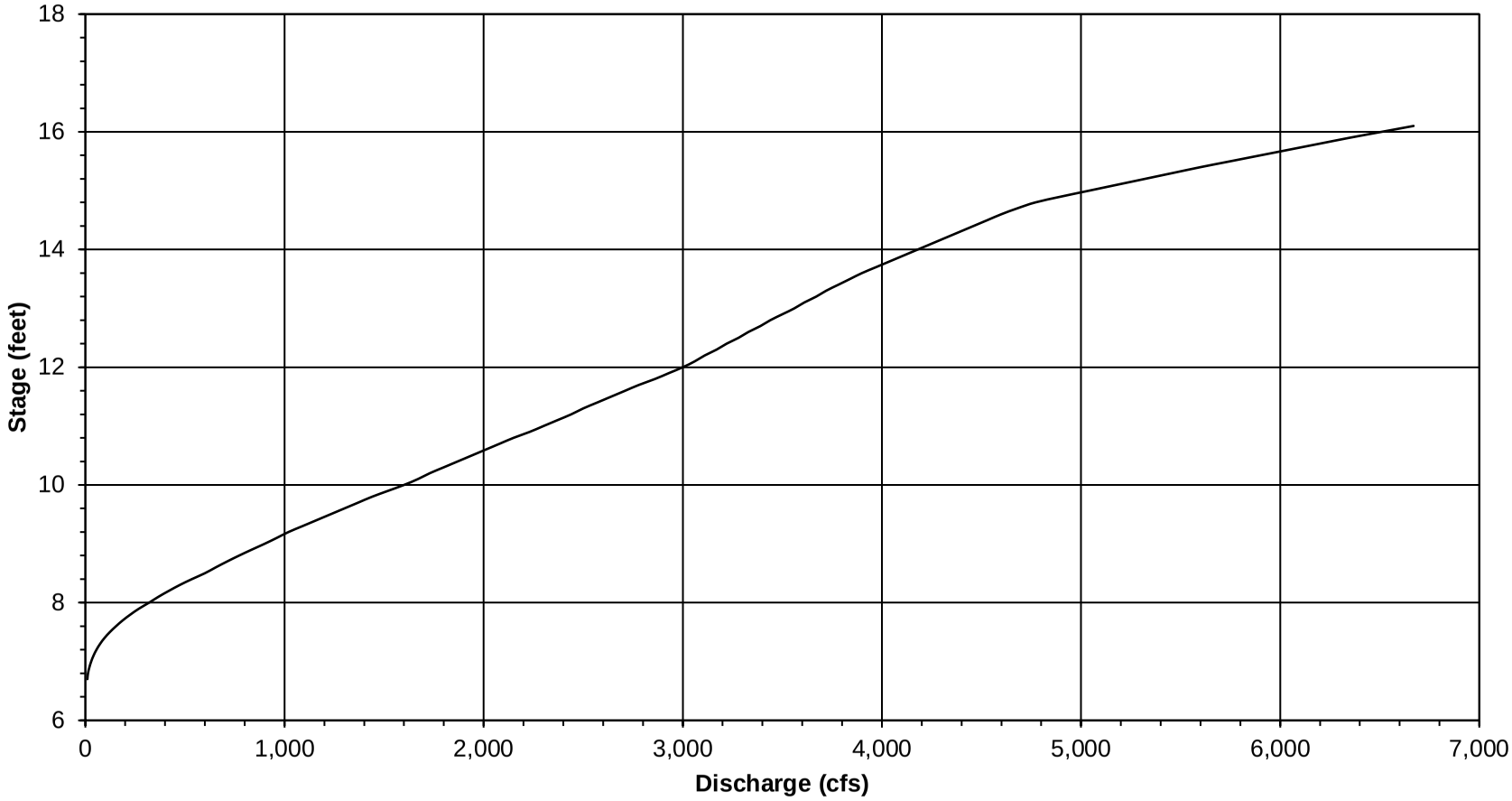
Source: USGS
Rating ID: 13.0, January 6, 2006

Prepared By: CC
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Rating Curve
James River at Jamestown, ND

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



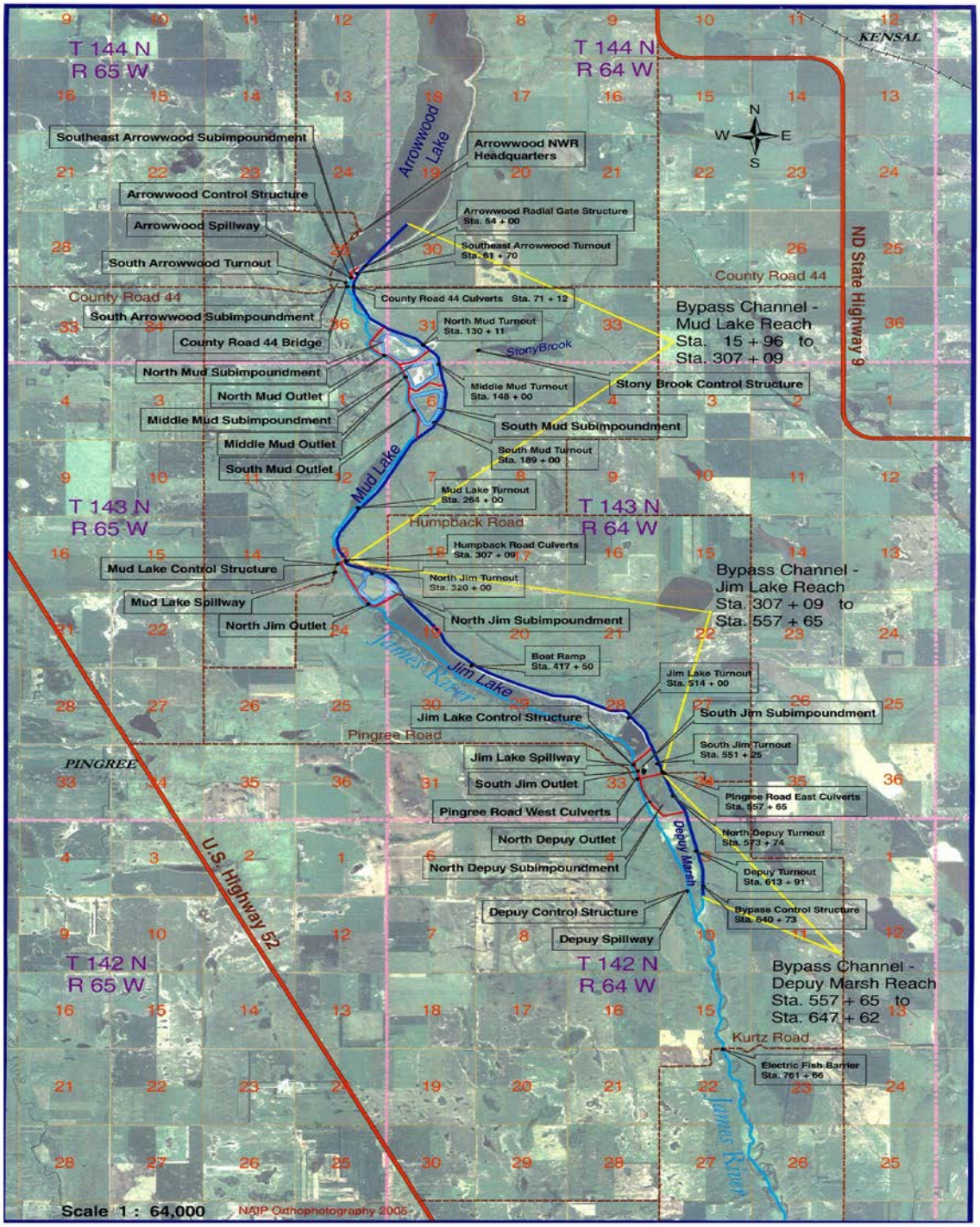
Source: USGS
Rating ID: 14.1, February 13, 2004

Prepared By: CC
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Rating Curve
James River at LaMoure, ND

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



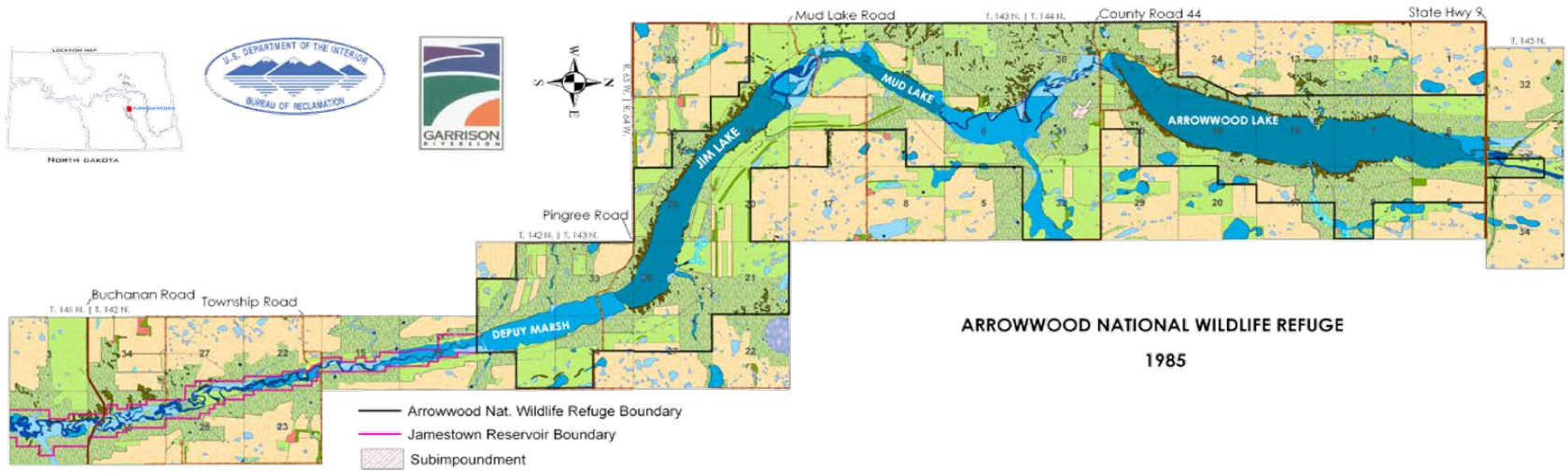
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

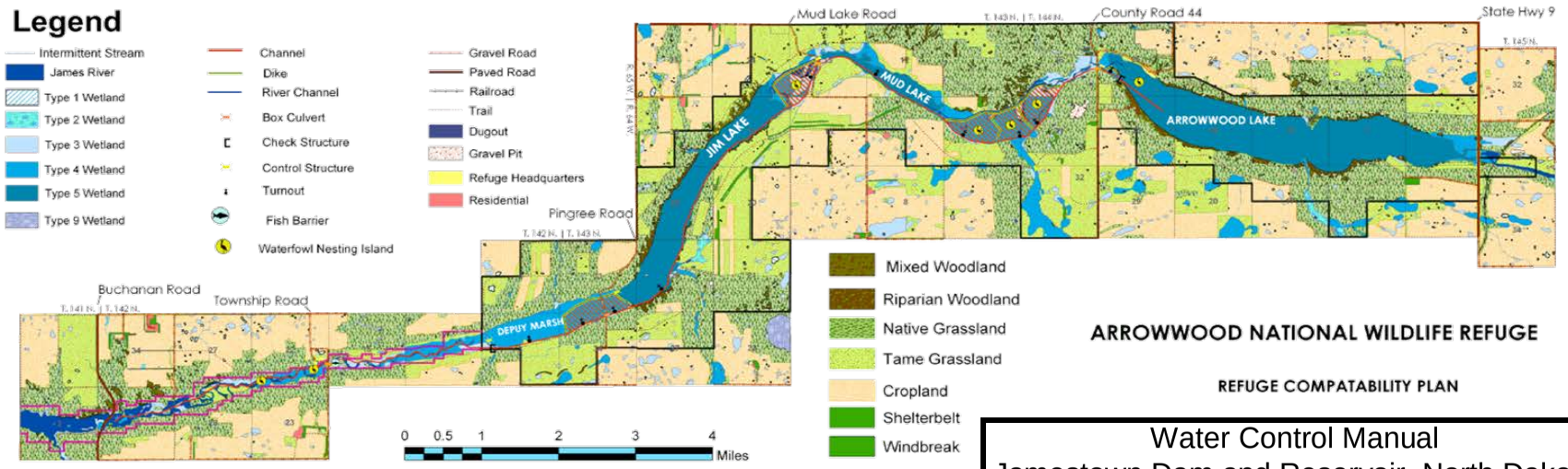
Aerial Photograph and Plan Map Arrowwood NWR

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: BT
Reviewed By: KB

Plate 4-17





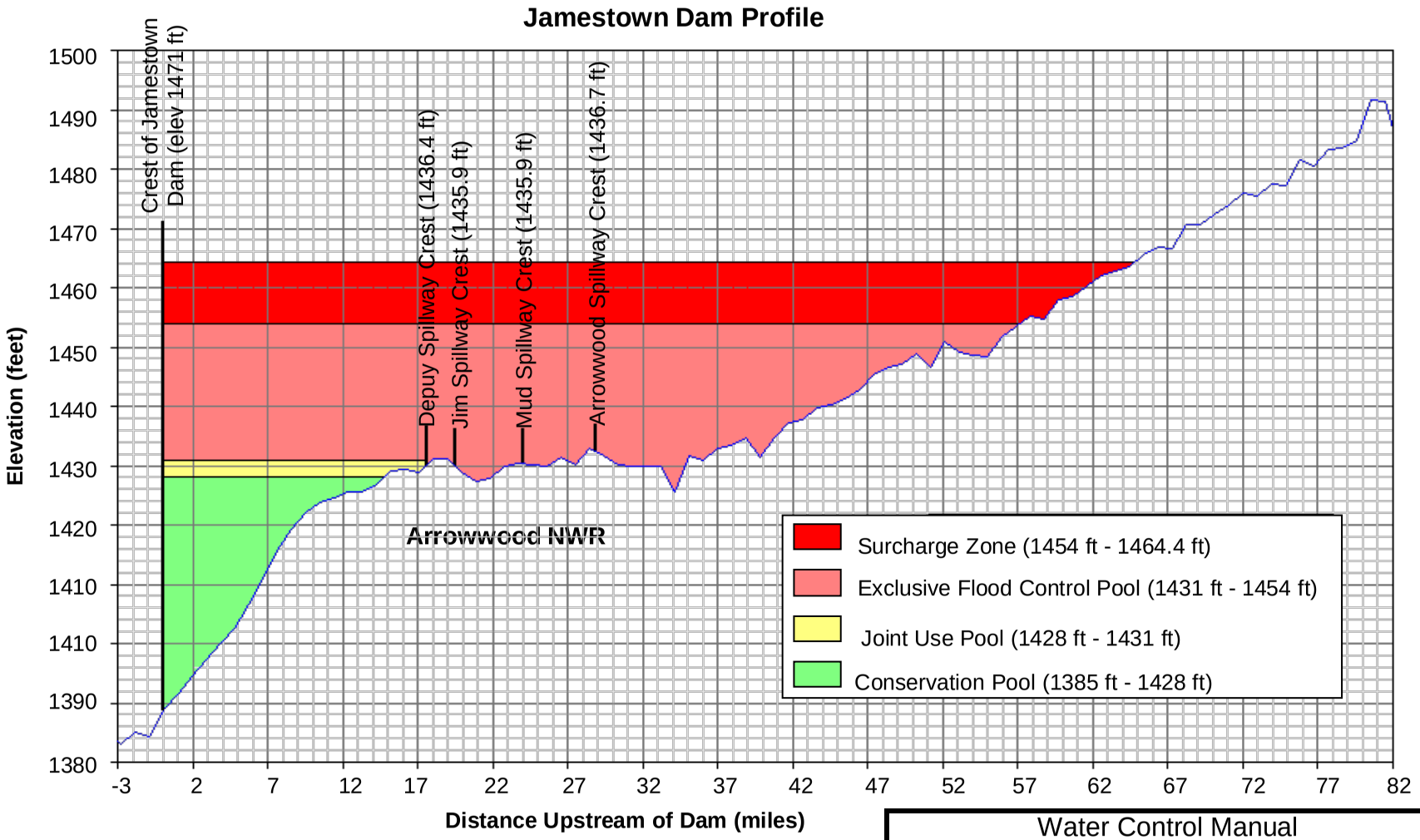
Source: Reclamation

Prepared By: BT
Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Arrowwood NWR
Detailed Plan

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



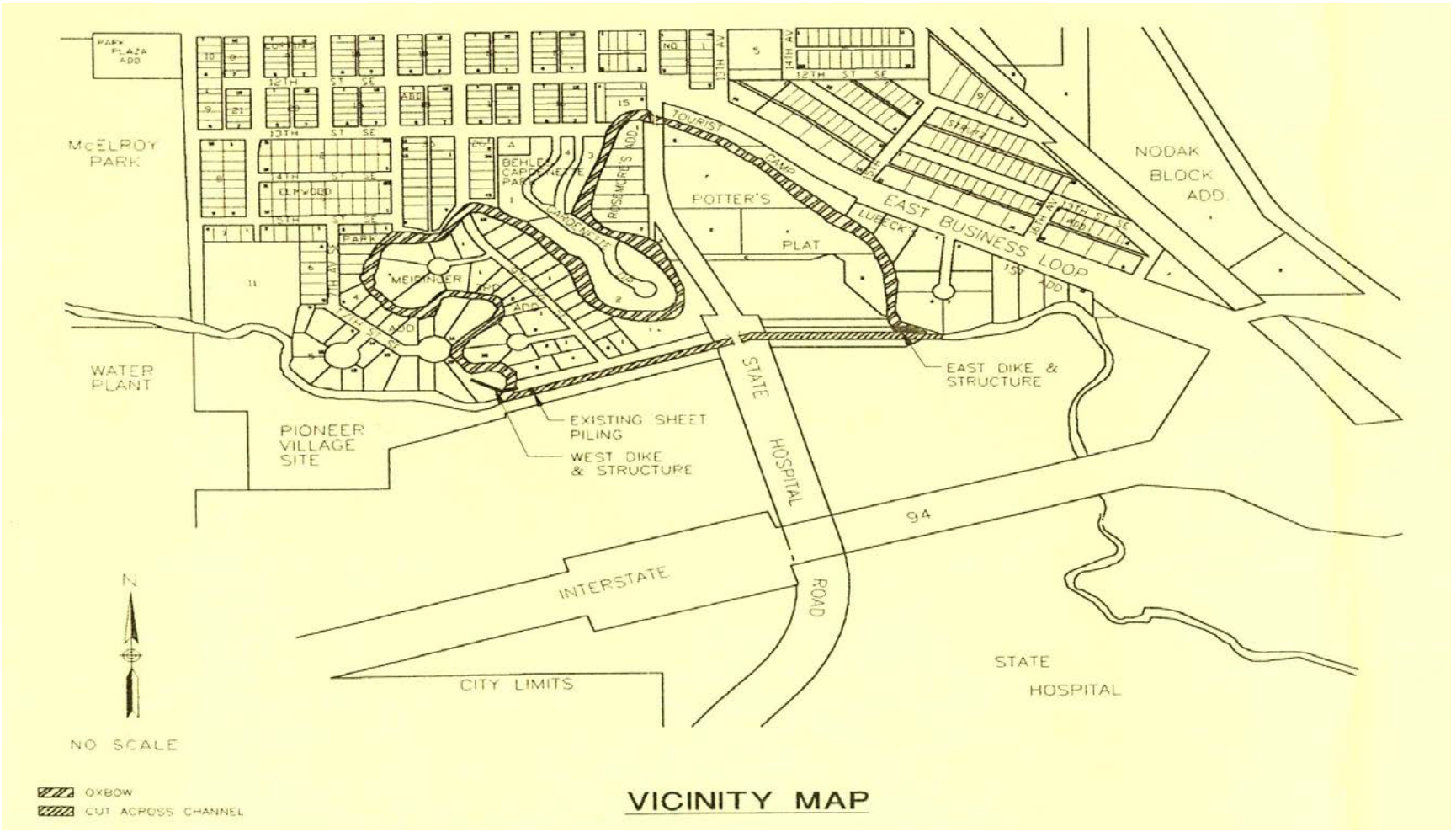
Prepared By: BT

Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Profile of Arrowwood NWR in Relation to Jamestown Reservoir

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



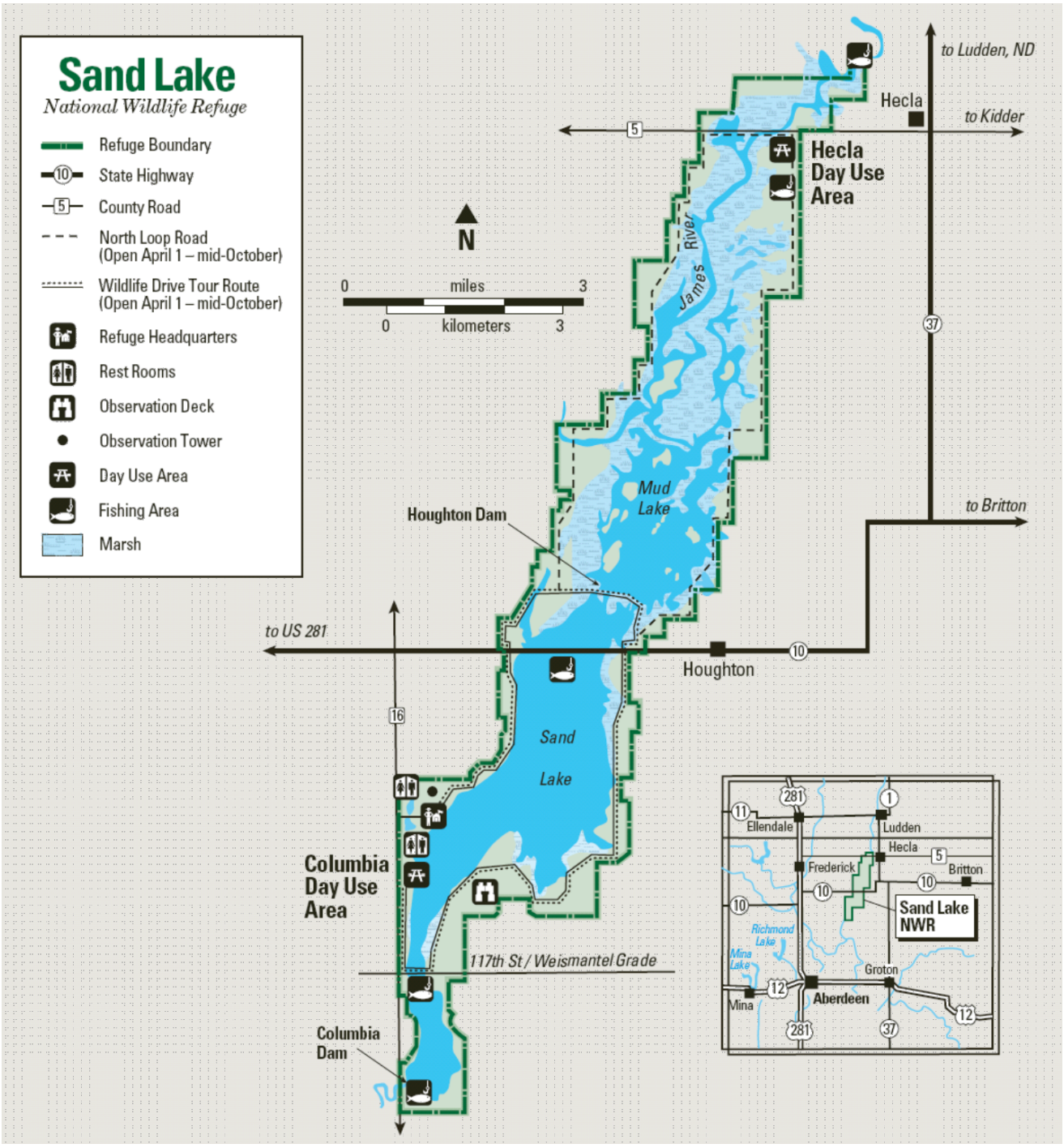
Source: City of Jamestown, ND record drawings for the FEMA oxbow dike project, 1998

Prepared By: JB
Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

FEMA Oxbow Dike Project
Jamestown, ND

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



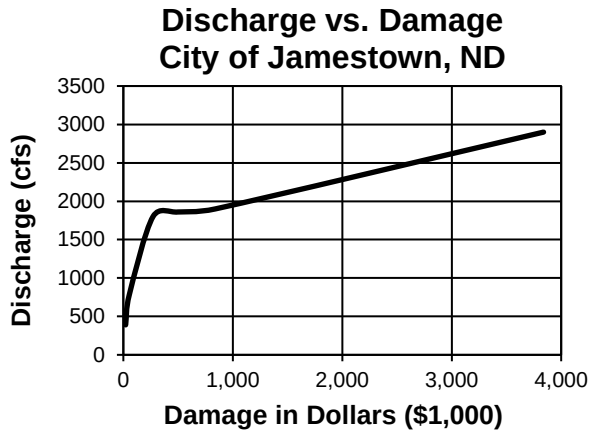
Source: Sand Lake NWR website

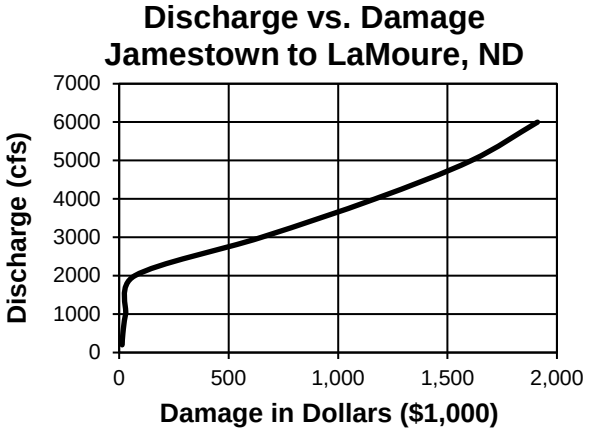
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

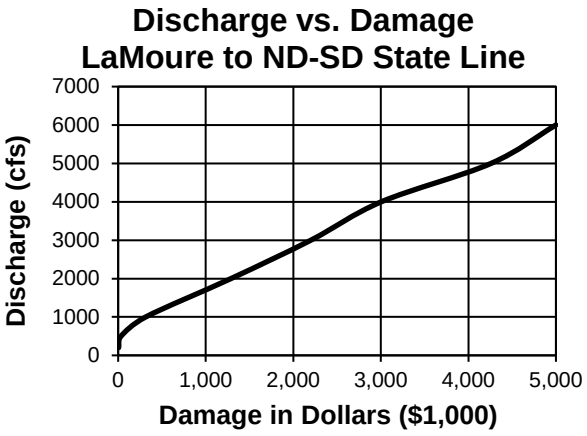
Plan Map
Sand Lake NWR

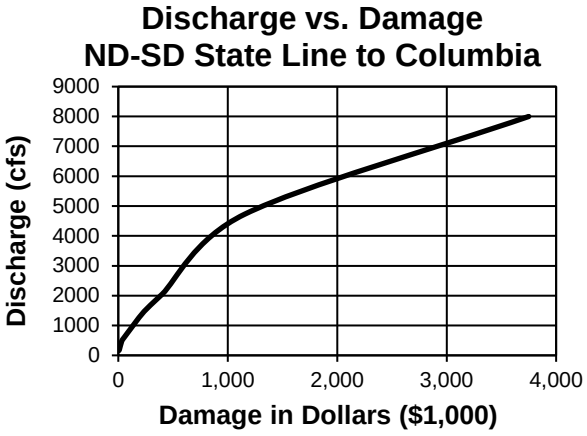
U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

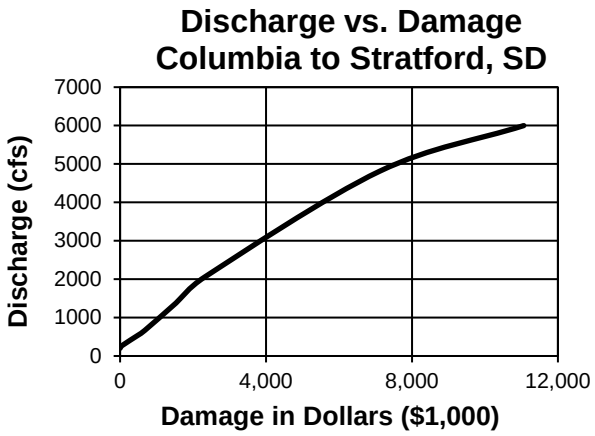
Prepared By: MB
Reviewed By: JL

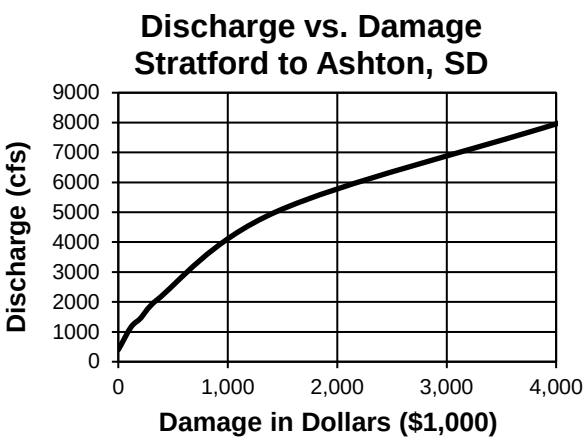










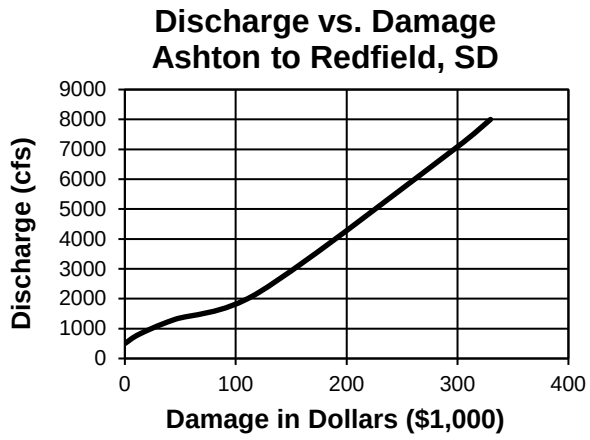


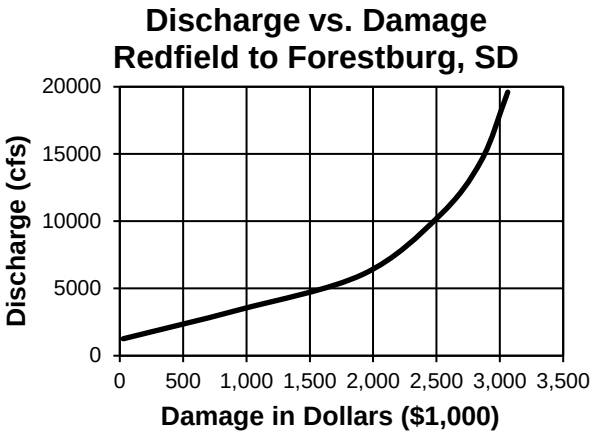
Prepared By: ES
Reviewed By: JL

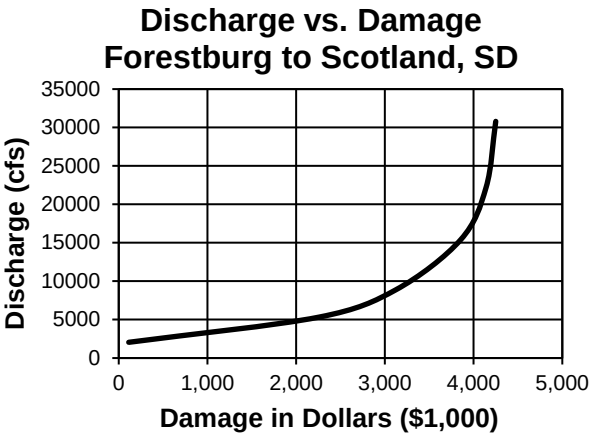
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

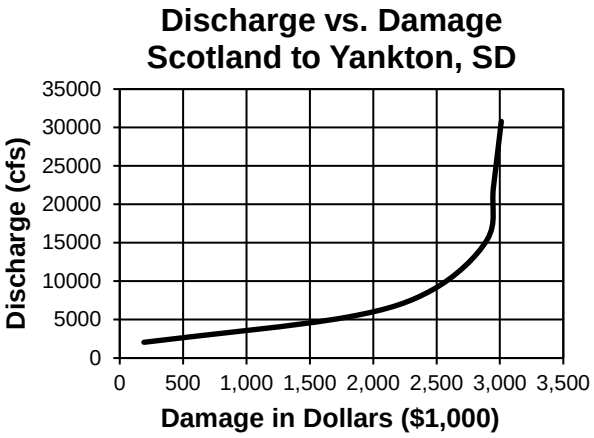
Discharge-Damage Curves
Jamestown, ND to Ashton, SD

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016







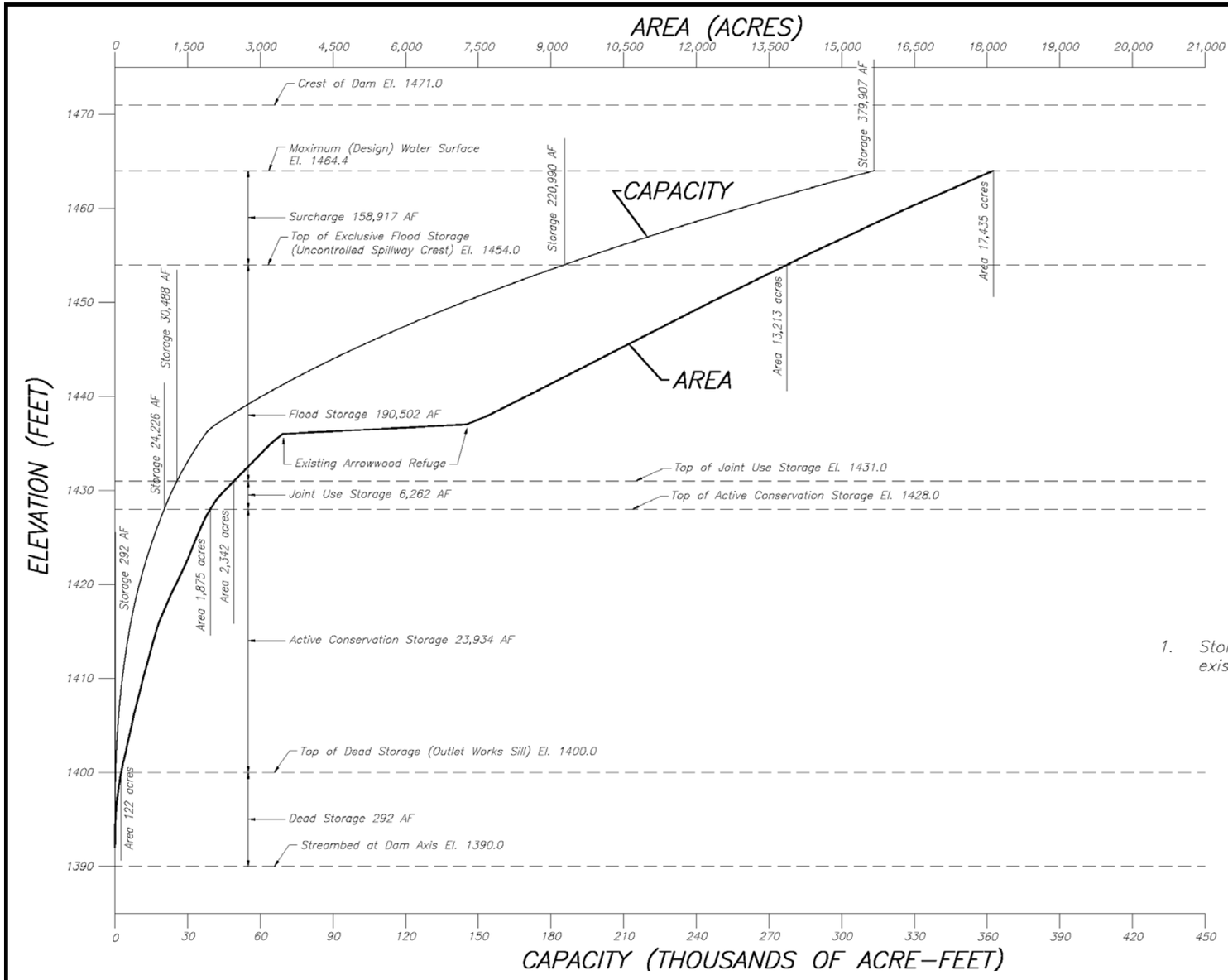


Prepared By: ES
Reviewed By: JL

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Discharge-Damage Curves
Ashton, SD to Yankton, SD

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



THIS DRAWING SUPERSEDES DRAWING 769-600-189, 10-02-2015

NOTE

1. Storage excludes volume within existing Arrowwood Refuge.

Source: Reclamation, scanned from drawing 769-600-60000-RD-1

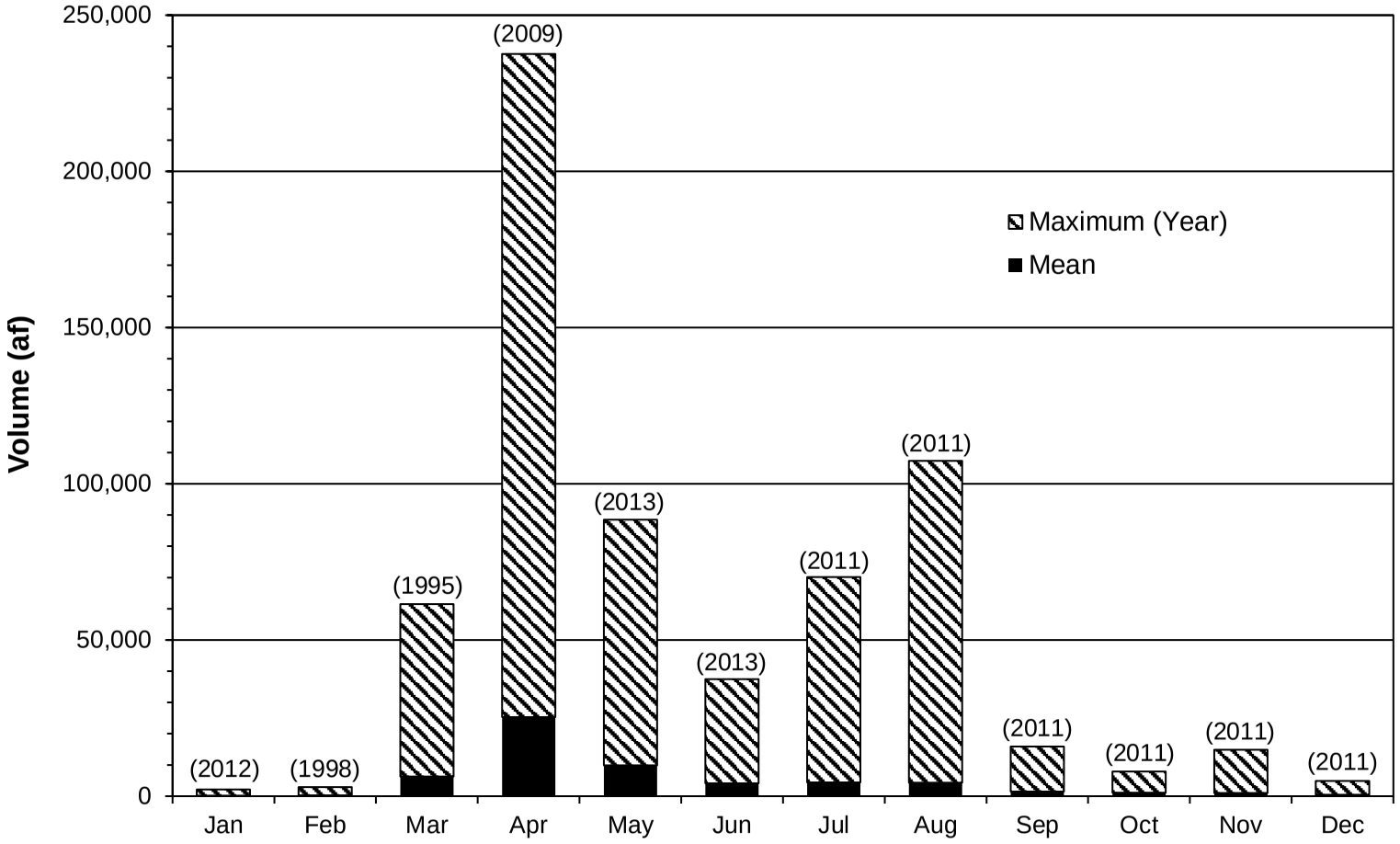
Prepared By: JB
Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Jamestown Reservoir
Area and Capacity Curves

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 5-1



Period analyzed: 1954-2013
Total average annual inflow = 58,321 af
Total average March-May inflow = 41,374 af (71% of total)
Maximum March-May inflow = 287,617 af (2009)

Source: Reclamation

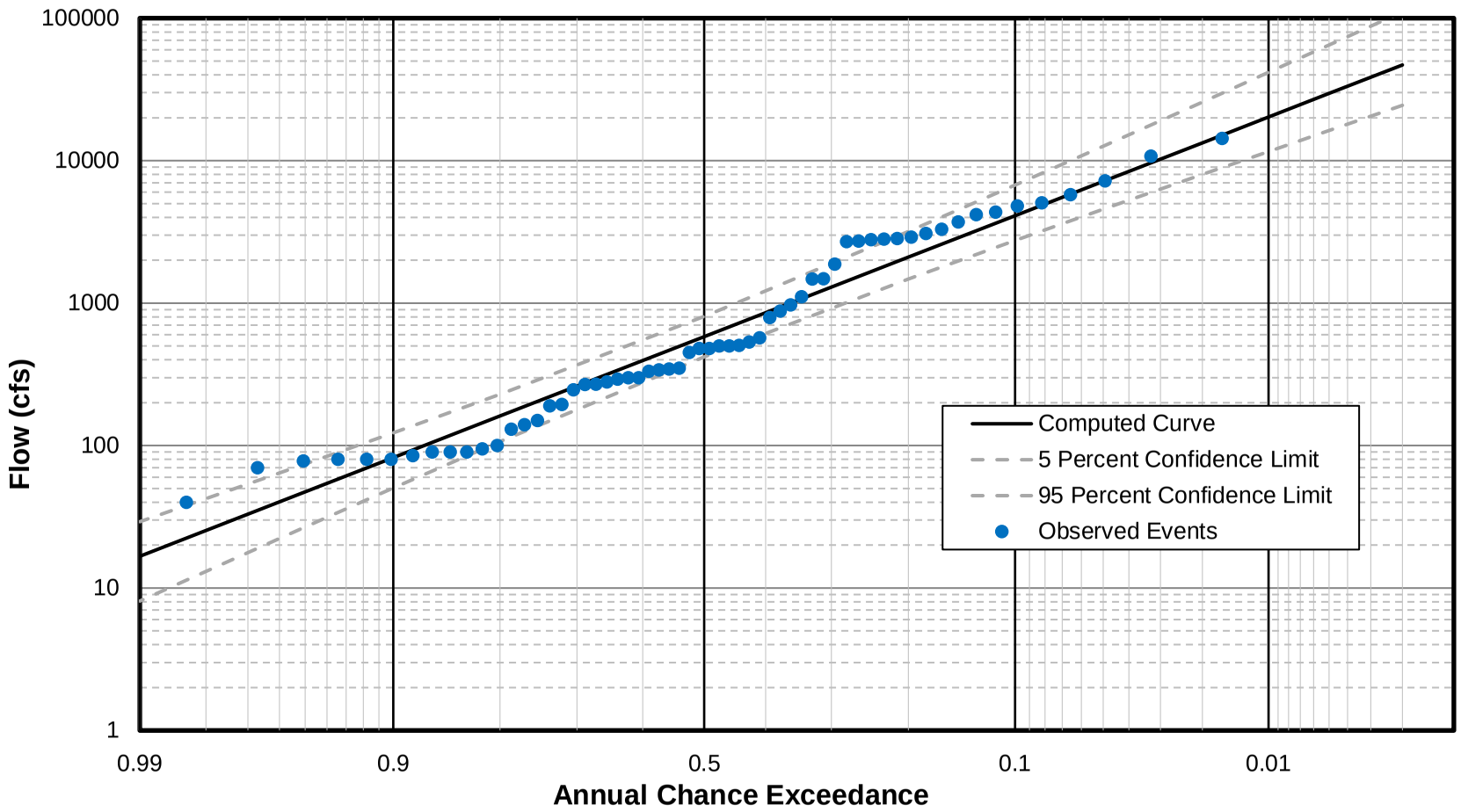
Prepared By: JM
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Monthly Inflow Volume
Jamestown Reservoir

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 6-1



Analysis was completed using Bulletin 17B in HEC-SSP 2.0. The computed curve uses a skew coefficient of 0.0. Data used daily average inflows for the period of record.

Source: Corps

Prepared By: BT

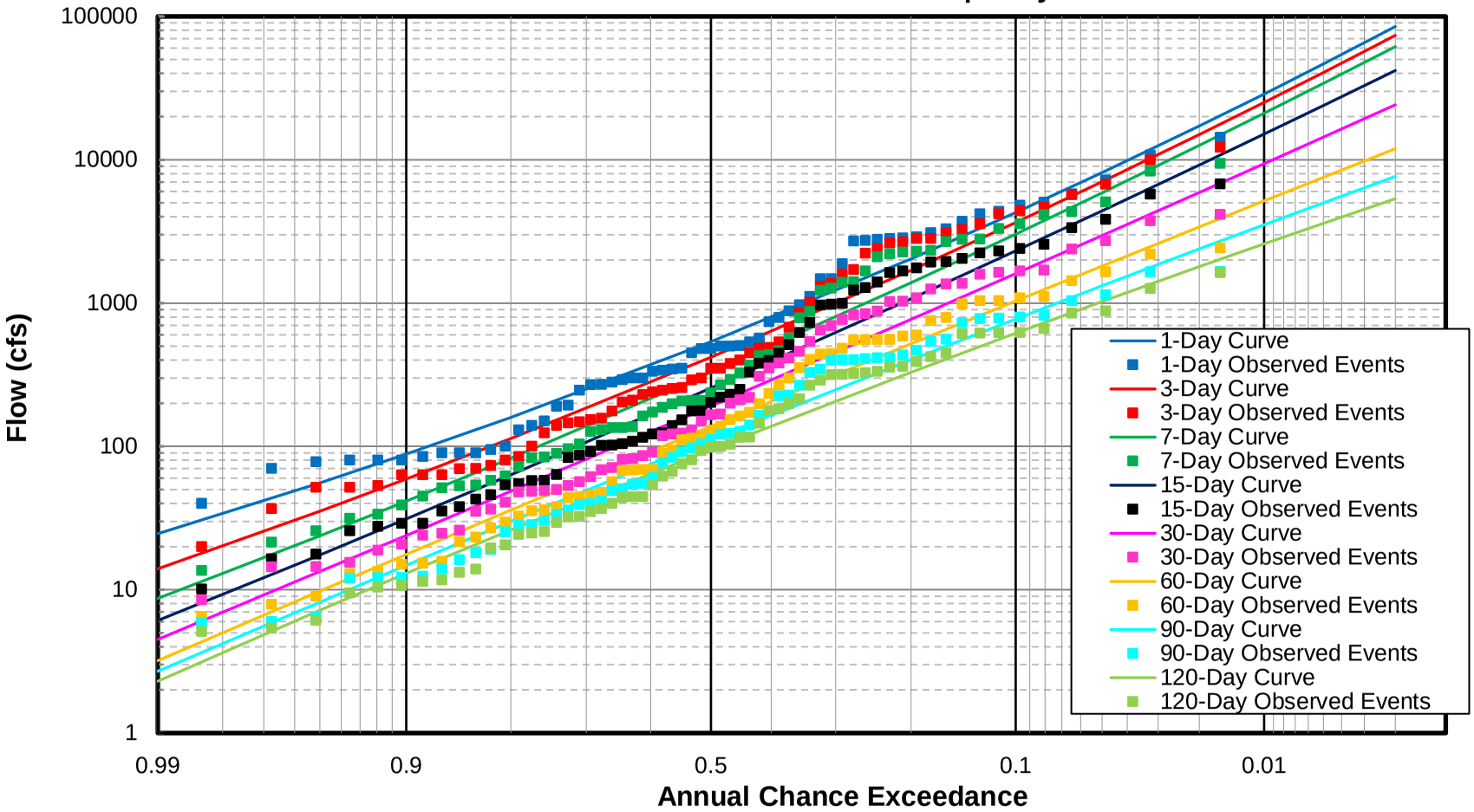
Reviewed By: DC

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Inflow Frequency Curve
Jamestown Reservoir, 1953-2013

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 6-2



Analysis was completed using the Volume Frequency Analysis in HEC-SSP 2.0.

Source: Corps

Prepared By: BT

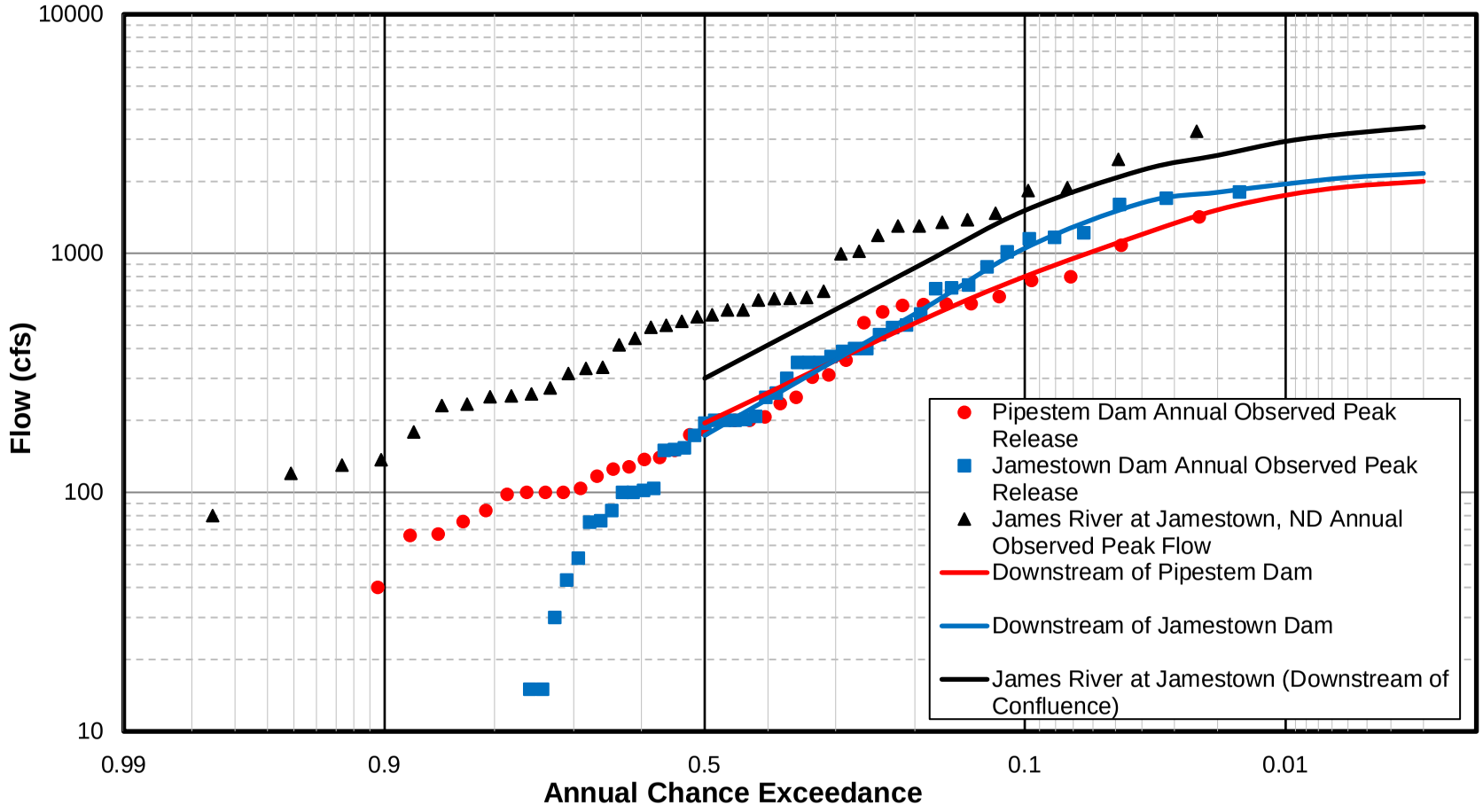
Reviewed By: DC

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Inflow Volume Frequency
Jamestown Reservoir, 1953-2014

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 6-3



Source: James River North Dakota Feasibility Study Hydrology Report, March 2013

Prepared By: BT

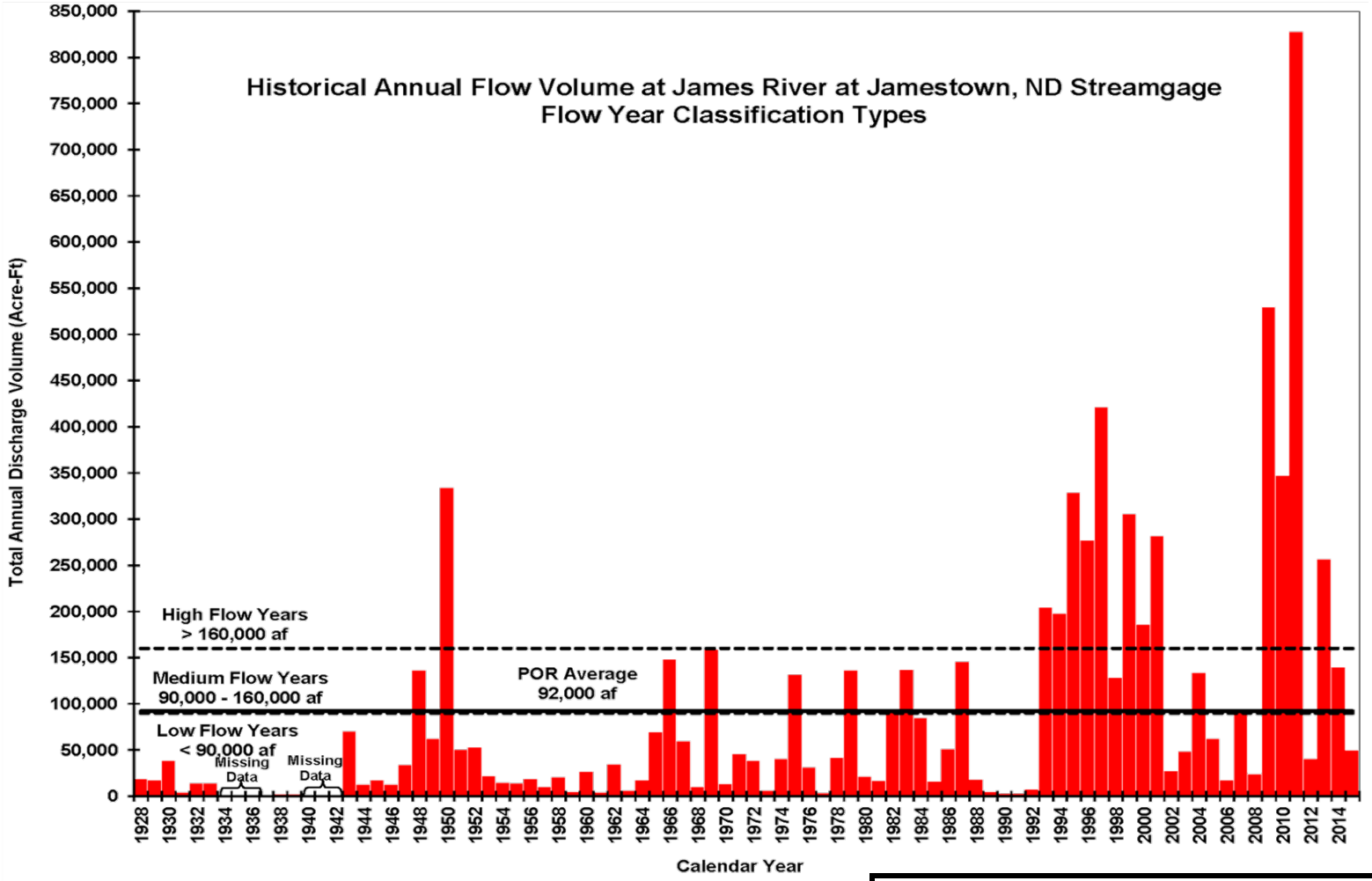
Reviewed By: DC

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Flow Frequencies Downstream of Jamestown and Pipestem Dams

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 6-4



Source: USGS

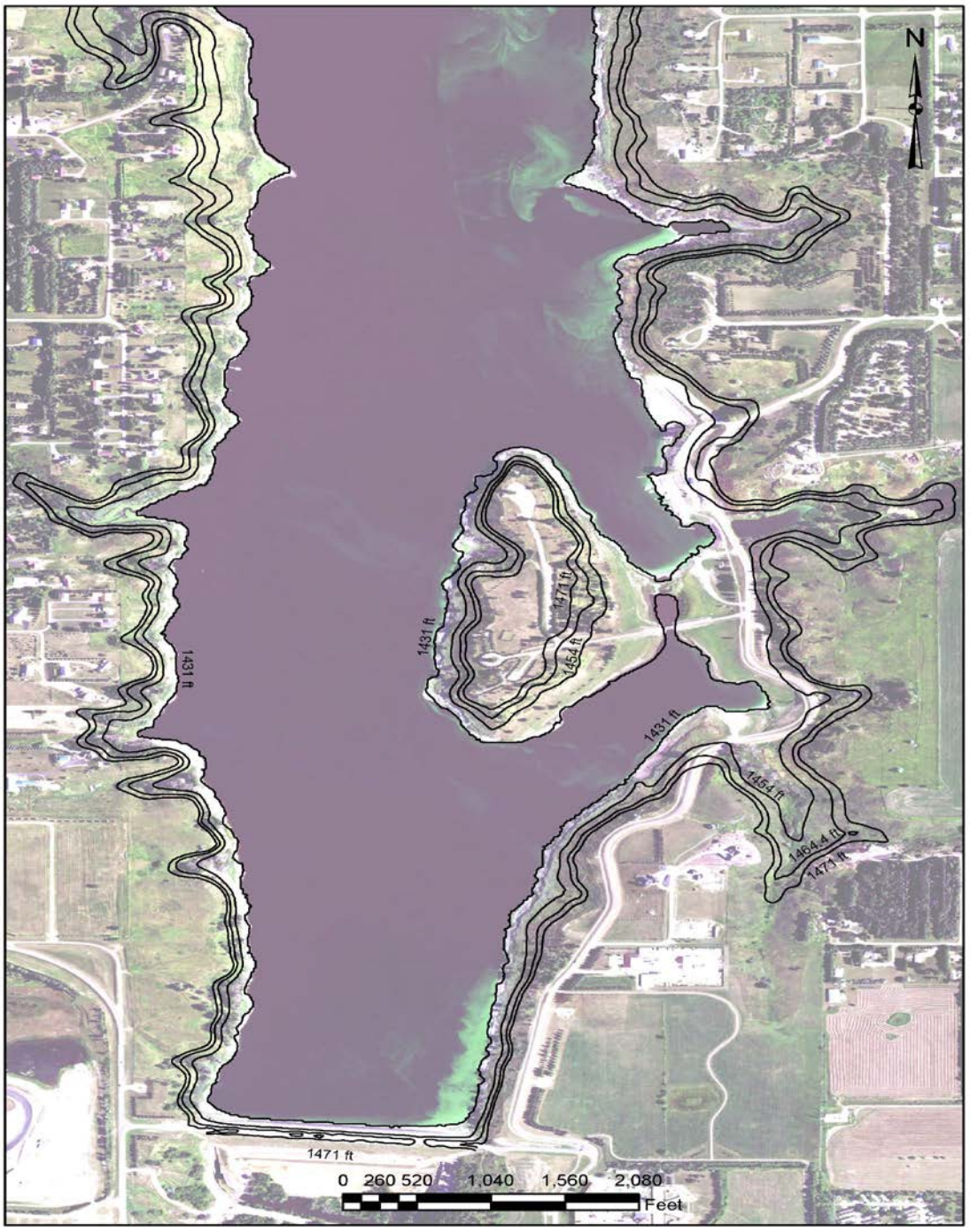
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Annual Flow Volume
James River at Jamestown, ND

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: BT
Reviewed By: JB

Plate 6-5



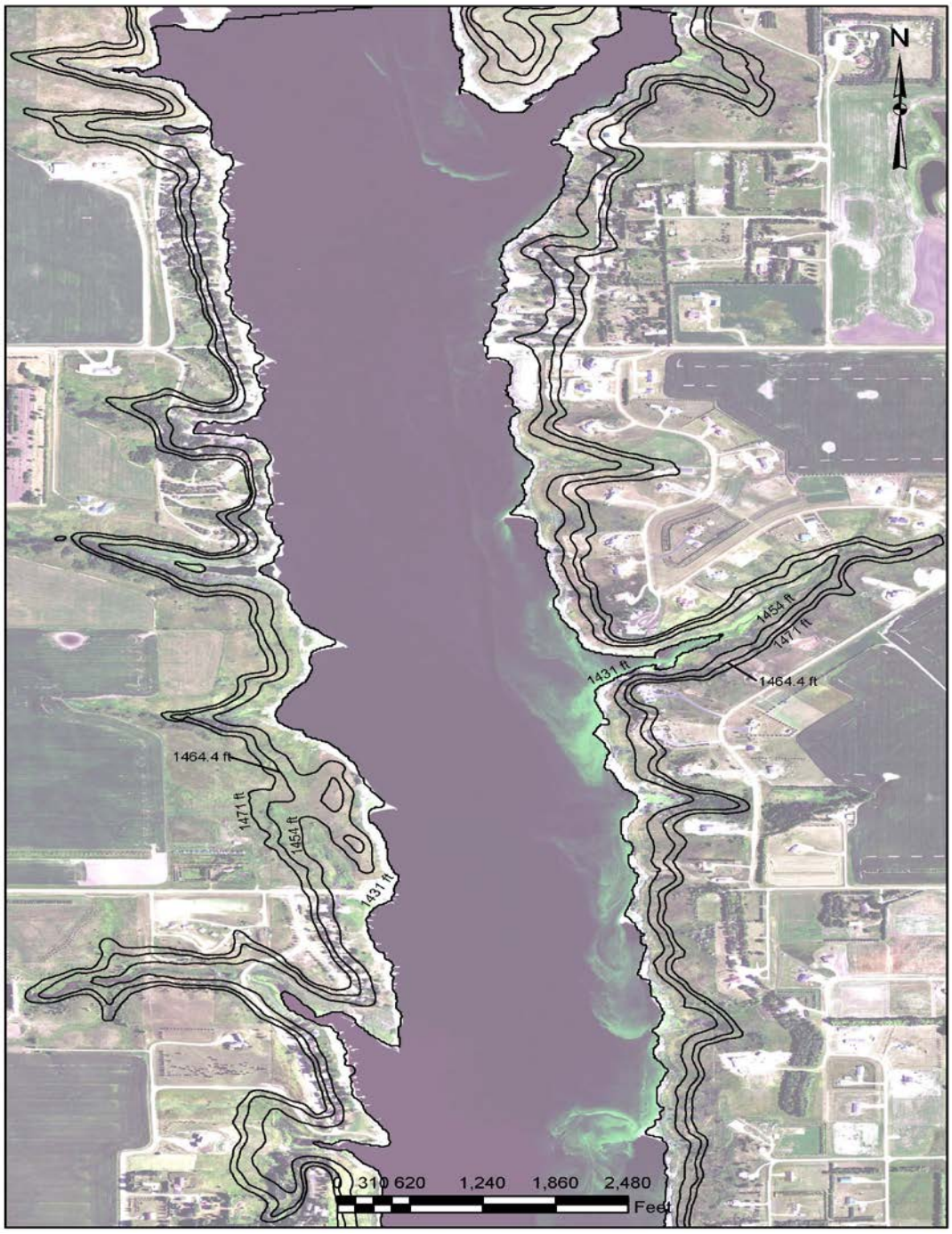
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Contour Curves for Jamestown Dam near Elevation 1431.0 feet

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: JM
Reviewed By: BT

Plate 7-1a



Water Control Manual
Jamestown Dam and Reservoir, North Dakota

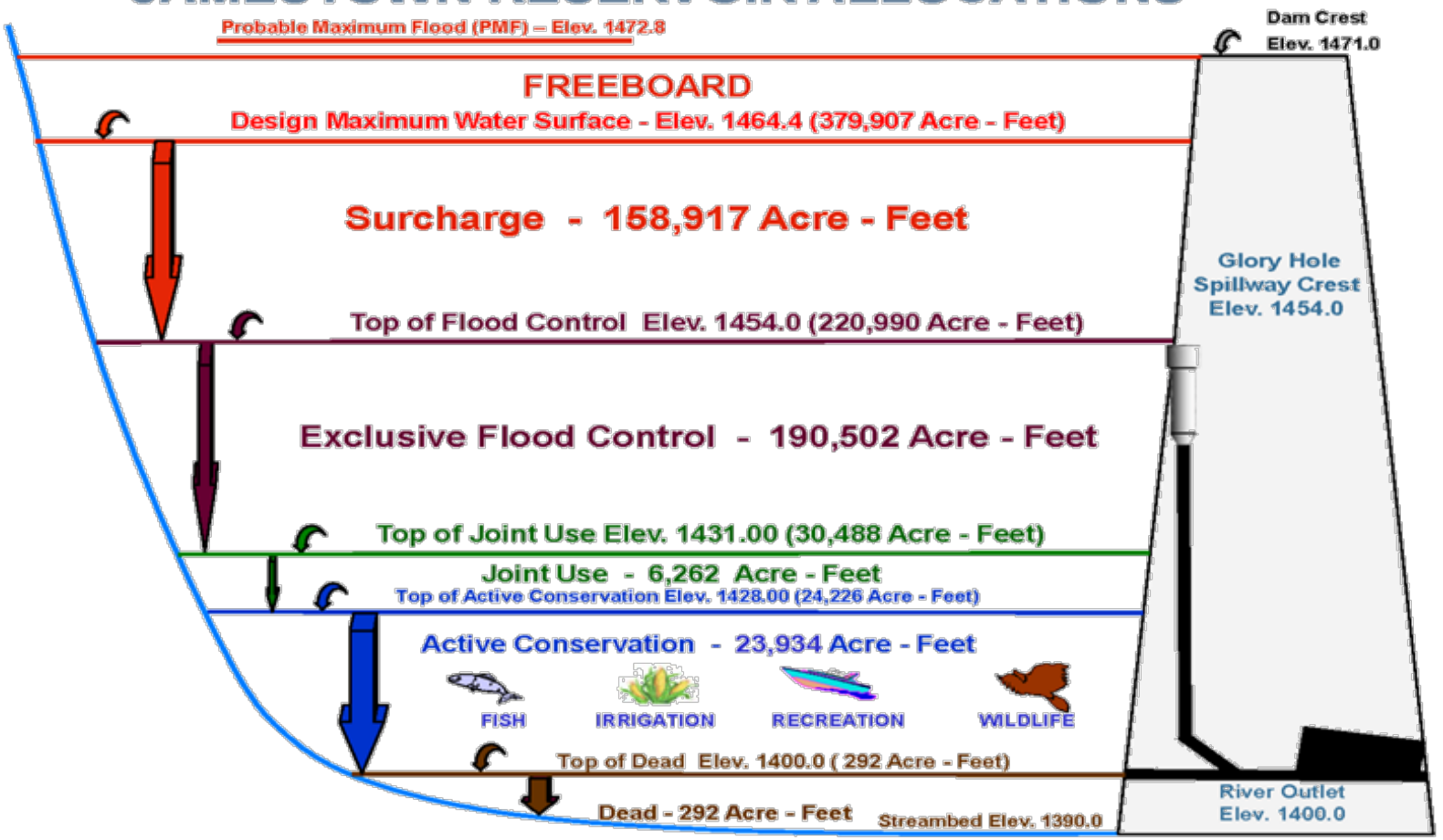
Contour Curves for Jamestown Dam near Elevation 1431.0 feet

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: JM
Reviewed By: BT

Plate 7-1b

JAMESTOWN RESERVOIR ALLOCATIONS



Source: Reclamation

Prepared By: JB
Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Jamestown Reservoir Storage Allocations

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 7-2

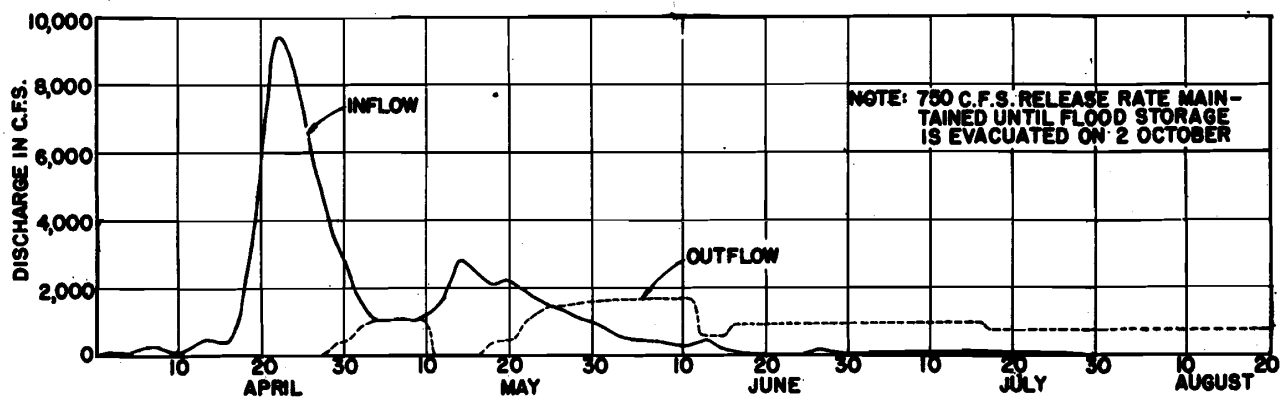


FIG. 1-SYNTHETIC SNOWMELT FLOOD, JAMESTOWN RESERVOIR INFLOW AND OUTFLOW HYDROGRAPHS

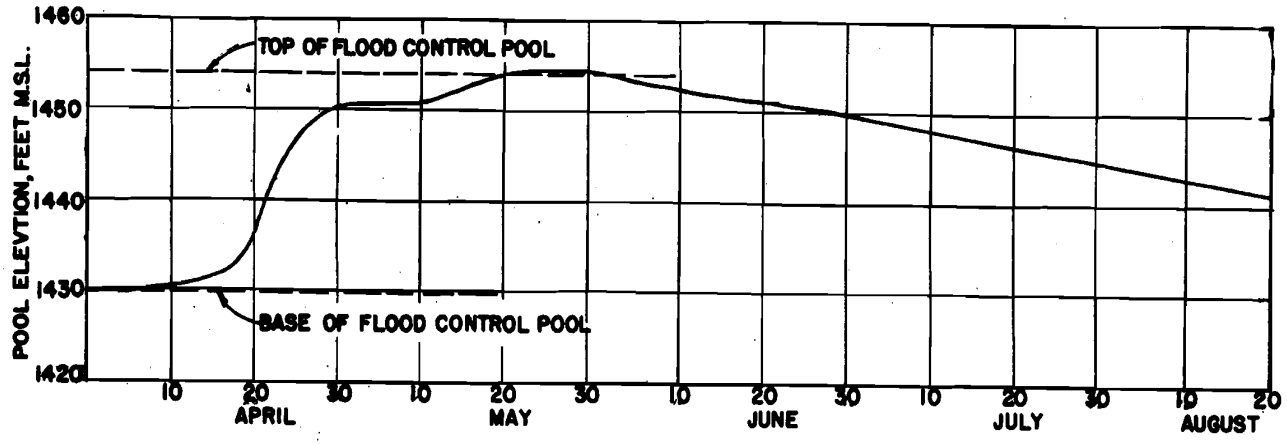


FIG. 2-SYNTHETIC SNOWMELT FLOOD, JAMESTOWN RESERVOIR, POOL ELEVATION HYDROGRAPH

Source: 1957 Jamestown Reservoir Regulation Manual

Prepared By: BT
Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Reservoir Design Flood

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

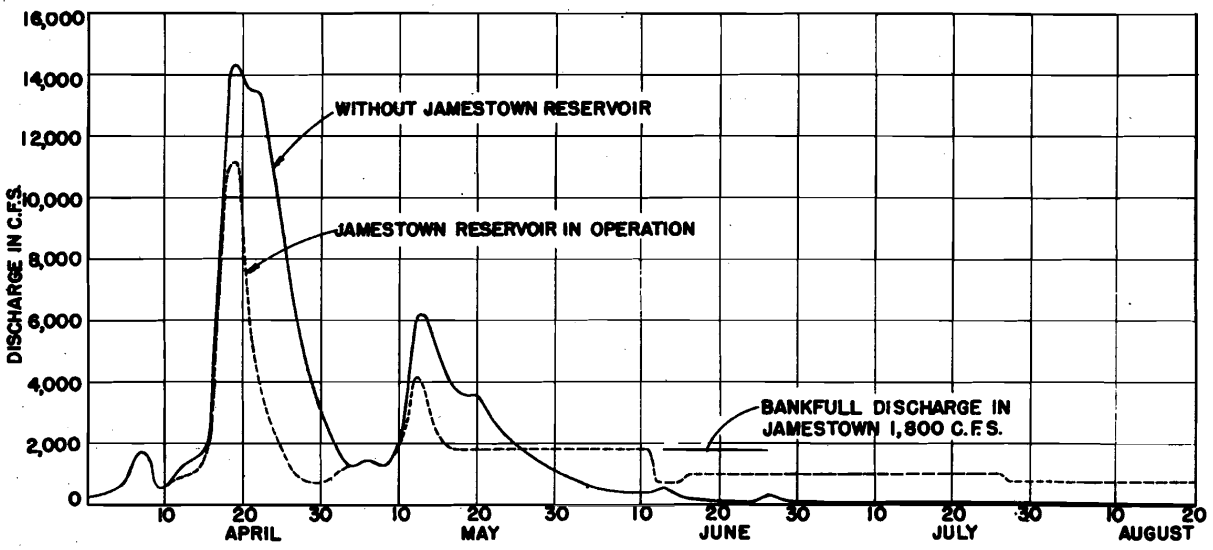


FIG. 3-SYNTHETIC SNOWMELT FLOOD, DISCHARGE HYDROGRAPHS, JAMESTOWN, NORTH DAKOTA

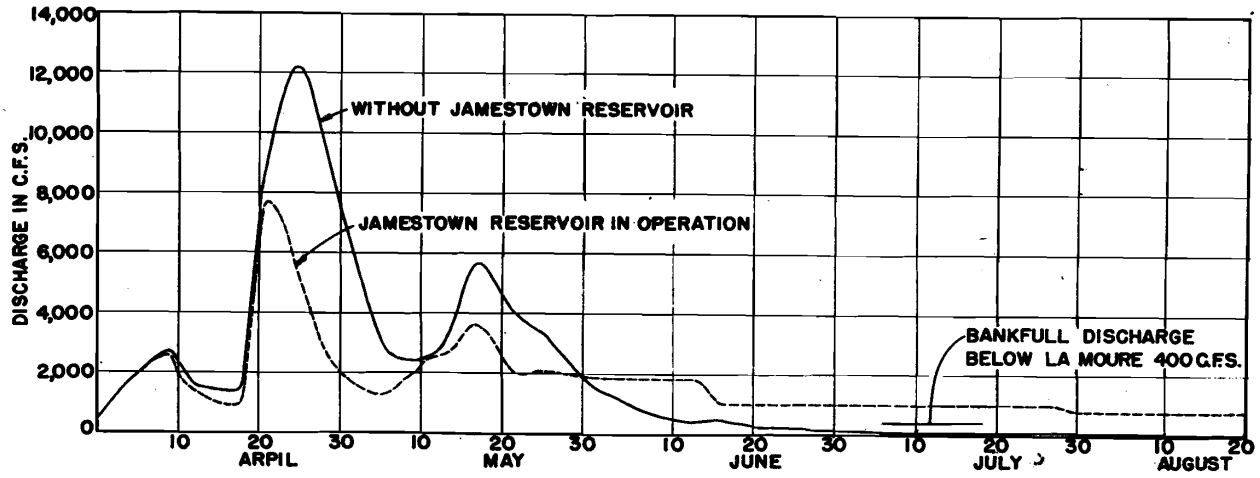


FIG. 4-SYNTHETIC SNOWMELT FLOOD, DISCHARGE HYDROGRAPHS, LA MOURE, NORTH DAKOTA

Source: 1957 Jamestown Reservoir Regulation Manual

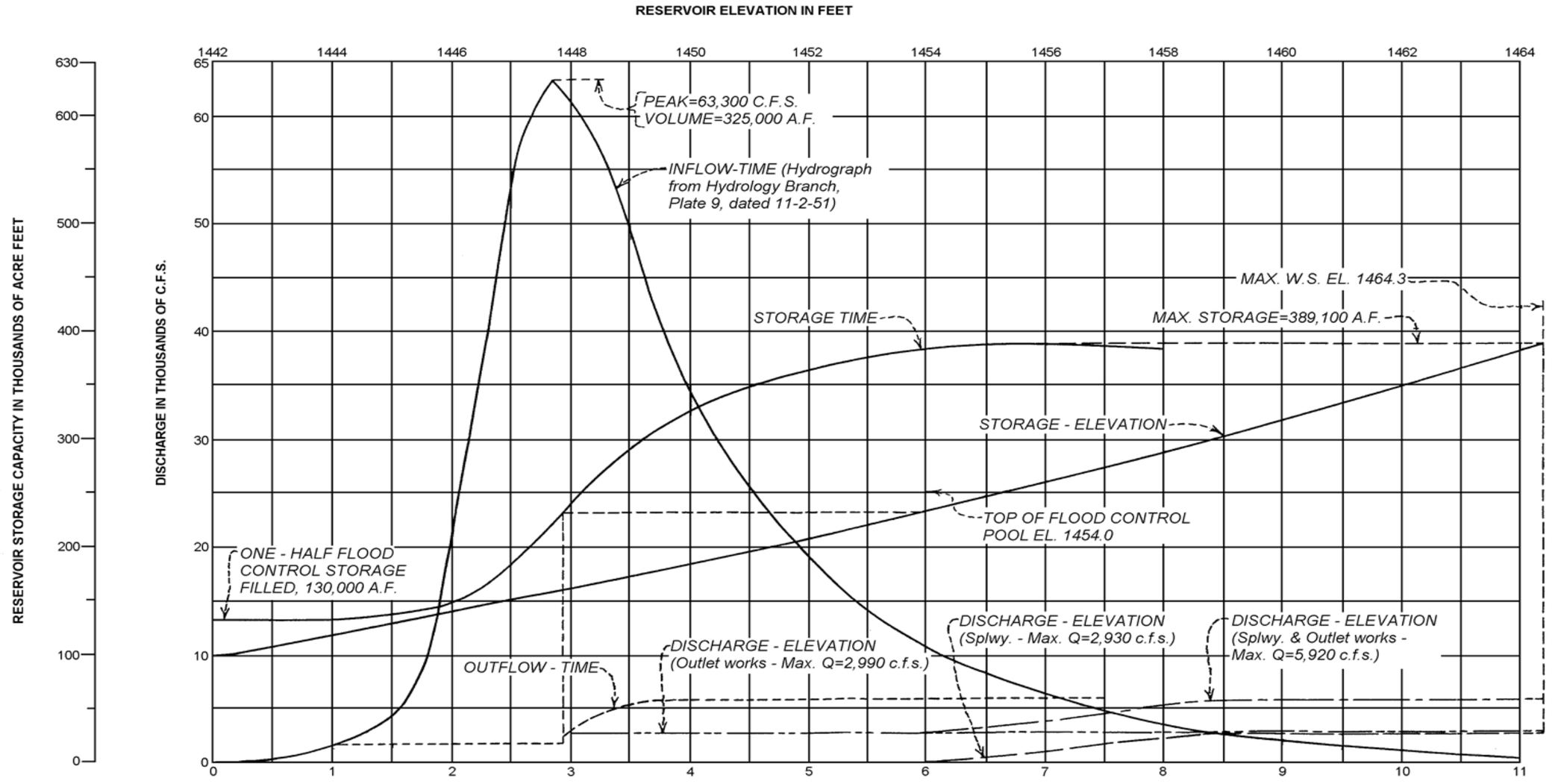
Prepared By: BT

Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Reservoir Design Flood Downstream Hydrographs

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



Notes Flood routing criteria: flood control pool one-half full at start of flood; releases through outlet works limited to 1500 cfs until flood control pool fills; allow max combined discharge for passing remainder of flood.

A revised Inflow Design Flood was developed in 1986 based on the Probable Maximum Flood. See Section 8-02 and Table 8-1 for further detail.

Source: Reclamation, Jamestown SOP

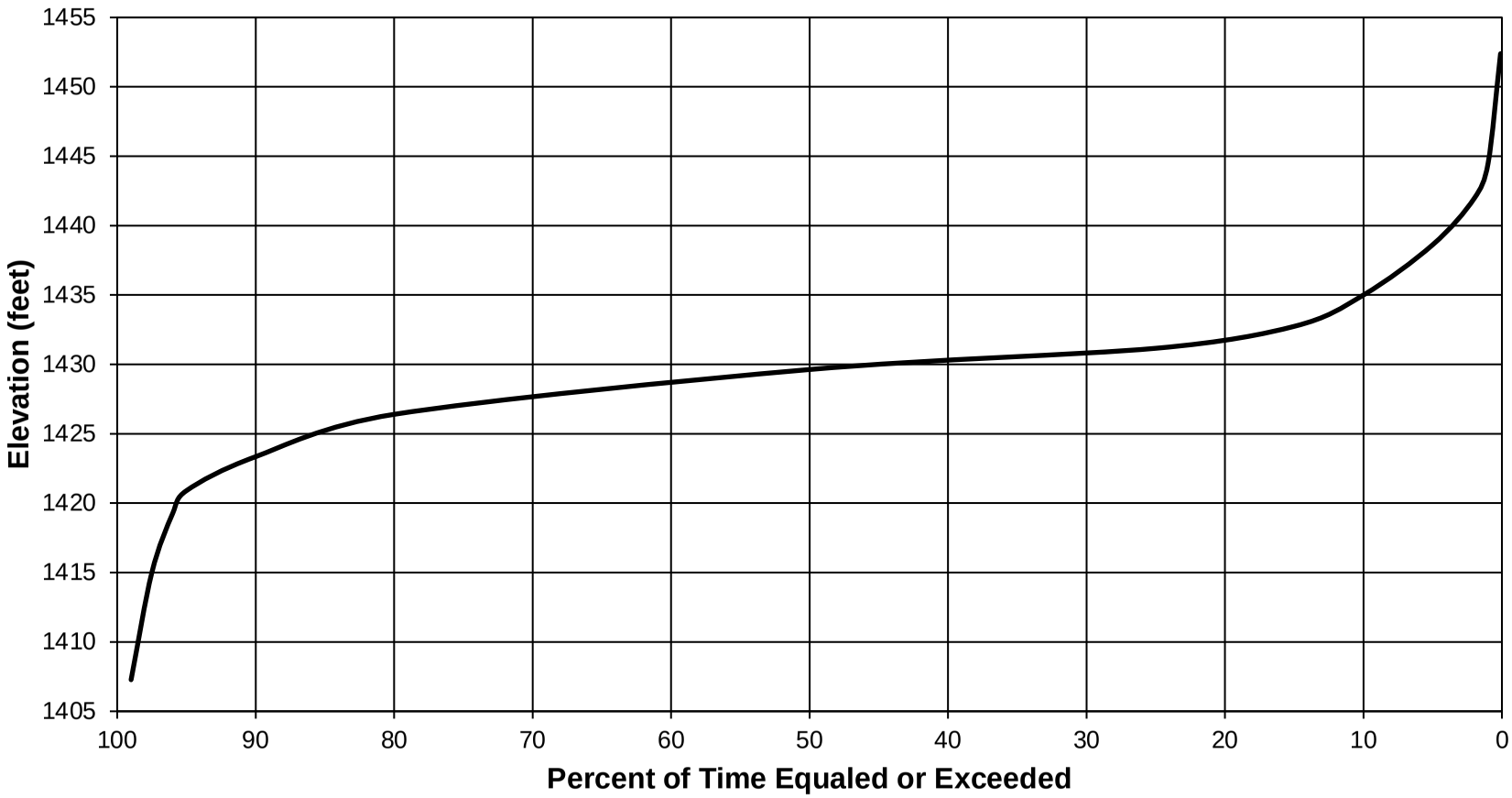
Prepared By: BT
Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Original Inflow Design Flood

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-3



Analysis was completed using HEC-SSP 2.0 duration analysis.

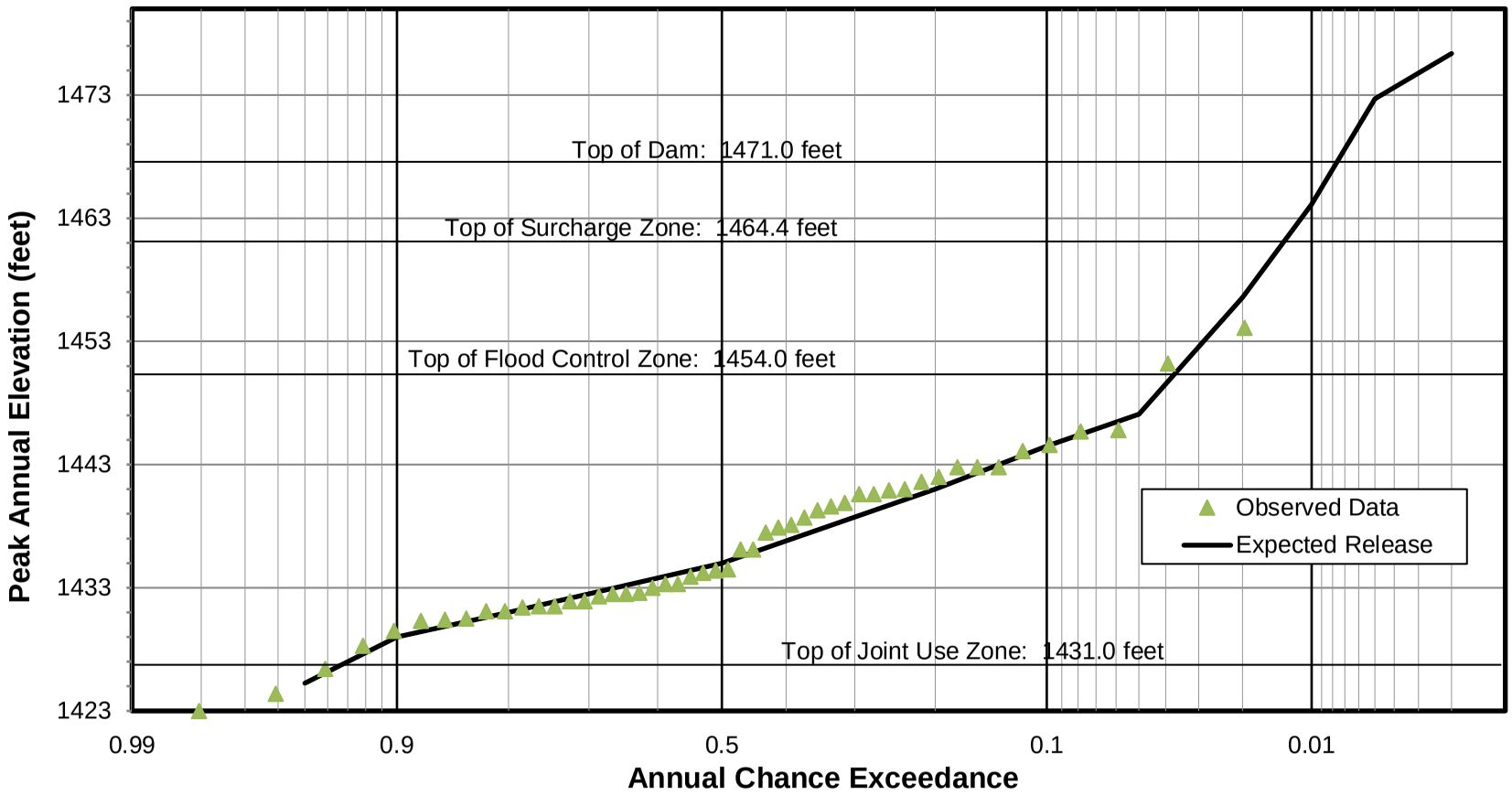
Prepared By: BT
Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Pool-Duration Curve
Jamestown Reservoir

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-4



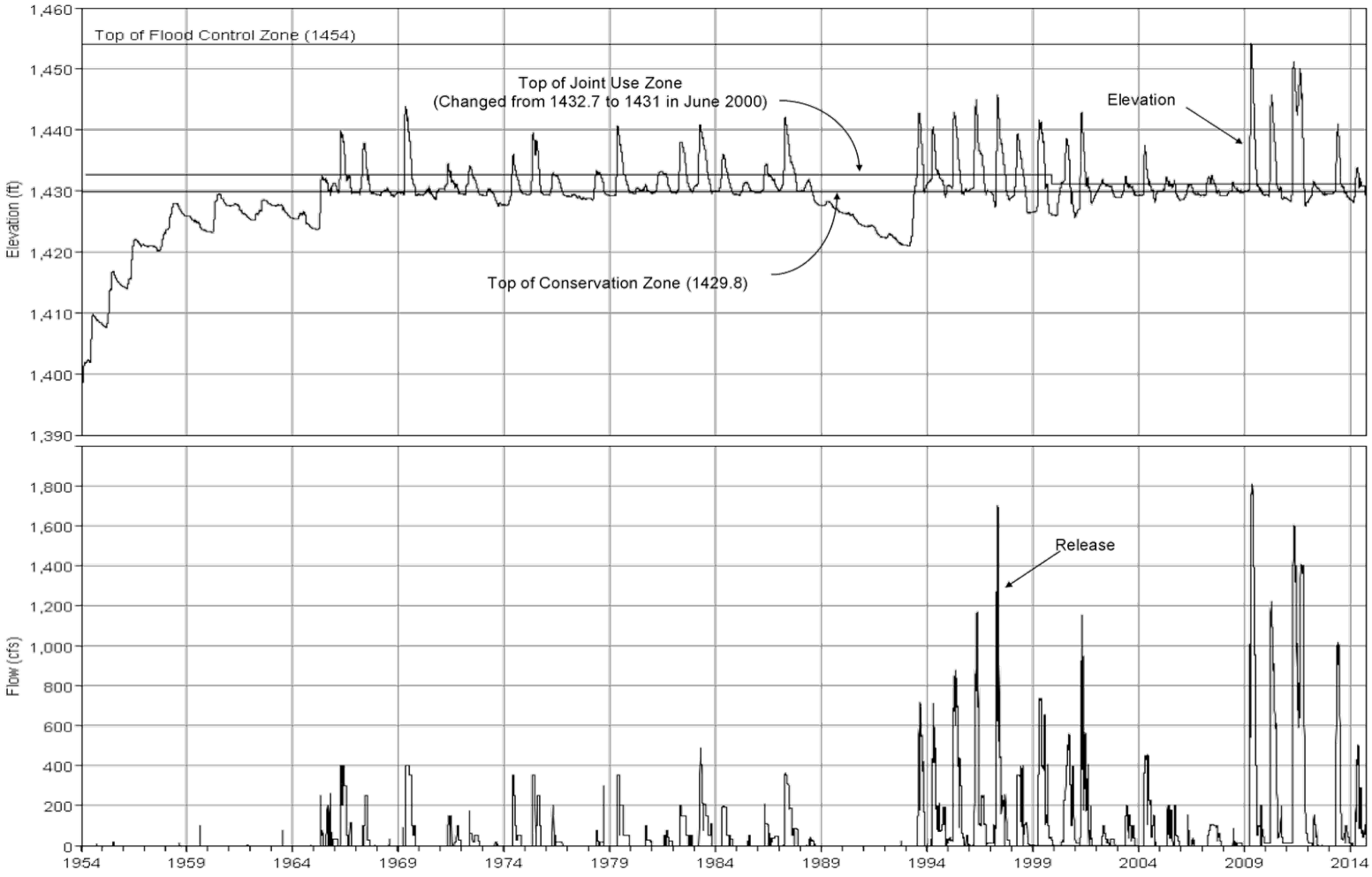
The Volume Frequency Analysis in Plate 6-3 was used to develop inflow hydrographs for the 500, 200, 100, 50, 20, 10, 5, and 2 year return period storms. These hydrographs were then routed through an HEC-HMS model with three different release scenarios to determine peak pool elevations between 2-year and 20-year return interval annual chance of exceedance. An eye-fit curve was used for expected releases between 150-year and 500-year return interval annual chance exceedance. Observed annual peak pool elevations from initial fill in 1965 to 2014 were plotted against exceedance frequencies using Weibull plotting positions.

Prepared By: BT
Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Peak Pool Frequency
Jamestown Reservoir, 1965-2014

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016



Source: Corps

Prepared By: BT
Reviewed By: KB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Pool Elevation and Release

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-6

(1) Maximum annual daily inflow (cfs)
(2) Maximum annual daily outflow (cfs)
(3) Maximum annual peak discharge at Jamestown, ND (cfs)

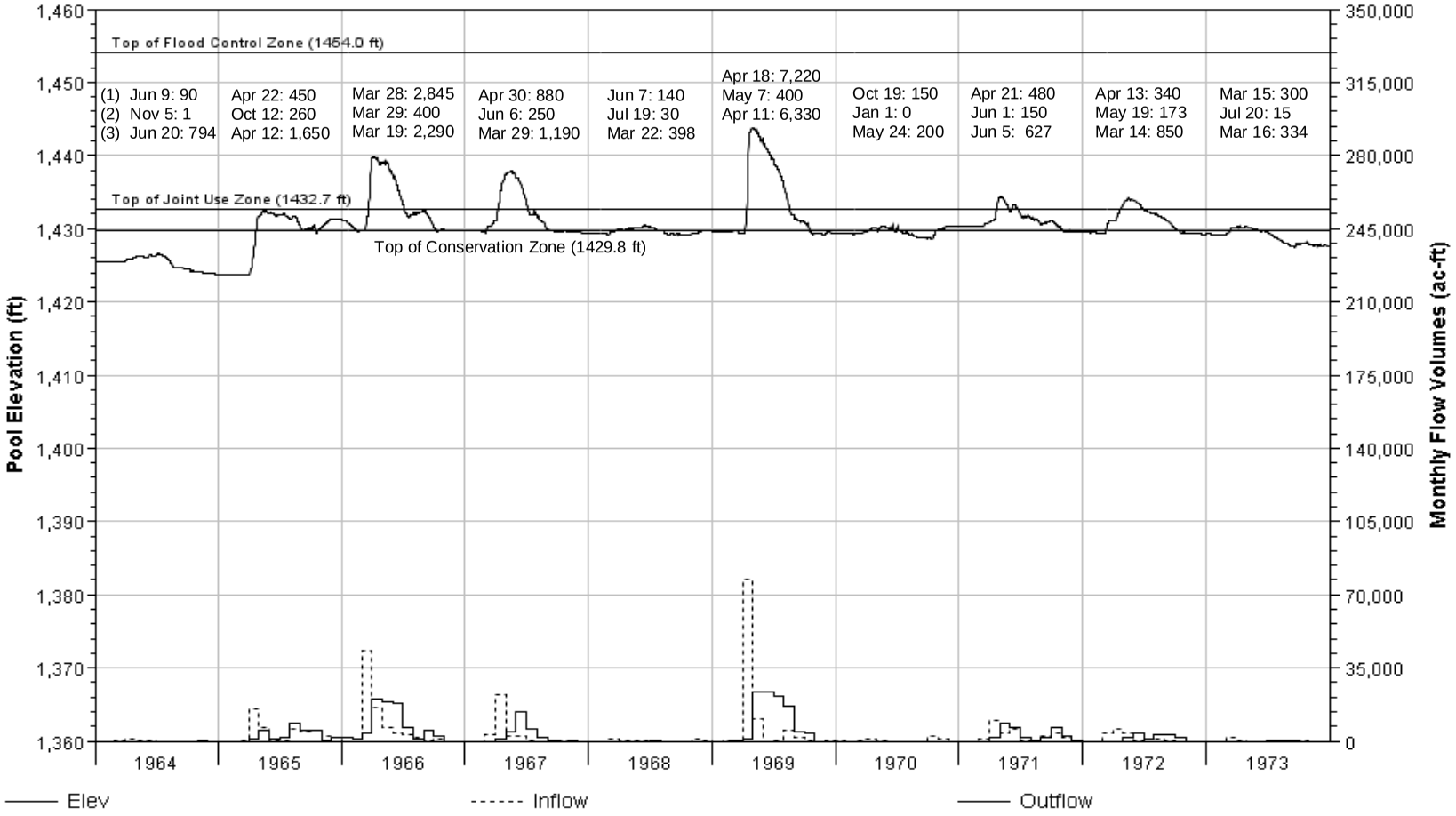
Prepared By: JB
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Pool Elevations, Inflows, and Releases, 1954-1963

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-7a



(1) Maximum annual daily inflow (cfs)
(2) Maximum annual daily outflow (cfs)
(3) Maximum annual peak discharge at Jamestown, ND (cfs)

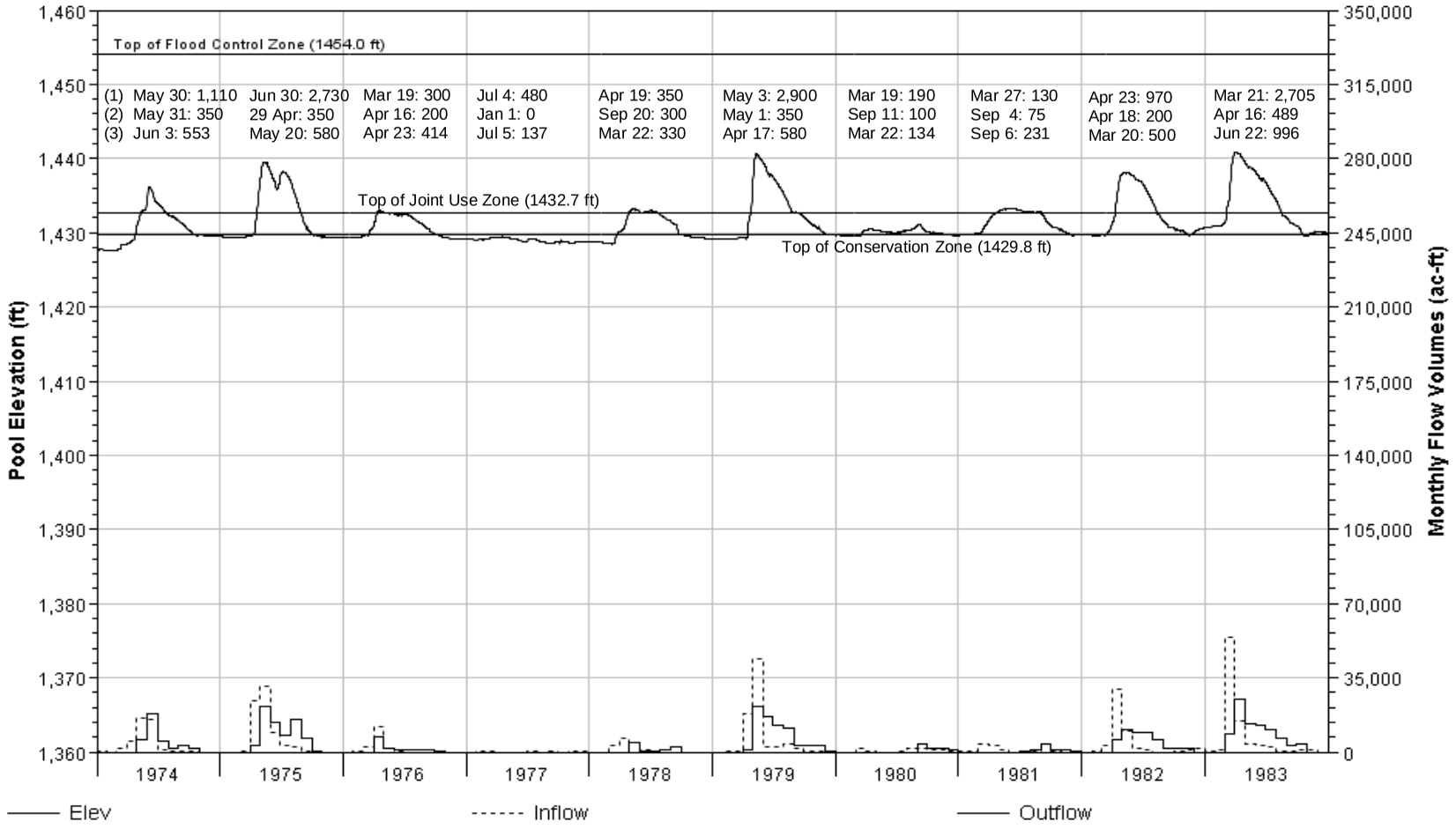
Prepared By: JB
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Pool Elevations, Inflows, and Releases, 1964-1973

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-7b



(1) Maximum annual daily inflow (cfs)
(2) Maximum annual daily outflow (cfs)
(3) Maximum annual peak discharge at Jamestown, ND (cfs)

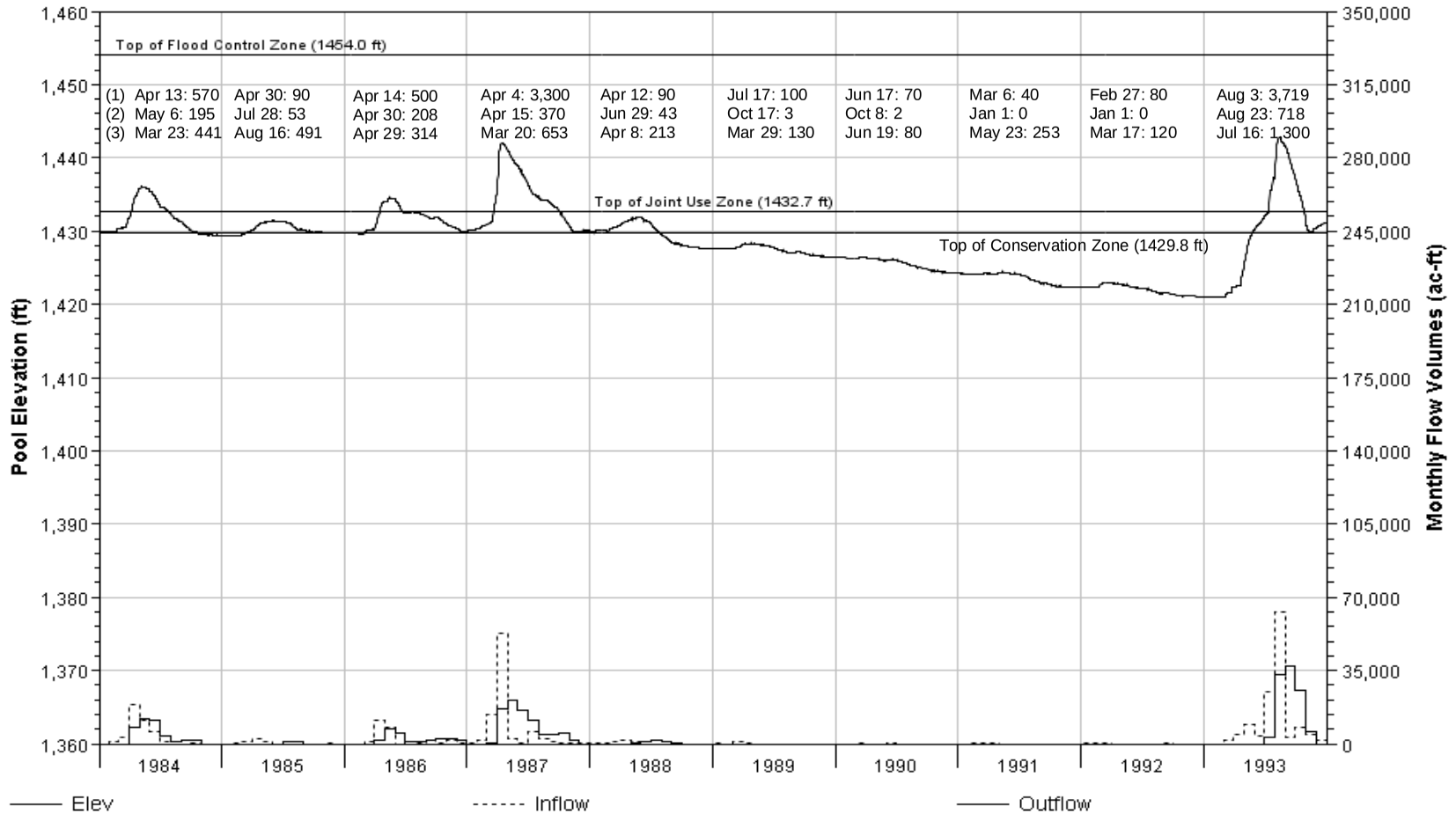
Prepared By: JB
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Pool Elevations, Inflows, and Releases, 1974-1983

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-7c



(1) Maximum annual daily inflow (cfs)
(2) Maximum annual daily outflow (cfs)
(3) Maximum annual peak discharge at Jamestown, ND (cfs)

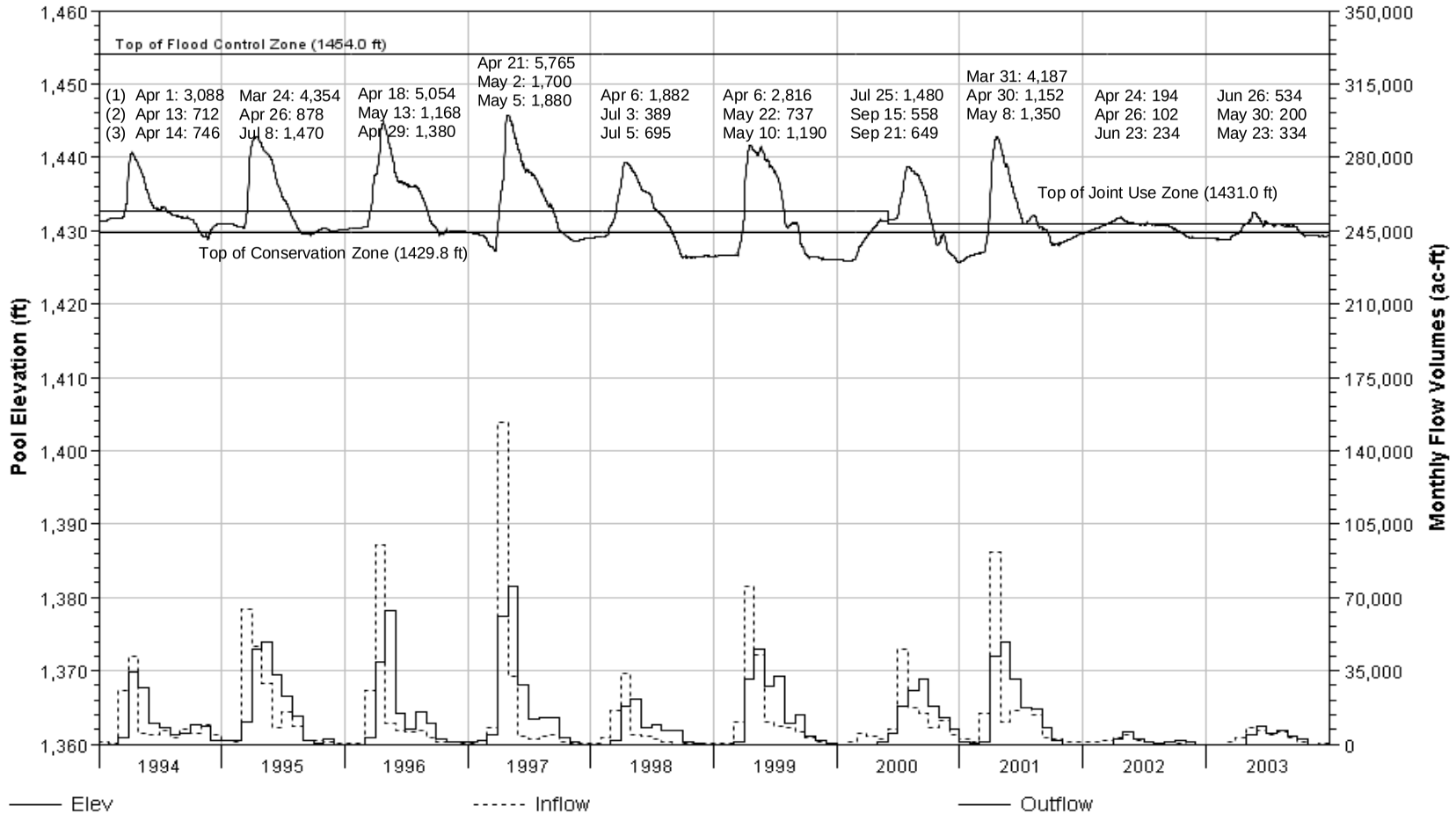
Prepared By: JB
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Pool Elevations, Inflows, and Releases, 1984-1993

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-7d



(1) Maximum annual daily inflow (cfs)
(2) Maximum annual daily outflow (cfs)
(3) Maximum annual peak discharge at Jamestown, ND (cfs)

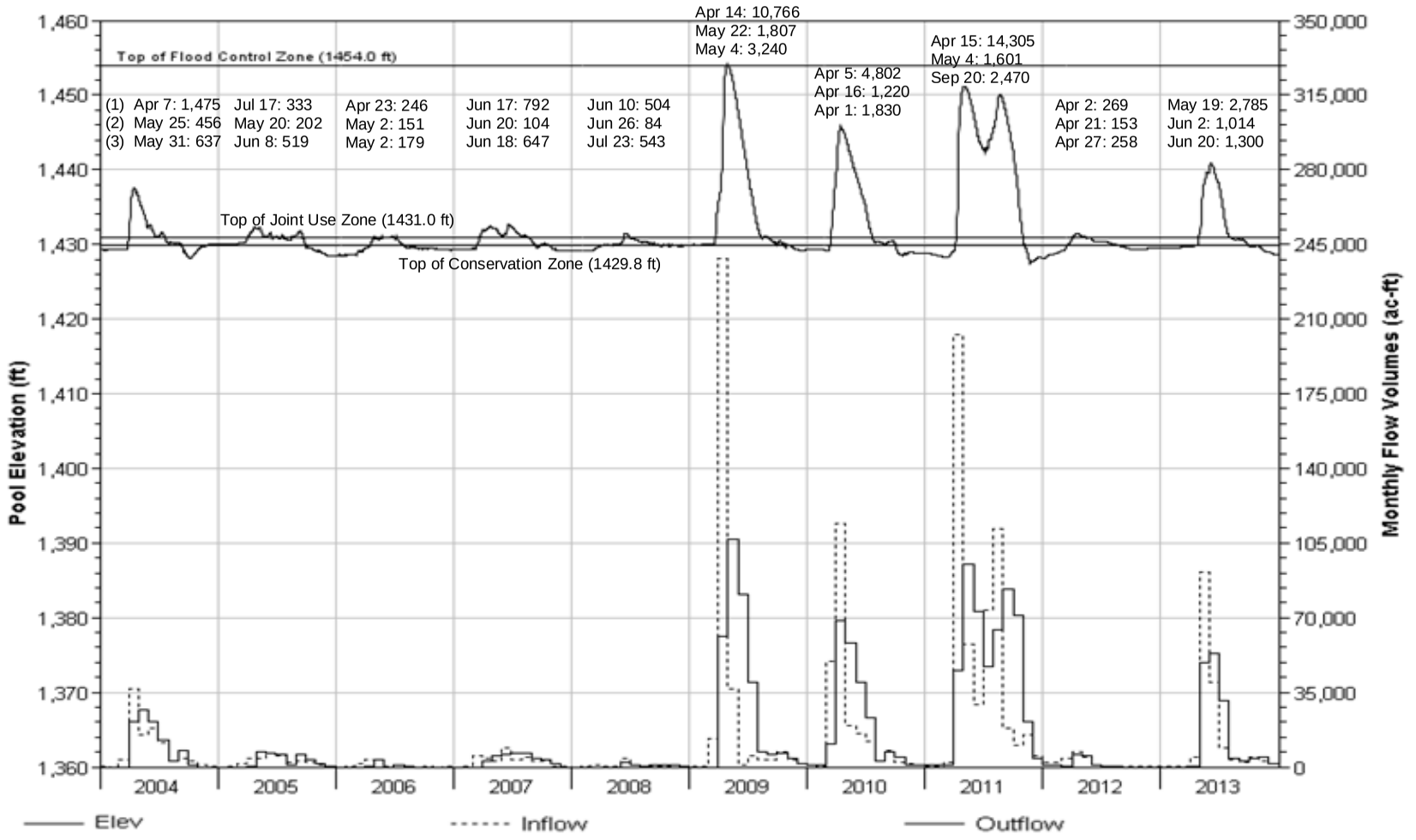
Prepared By: JB
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Pool Elevations, Inflows, and Releases, 1994-2003

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-7e



(1) Maximum annual daily inflow (cfs)
(2) Maximum annual daily outflow (cfs)
(3) Maximum annual peak discharge at Jamestown, ND (cfs)

Prepared By: JB
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Pool Elevations, Inflows, and Releases, 2004-2013

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-7f

(1) Maximum annual daily inflow (cfs)
(2) Maximum annual daily outflow (cfs)
(3) Maximum annual peak discharge at Jamestown, ND (cfs)

Prepared By: JB
Reviewed By: BT

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Historical Pool Elevations, Inflows, and Releases, 2014-2023

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Flow Frequency Downstream of Jamestown and Pipestem Reservoirs

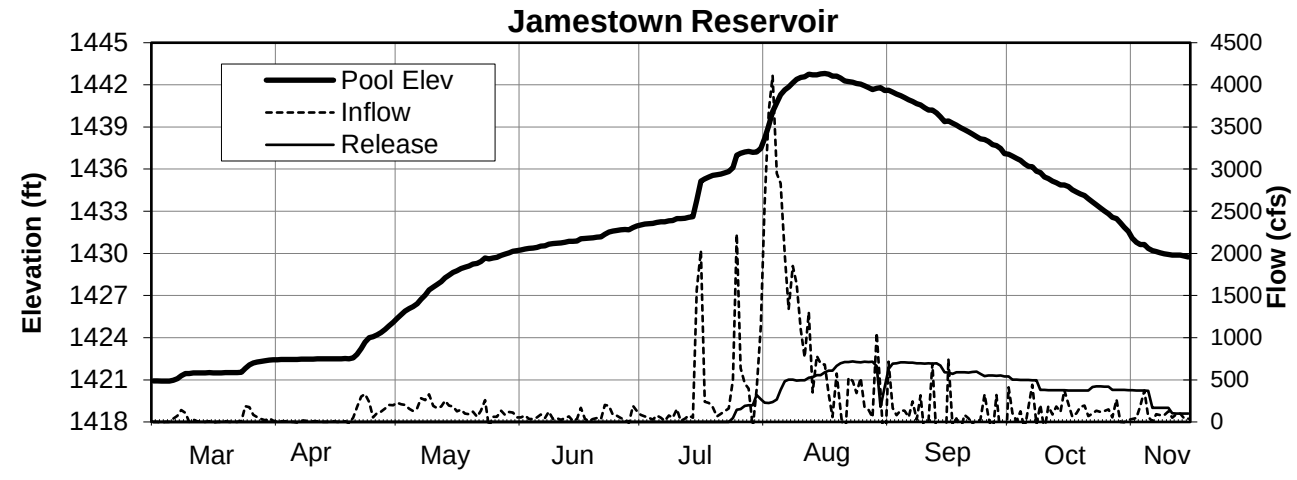
River Reach or Location	Peak Discharge (cfs) for Return Period							
	2	5	10	25	50	100	200	500
Pipestem Cr from Pipestem Dam to the confluence with the James River	195	510	800	1,200	1,520	1,750	1,900	2,000
James River from Jamestown Dam to the confluence with Pipestem Cr	173	558	1,050	1,625	1,800	1,950	2,075	2,160
James River at Jamestown	300	870	1,510	2,230	2,570	2,940	3,170	3,380
James River at LaMoure	1,310	3,330	5,090	8,770	10,240	11,620	12,880	14,000
James River at ND-SD State Line	1,230	2,770	4,330	7,570	8,910	10,270	11,660	13,010

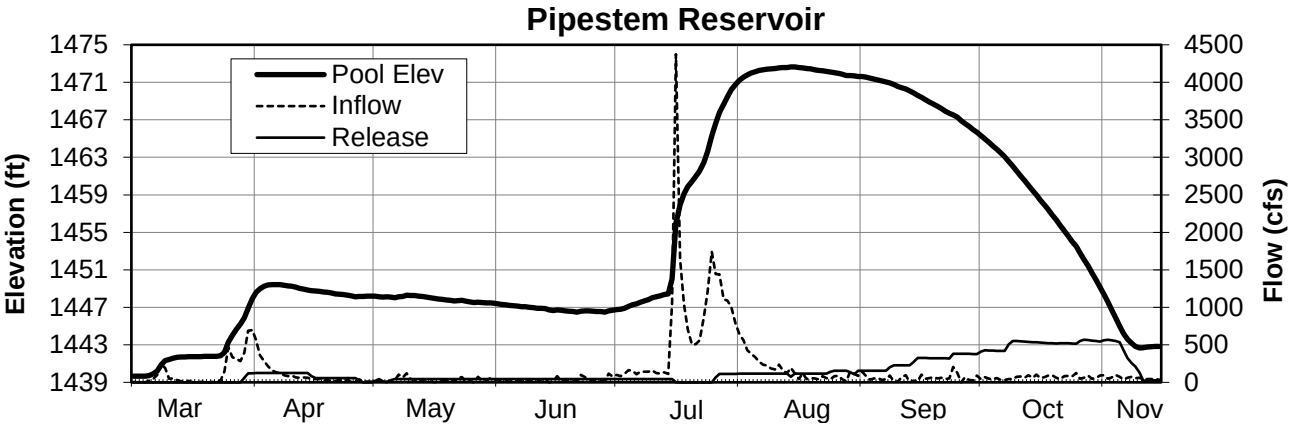
Prepared By: BT
Reviewed By: NS

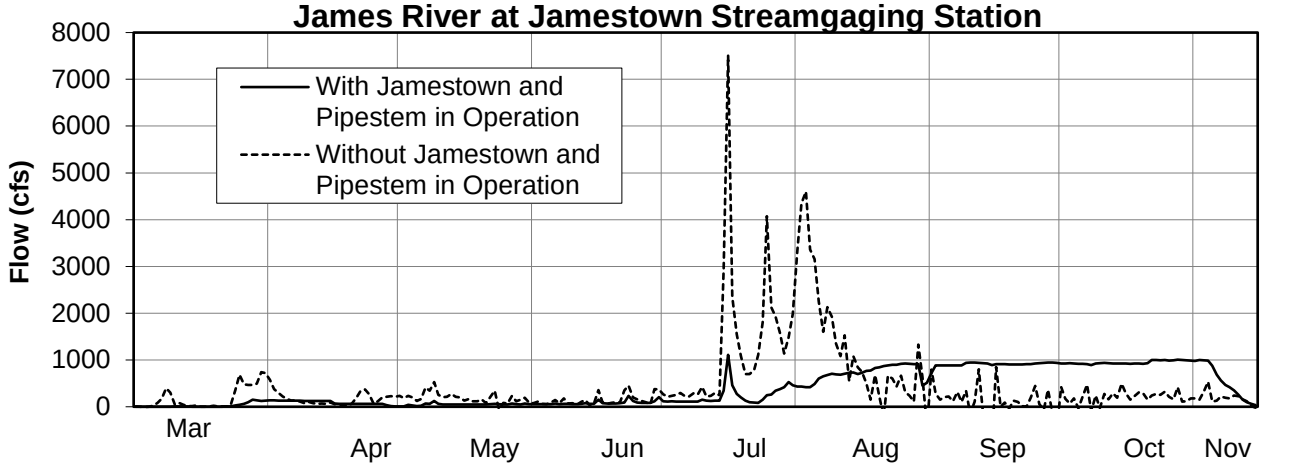
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Flow Frequency Downstream of Jamestown and Pipestem Dams

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016







Source: Reclamation

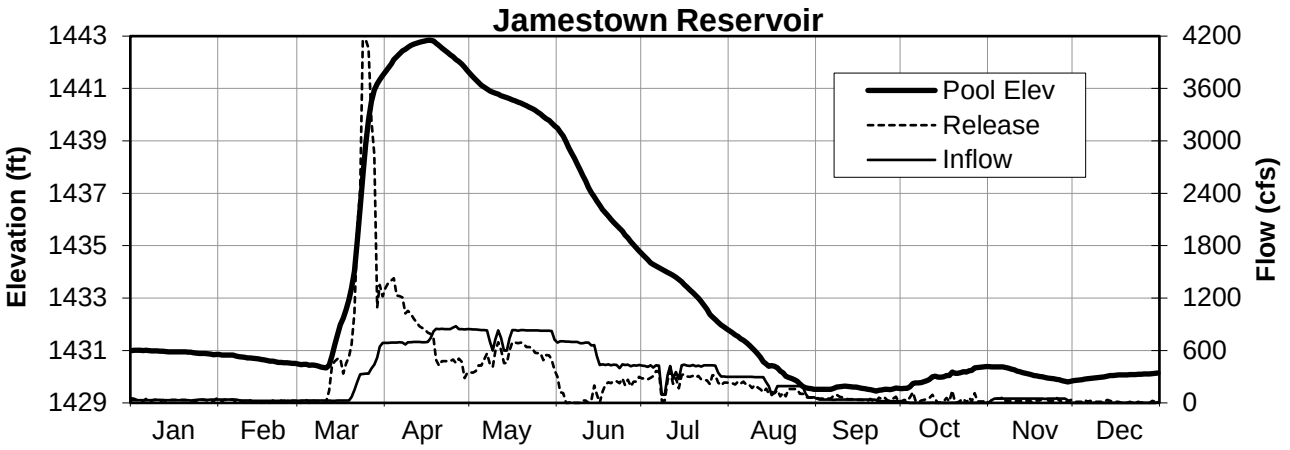
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

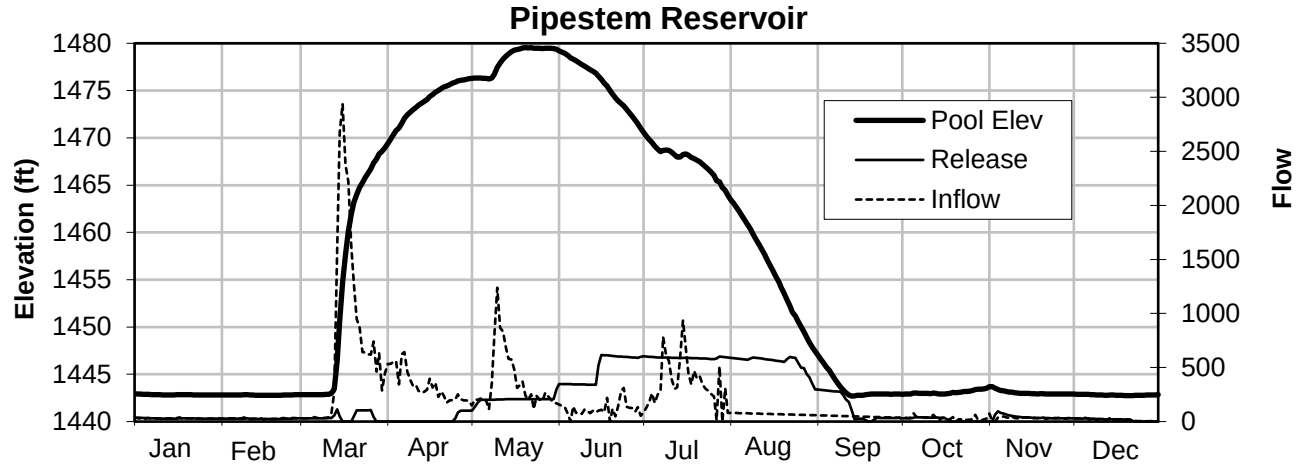
1993 Flood Routing

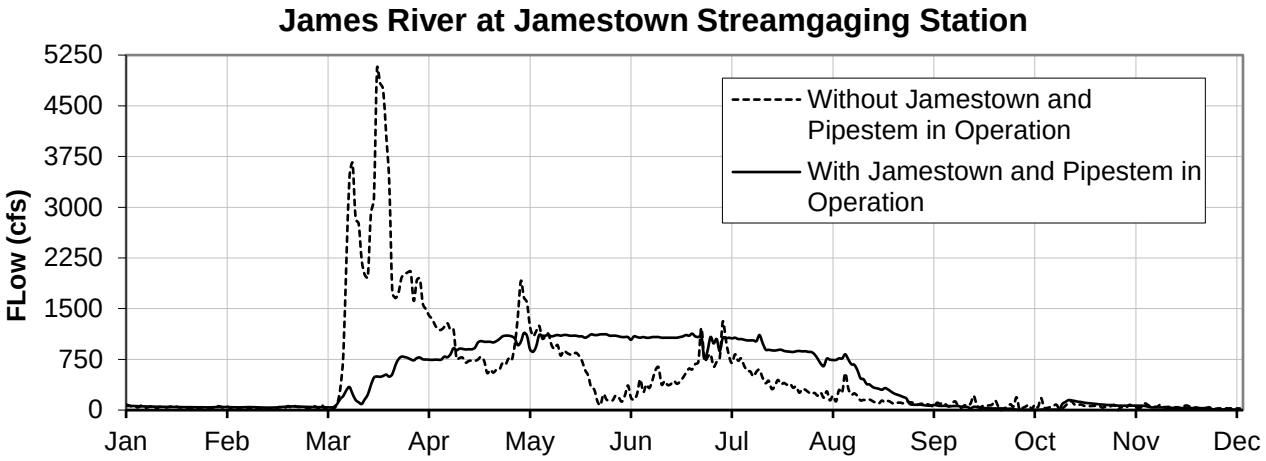
Prepared By: MB
Reviewed By: JL

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-9







Source: Reclamation

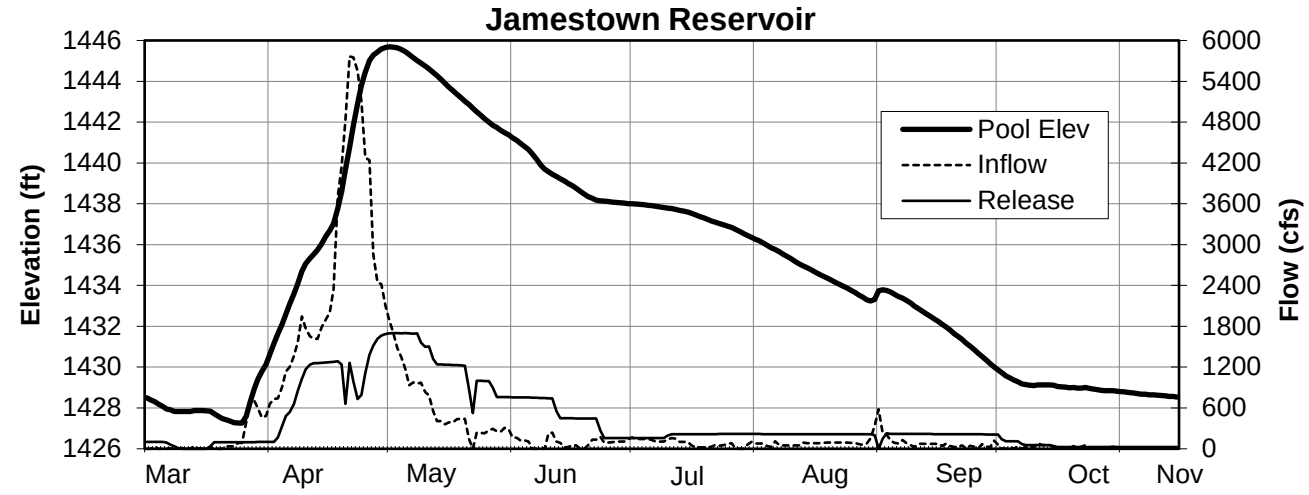
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

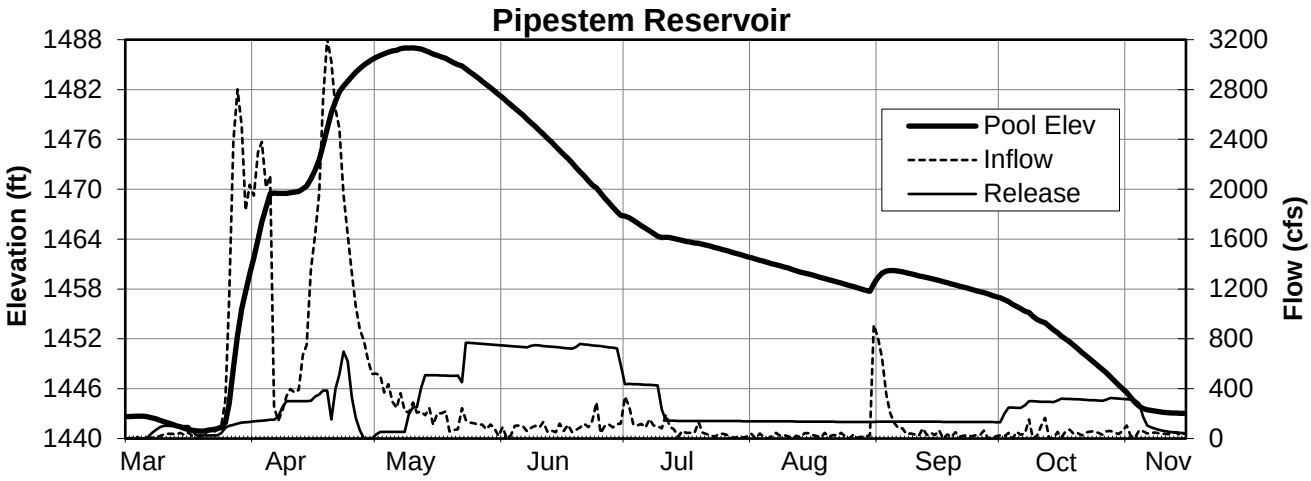
1995 Flood Routing

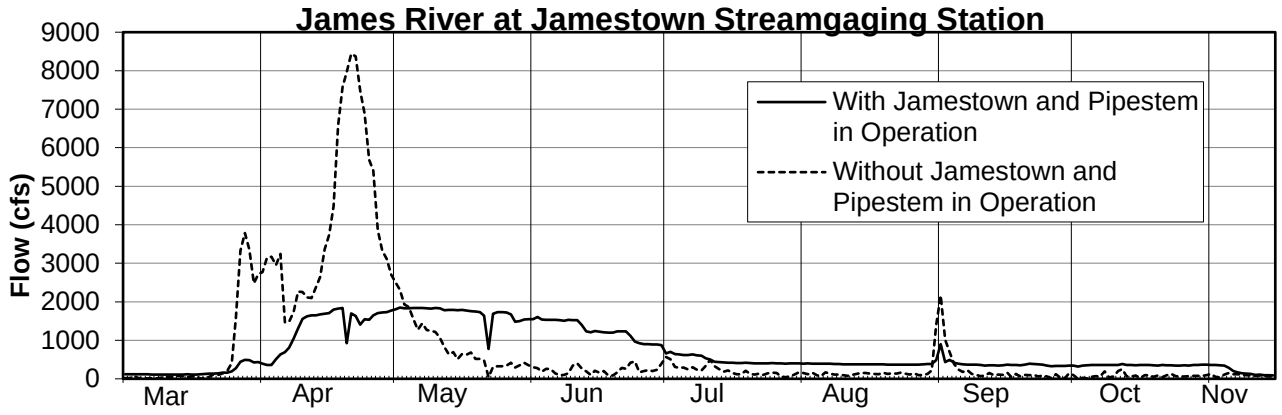
Prepared By: MB
Reviewed By: JL

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-10







Source: Reclamation

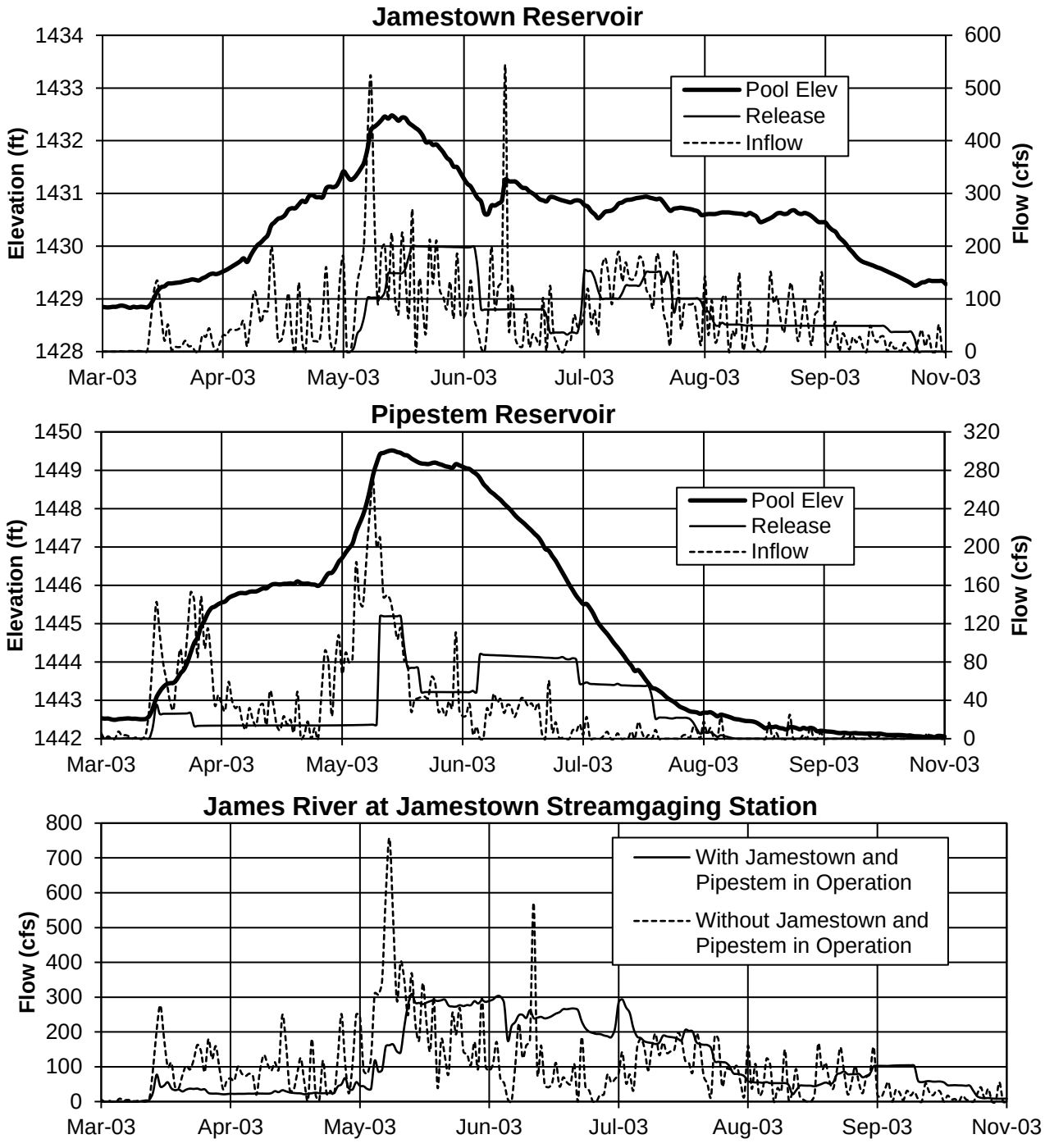
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

1997 Flood Routing

Prepared By: MB
Reviewed By: JL

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-11



Source: Reclamation

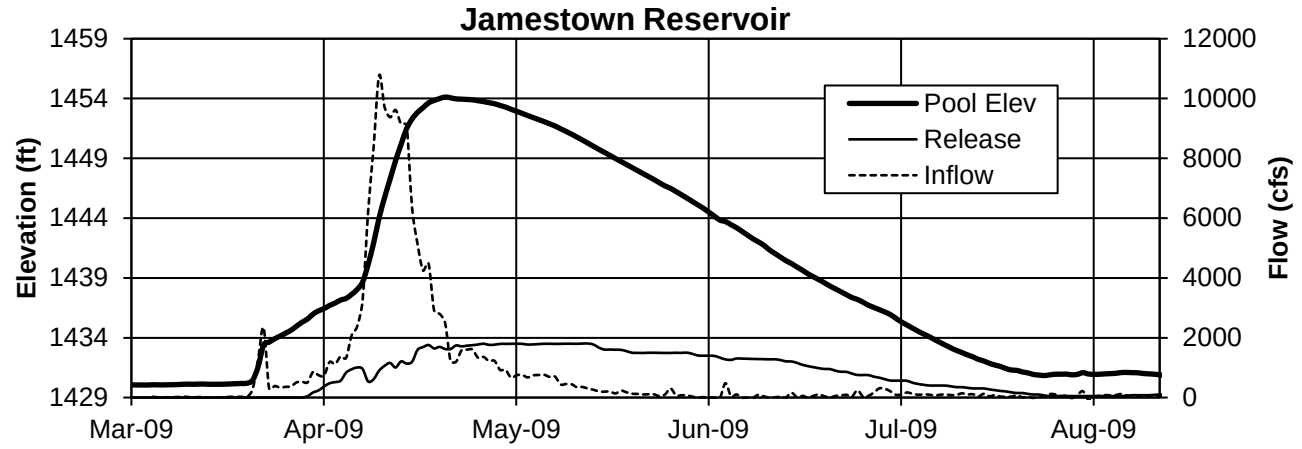
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

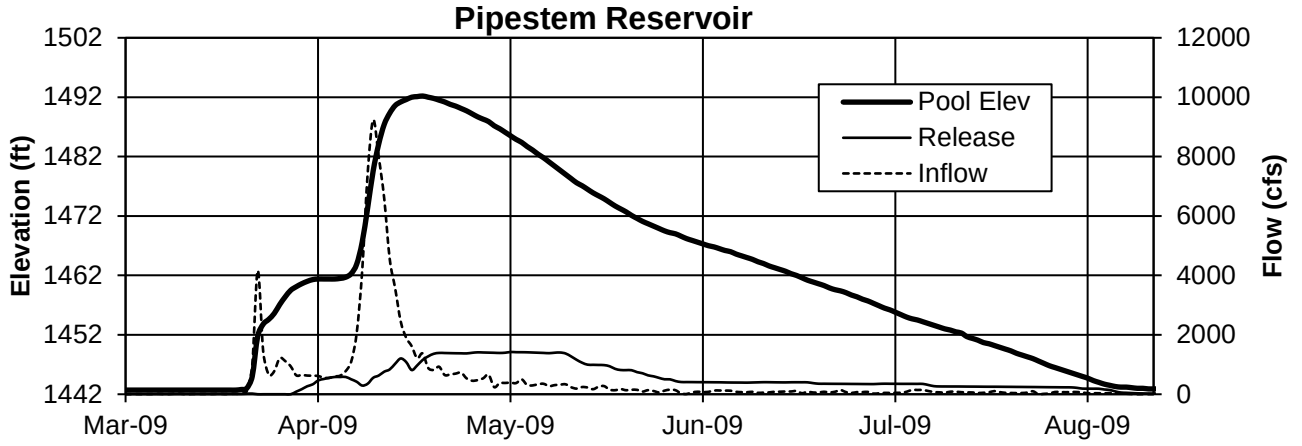
2003 Flood Routing

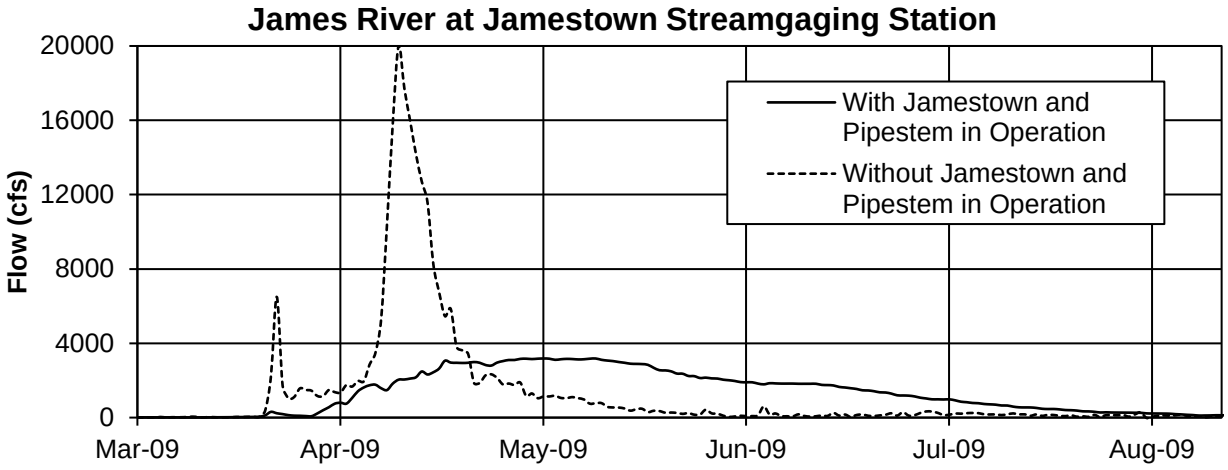
Prepared By: MB
Reviewed By: JL

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-12







Source: Reclamation

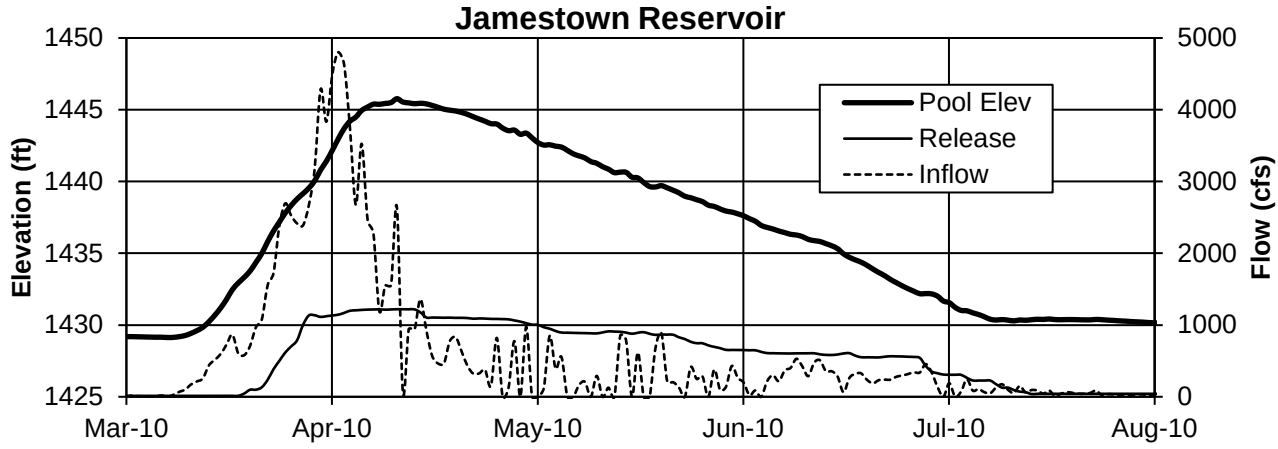
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

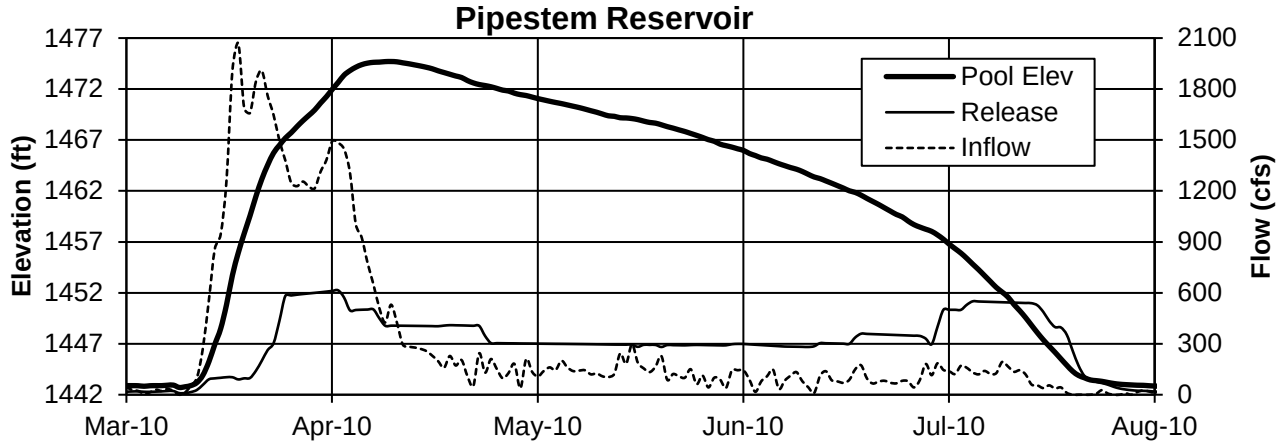
2009 Flood Routing

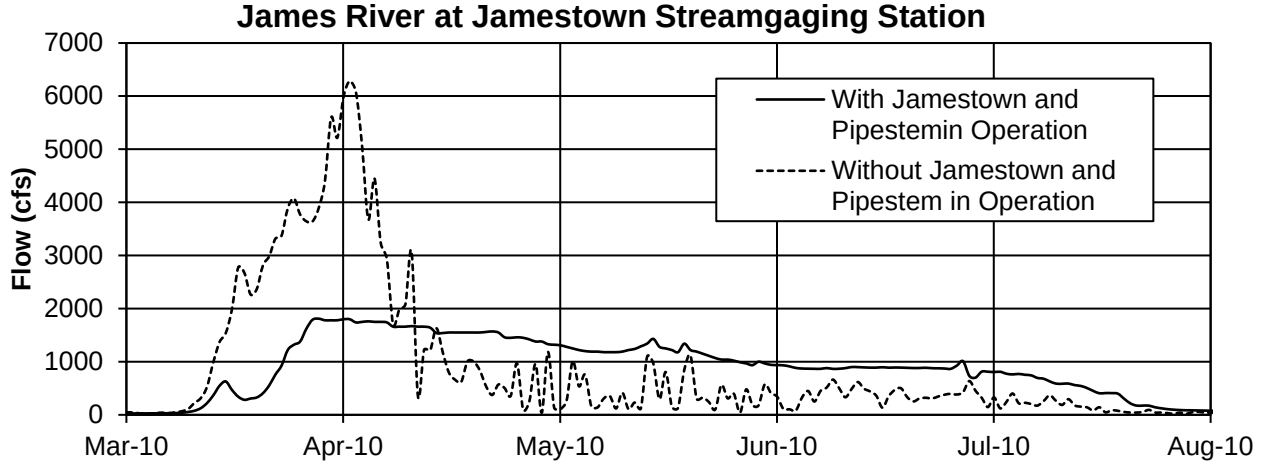
Prepared By: CC
Reviewed By: BT

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-13







Source: Reclamation

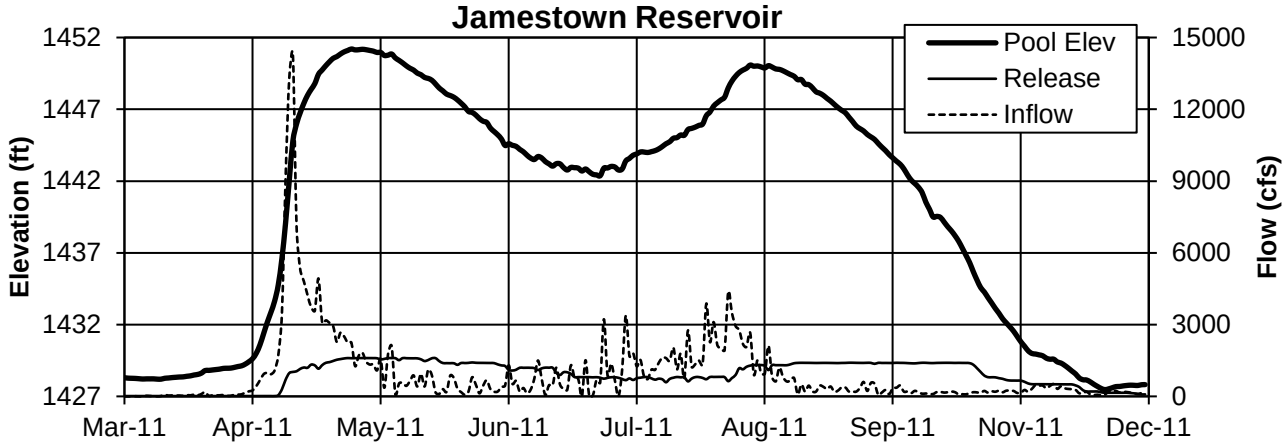
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

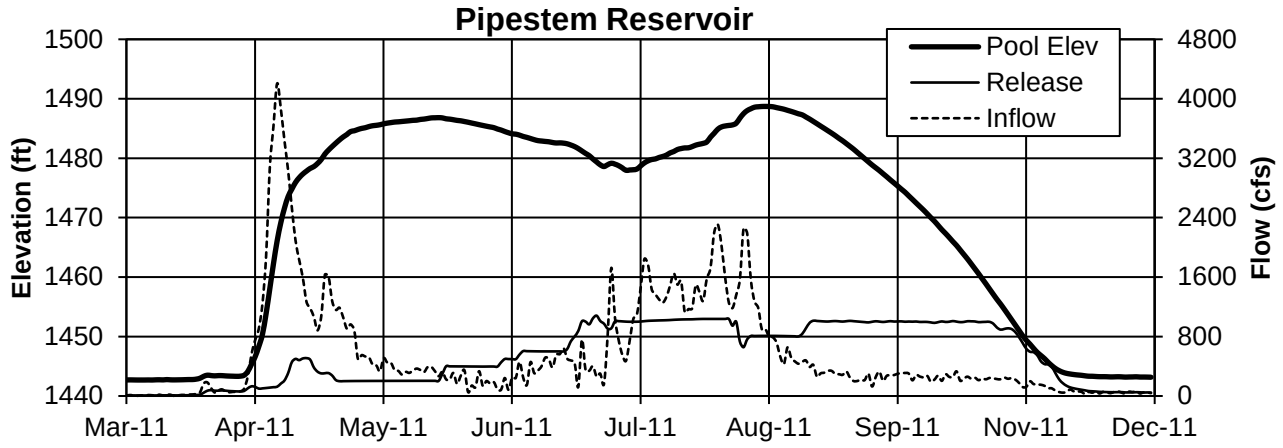
2010 Flood Routing

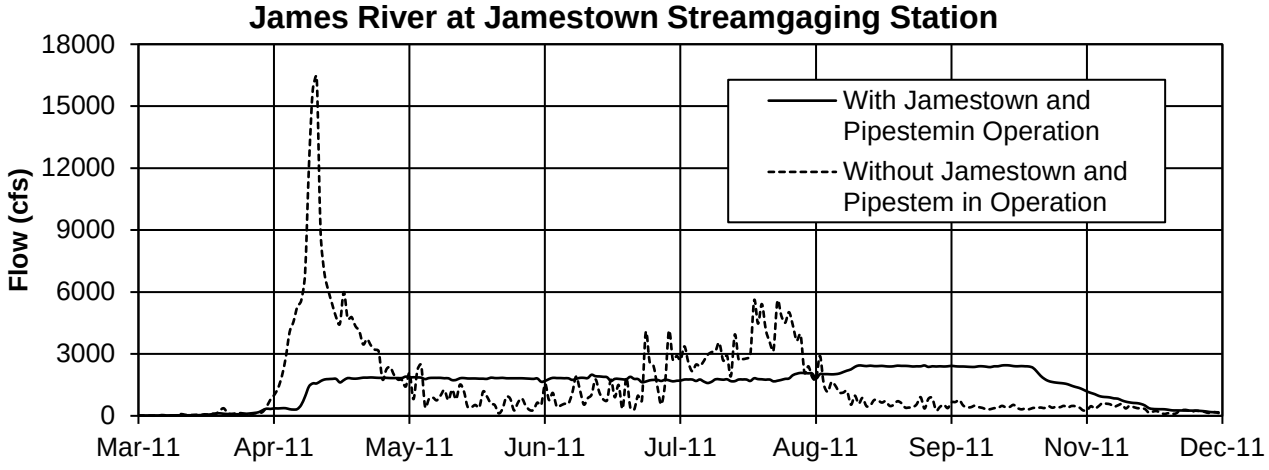
Prepared By: CC
Reviewed By: BT

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-14







Source: Reclamation

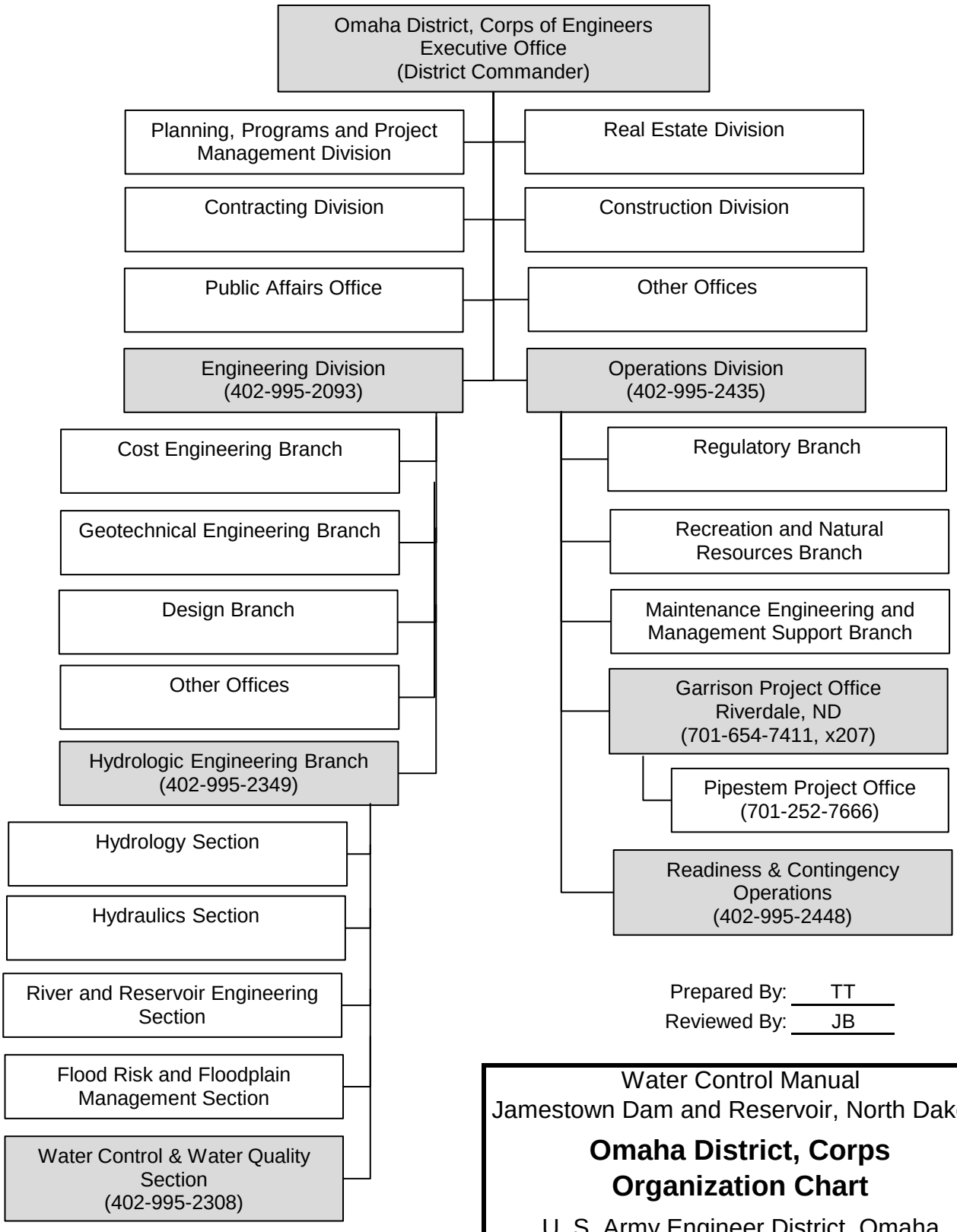
Water Control Manual
Jamestown Dam and Reservoir, North Dakota

2011 Flood Routing

Prepared By: CC
Reviewed By: BT

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 8-15



Prepared By: TT

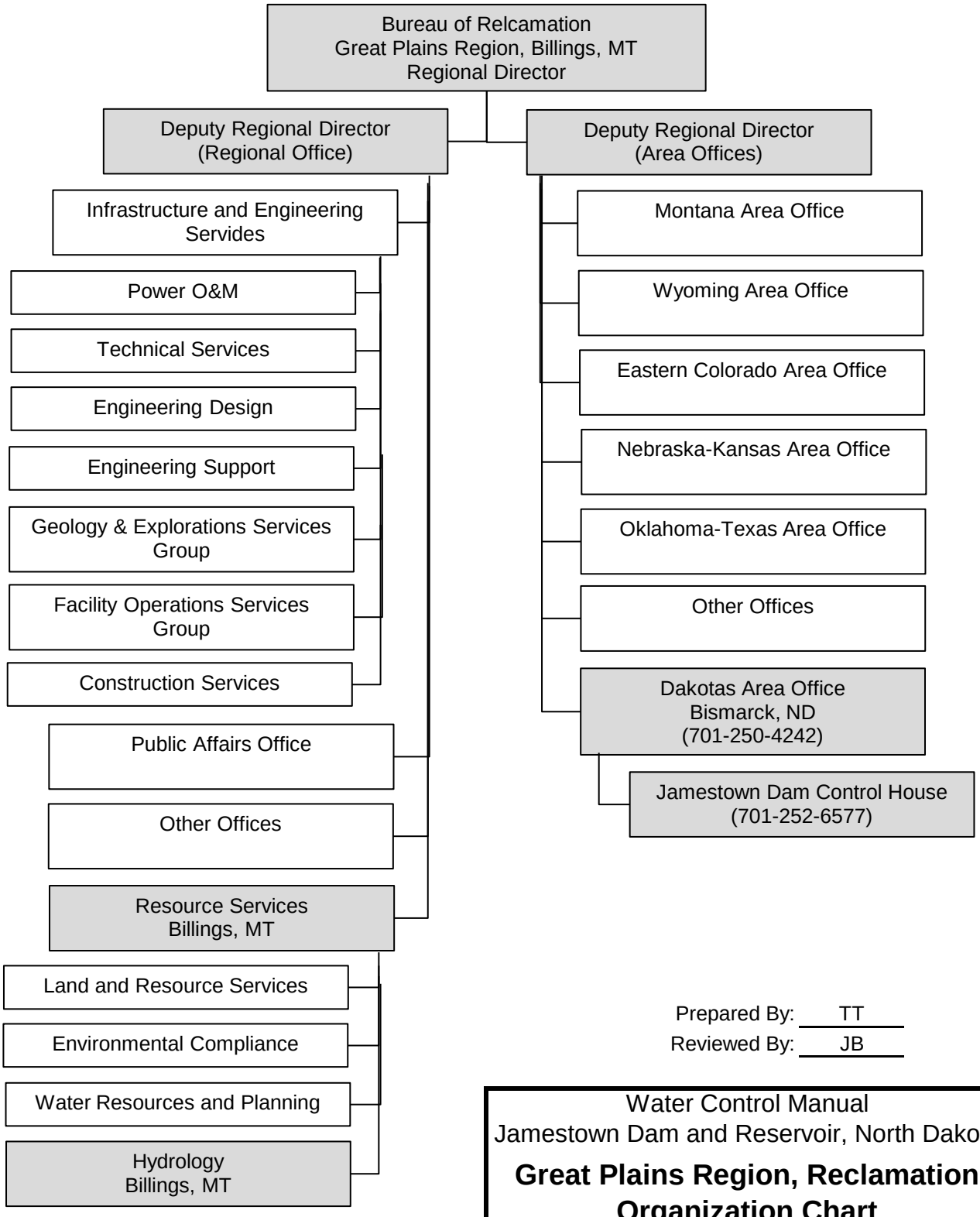
Reviewed By: JB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Omaha District, Corps Organization Chart

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 9-1



Prepared By: TT

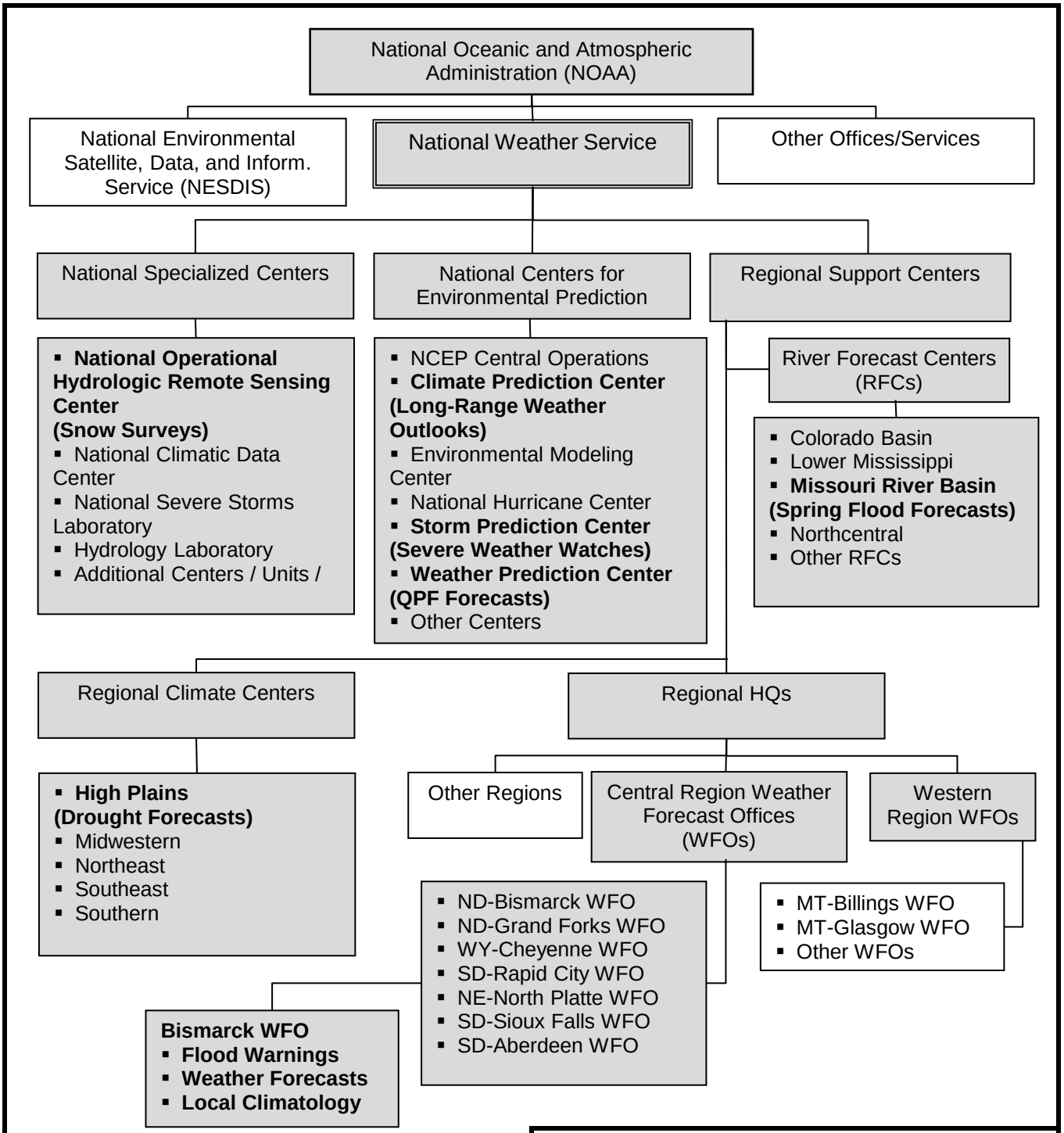
Reviewed By: JB

Water Control Manual
Jamestown Dam and Reservoir, North Dakota

Great Plains Region, Reclamation Organization Chart

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Plate 9-2



Water Control Manual
Jamestown Dam and Reservoir, North Dakota

National Weather Service Organization Chart

U. S. Army Engineer District, Omaha
Corps of Engineers, Omaha, Nebraska
March 2016

Prepared By: TT
Reviewed By: CM

Plate 9-3

EXHIBIT 1

33 CFR Chapter II Part 208, Flood Control Regulations, Section 208.11

This exhibit contains text and table from 33 CFR Chapter II, Part 208, Flood Control Regulations, Section 208.11, Regulations for use of storage allocated for flood control or navigation and/or project operation at reservoirs subject to prescription of rules and regulations by the Secretary of the Army in the interest of flood control and navigation (7-1-12 Edition). In this document, the text of Section 208.11 has been reformatted (indented) for clarity, and the List of Projects table at the end of document has been shortened to only include reservoirs within the Missouri River basin. Section 208.11 should be reviewed on an annual basis to identify any changes and these changes should be included in an updated exhibit to this manual. Updated editions of Section 208.11 can be found at the following website: http://www.ecfr.gov.

Exhibit 1

33 CFR Chapter II Part 208 Flood Control Regulations, Section 208.11 (7-1-12 Edition), Regulations for use of storage allocated for flood control or navigation and/or project operation at reservoirs subject to prescription of rules and regulations by the Secretary of the Army in the interest of flood control and navigation.

(a) *Purpose.* This regulation prescribes the responsibilities and general procedures for regulating reservoir projects capable of regulation for flood control or navigation and the use of storage allocated for such purposes and provided on the basis of flood control and navigation, except projects owned and operated by the Corps of Engineers; the International Boundary and Water Commission, United States and Mexico; and those under the jurisdiction of the International Joint Commission, United States, and Canada, and the Columbia River Treaty. The intent of this regulation is to establish an understanding between project owners, operating agencies, and the Corps of Engineers.

(b) *Responsibilities.* The basic responsibilities of the Corps of Engineers regarding project operation are set out in the cited authority and described in the following paragraphs:

(1) Section 7 of the Flood Control Act of 1944 (58 Stat. 890, 33 U.S.C. 709) directs the Secretary of the Army to prescribe regulations for flood control and navigation in the following manner:

> Hereafter, it shall be the duty of the Secretary of War to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds provided on the basis of such purposes, and the operation of any such project shall be in accordance with such regulations: Provided, That this section shall not apply to the Tennessee Valley Authority, except that in case of danger from floods on the lower Ohio and Mississippi Rivers the Tennessee Valley Authority is directed to regulate the release of water from the Tennessee River into the Ohio River in accordance with such instructions as may be issued by the War Department

(2) Section 9 of Public Law 436–83d Congress (68 Stat. 303) provides for the development of the Coosa River, Alabama and Georgia, and directs the Secretary of the Army to prescribe rules and regulations for project operation in the interest of flood control and navigation as follows:

> The operation and maintenance of the dams shall be subject to reasonable rules and regulations of the Secretary of the Army in the interest of flood control and navigation. NOTE: This Regulation will also be applicable to dam and reservoir projects operated under provisions of future legislative acts wherein the Secretary of the Army is directed to prescribe rules and regulations in the interest of flood control and navigation. The Chief of Engineers, U.S. Army Corps of Engineers, is designated the duly authorized representative of the Secretary of the Army to exercise the authority set out in the Congressional Acts. This Regulation will normally be implemented by letters of understanding between the Corps of Engineers and project owner and will incorporate the provisions of such letters of understanding prior to the time construction renders the project capable of significant impoundment of water. A water control agreement signed by both parties will follow when deliberate impoundment first begins or at such time as the responsibilities of any Corps-owned projects may be transferred to another entity. Promulgation of this Regulation for a given project will occur at such time as the name of the project appears in the FEDERAL

> REGISTER in accordance with the requirements of paragraph 6k. When agreement on a water control plan cannot be reached between the Corps and the project owner after coordination with all interested parties, the project name will be entered in the FEDERAL REGISTER and the Corps of Engineers plan will be the official water control plan until such time as differences can be resolved.

(3) Federal Energy Regulatory Commission (FERC), formerly Federal Power Commission (FPC), Licenses.

(i) Responsibilities of the Secretary of the Army and/or the Chief of Engineers in FERC licensing actions are set forth in reference 3c above and pertinent sections are cited herein. The Commission may further stipulate as a licensing condition, that a licensee enter into an agreement with the Department of the Army providing for operation of the project during flood times, in accordance with rules and regulations prescribed by the Secretary of the Army.

(A) Section 4(e) of the Federal Power Act requires approval by the Chief of Engineers and the Secretary of the Army of plans of dams or other structures affecting the navigable capacity of any navigable waters of the United States, prior to issuance of a license by the Commission as follows:

> The Commission is hereby authorized and empowered to issue licenses to citizens * * * for the purpose of constructing, operating and maintaining dams, water conduits, reservoirs, powerhouses, transmission lines, or other project works necessary or convenient for the development and improvement of navigation and for the development, transmission, and utilization of power across, along, from or in any of the streams or other bodies of water over which Congress has jurisdiction * * * Provided further, That no license affecting the navigable capacity of any navigable waters of the United States shall be issued until the plans of the dam or other structures affecting navigation have been approved by the Chief of Engineers and the Secretary of the Army.

(B) Sections 10(a) and 10(c) of the Federal Power Act specify conditions of project licenses including the following:

(1) Section 10(a). ‘‘That the project adopted * * * shall be such as in the judgment of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of waterpower development, and for other beneficial public uses * * *.’’

(2) Section 10(c). ‘‘That the licensee shall * * * so maintain and operate said works as not to impair navigation, and shall conform to such rules and regulations as the Commission may from time to time prescribe for the protection of life, health, and property * * *.’’

(C) Section 18 of the Federal Power Act directs the operation of any navigation facilities built under the provision of that Act, be controlled by rules and regulations prescribed by the Secretary of the Army as follows:

> The operation of any navigation facilities which may be constructed as part of or in connection with any dam or diversion structure built under the provisions of this Act, whether at the expense of a licensee hereunder or of the United States, shall at all times be controlled by such reasonable rules and regulations in the interest of navigation; including the control of the pool caused by such dam or diversion structure as may be made from time to time by the Secretary of the Army, * * *.

(ii) Federal Power Commission Order No. 540 issued October 31, 1975, and published November 7, 1975 (40 FR 51998), amending § 2.9 of the Commission's General Policy and Interpretations prescribed Standardized Conditions (Forms) for Inclusion in Preliminary Permits and Licenses Issued Under part I of the Federal Power Act. As an example, Article 12 of Standard Form L–3, titled: ''Terms and Conditions of License for Constructed Major Projects Affecting Navigable Waters of the United States,'' sets forth the Commission's interpretation of appropriate sections of the Act, which deal with navigation aspects, and attendant responsibilities of the Secretary of the Army in licensing actions as follows:

> The United States specifically retains and safeguards the right to use water in such amount, to be determined by the Secretary of the Army, as may be necessary for the purposes of navigation on the navigable waterway affected; and the operations of the Licensee, so far as they affect the use, storage and discharge from storage of waters affected by the license, shall at all times be controlled by such reasonable rules and regulations as the Secretary of the Army may prescribe in the interest of navigation, and as the Commission may prescribe for the protection of life, health, and property, * * * and the Licensee shall release water from the project reservoir at such rate * * * as the Secretary of the Army may prescribe in the interest of navigation, or as the Commission may prescribe for the other purposes hereinbefore mentioned.

(c) *Scope and terminology*. This regulation applies to Federal authorized flood control and/or navigation storage projects, and to non-Federal projects which require the Secretary of the Army to prescribe regulations as a condition of the license, permit or legislation, during the planning, design and construction phases, and throughout the life of the project. In compliance with the authority cited above, this regulation defines certain activities and responsibilities concerning water control management throughout the Nation in the interest of flood control and navigation. In carrying out the conditions of this regulation, the owner and/or operating agency will comply with applicable provisions of Pub. L. 85–624, the Fish and Wildlife Coordination Act of 1958, and Pub. L. 92–500, the Federal Water Pollution Control Act Amendments of 1972. This regulation does not apply to local flood protection works governed by § 208.10, or to navigation facilities and associated structures which are otherwise covered by part 207 (Navigation Regulations) of title 33 of the code. Small reservoirs, containing less than 12,500 acre-feet of flood control or navigation storage, may be excluded from this regulation and covered under § 208.10, unless specifically required by law or conditions of the license or permit.

(1) The terms *reservoir* and *project* as used herein include all water resource impoundment projects constructed or modified, including natural lakes, that are subject to this regulation.

(2) The term *project owner* refers to the entity responsible for maintenance, physical operation, and safety of the project, and for carrying out the water control plan in the interest of flood control and/or navigation as prescribed by the Corps of Engineers. Special arrangements may be made by the project owner for ''operating agencies'' to perform these tasks.

(3) The term *letter of understanding* as used herein includes statements which consummate this regulation for any given project and define the general provisions or conditions of the local sponsor, or owner, cooperation agreed to in the authorizing legislative document, and the requirements for compliance with section 7 of the 1944 Flood Control Act, the Federal Power Act or other special congressional act. This information will be specified in the water control plan and manual. The letter of understanding will be signed by a duly authorized representative of the Chief of Engineers and the project owner. A ''field working agreement'' may be substituted for a letter of understanding, provided that the specified minimum requirements of the latter, as stated above, are met.

(4) The term *water control agreement* refers to a compilation of water control criteria, guidelines, diagrams, release schedules, rule curves and specifications that basically govern the use of reservoir storage space allocated for flood control or navigation and/or release functions of a water control project for these purposes. In general, they indicate controlling or limiting rates of discharge and storage space required for flood control and/or navigation, based on the runoff potential during various seasons of the year.

(5) For the purpose of this regulation, the term *water control plan* is limited to the plan of regulation for a water resources project in the interest of flood control and/or navigation. The water control plan must conform with proposed allocations of storage capacity and downstream conditions or other requirements to meet all functional objectives of the particular project, acting separately or in combination with other projects in a system.

(6) The term *real-time* denotes the processing of current information or data in a sufficiently timely manner to influence a physical response in the system being monitored and controlled. As used herein the term connotes * * * the analyses for and execution of water control decisions for both minor and major flood events and for navigation, based on prevailing hydrometeorological and other conditions and constraints, to achieve efficient management of water resource systems.

(d) *Procedures—*

(1) *Conditions during project formulation.* During the planning and design phases, the project owner should consult with the Corps of Engineers regarding the quantity and value of space to reserve in the reservoir for flood control and/or navigation purposes, and for utilization of the space, and other requirements of the license, permit or conditions of the law. Relevant matters that bear upon flood control and navigation accomplishment include: Runoff potential, reservoir discharge capability, downstream channel characteristics, hydrometeorological data collection, flood hazard, flood damage characteristics, real estate acquisition for flowage requirements (fee

and easement), and resources required to carry out the water control plan. Advice may also be sought on determination of and regulation for the probable maximum or other design flood under consideration by the project owner to establish the quantity of surcharge storage space, and freeboard elevation of top of dam or embankment for safety of the project.

(2) *Corps of Engineers involvement.* If the project owner is responsible for real-time implementation of the water control plan, consultation and assistance will be provided by the Corps of Engineers when appropriate and to the extent possible. During any emergency that affects flood control and/or navigation, the Corps of Engineers may temporarily prescribe regulation of flood control or navigation storage space on a day-to-day (real-time) basis without request of the project owner. Appropriate consideration will be given for other authorized project functions. Upon refusal of the project owner to comply with regulations prescribed by the Corps of Engineers, a letter will be sent to the project owner by the Chief of Engineers or his duly authorized representative describing the reason for the regulations prescribed, events that have transpired, and notification that the project owner is in violation of the Code of Federal Regulations. Should an impasse arise, in that the project owner or the designated operating entity persists in noncompliance with regulations prescribed by the Corps of Engineers, measures may be taken to assure compliance.

(3) *Corps of Engineers implementation of real-time water control decisions.* The Corps of Engineers may prescribe the continuing regulation of flood control storage space for any project subject to this regulation on a day-to-day (real-time) basis. When this is the case, consultation and assistance from the project owner to the extent possible will be expected. Special requests by the project owner, or appropriate operating entity, are preferred before the Corps of Engineers offers advice on real-time regulation during surcharge storage utilization.

(4) *Water control plan and manual.* Prior to project completion, water control managers from the Corps of Engineers will visit the project and the area served by the project to become familiar with the water control facilities, and to insure sound formulation of the water control plan. The formal plan of regulation for flood control and/or navigation, referred to herein as the water control plan, will be developed and documented in a water control manual prepared by the Corps of Engineers. Development of the manual will be coordinated with the project owner to obtain the necessary pertinent information, and to insure compatibility with other project purposes and with surcharge regulation. Major topics in the manual will include: Authorization and description of the project, hydrometeorology, data collection and communication networks, hydrologic forecasting, the water control plan, and water resource management functions, including responsibilities and coordination for water control decision-making. Special instructions to the dam tender or reservoir manager on data collection, reporting to higher Federal authority, and on procedures to be followed in the event of a communication outage under emergency conditions, will be prepared as an exhibit in the manual. Other exhibits will include copies of this regulation, letters of understanding consummating this regulation, and the water control agreements. After approval by the Chief of Engineers or his duly authorized representative, the manual will be furnished the project owner.

(5) *Water control agreement.*

(i) A water control diagram (graphical) will be prepared by the Corps of Engineers for each project having variable space reservation for flood control and/or navigation during the year; e.g., variable seasonal storage, joint-use space, or other rule curve designation. Reservoir inflow parameters will be included on the diagrams when appropriate. Concise notes will be included on the diagrams prescribing the use of storage space in terms of release schedules, runoff, nondamaging or other controlling flow rates downstream of the damsite, and other major factors as appropriate. A water control release schedule will be prepared in tabular form for projects that do not have variable space reservation for flood control and/or navigation. The water control diagram or release schedule will be signed by a duly authorized representative of the Chief of Engineers, the project owner, and the designated operating agency, and will be used as the basis for carrying out this regulation. Each diagram or schedule will contain a reference to this regulation.

(ii) When deemed necessary by the Corps of Engineers, information given on the water control diagram or release schedule will be supplemented by appropriate text to assure mutual understanding on certain details or other important aspects of the water control plan not covered in this regulation, on the water control diagram or in the release schedule. This material will include clarification of any aspects that might otherwise result in unsatisfactory project performance in the interest of flood control and/or navigation. Supplementation of the agreement will be necessary for each project where the Corps of Engineers exercises the discretionary authority to prescribe the flood control regulation on a day-today (real-time) basis. The agreement will include delegation of the responsibility. The document should also cite, as appropriate, section 7 of the 1944 Flood Control Act, the Federal Power Act and/or other congressional legislation authorizing construction and/or directing operation of the project.

(iii) All flood control regulations published in the FEDERAL REGISTER under this section (part 208) of the code prior to the date of this publication which are listed in § 208.11(e) are hereby superseded.

(iv) Nothing in this regulation prohibits the promulgation of specific regulations for a project in compliance with the authorizing acts, when agreement on acceptable regulations cannot be reached between the Corps of Engineers and the owner.

(6) *Hydrometeorological instrumentation.* The project owner will provide instrumentation in the vicinity of the damsite and will provide communication equipment necessary to record and transmit hydrometeorological and reservoir data to all appropriate Federal authorities on a real-time basis unless there are extenuating circumstances or are otherwise provided for as a condition of the license or permit. For those projects where the owner retains responsibility for real-time implementation of the water control plan, the owner will also provide or arrange for the measurement and reporting of hydrometeorological parameters required within and adjacent to the watershed and downstream of the damsite, sufficient to regulate the project for flood control and/or navigation in an efficient manner. When data collection stations outside the immediate vicinity of the damsite are required, and funds for installation, observation, and maintenance are

not available from other sources, the Corps of Engineers may agree to share the costs for such stations with the project owner. Availability of funds and urgency of data needs are factors which will be considered in reaching decisions on cost sharing.

(7) *Project safety.* The project owner is responsible for the safety of the dam and appurtenant facilities and for regulation of the project during surcharge storage utilization. Emphasis upon the safety of the dam is especially important in the event surcharge storage is utilized, which results when the total storage space reserved for flood control is exceeded. Any assistance provided by the Corps of Engineers concerning surcharge regulation is to be utilized at the discretion of the project owner, and does not relieve the owner of the responsibility for safety of the project.

(8) *Notification of the general public.* The Corps of Engineers and other interested Federal and State agencies, and the project owner will jointly sponsor public involvement activities, as appropriate, to fully apprise the general public of the water control plan. Public meetings or other effective means of notification and involvement will be held, with the initial meeting being conducted as early as practicable but not later than the time the project first becomes operational. Notice of the initial public meeting shall be published once a week for 3 consecutive weeks in one or more newspapers of general circulation published in each county covered by the water control plan. Such notice shall also be used when appropriate to inform the public of modifications in the water control plan. If no newspaper is published in a county, the notice shall be published in one or more newspapers of general circulation within that county. For the purposes of this section a newspaper is one qualified to publish public notices under applicable State law. Notice shall be given in the event significant problems are anticipated or experienced that will prevent carrying out the approved water control plan or in the event that an extreme water condition is expected that could produce severe damage to property or loss of life. The means for conveying this information shall be commensurate with the urgency of the situation. The water control manual will be made available for examination by the general public upon request at the appropriate office of the Corps of Engineers, project owner or designated operating agency.

(9) *Other generalized requirements for flood control and navigation.*

(i) Storage space in the reservoirs allocated for flood control and navigation purposes shall be kept available for those purposes in accordance with the water control agreement, and the plan of regulation in the water control manual.

(ii) Any water impounded in the flood control space defined by the water control agreement shall be evacuated as rapidly as can be safely accomplished without causing downstream flows to exceed the controlling rates; i.e., releases from reservoirs shall be restricted insofar as practicable to quantities which, in conjunction with uncontrolled runoff downstream of the dam, will not cause water levels to exceed the controlling stages currently in force. Although conflicts may arise with other purposes, such as hydropower, the plan or regulation may require releases to be completely curtailed in the interest of flood control or safety of the project.

(iii) Nothing in the plan of regulation for flood control shall be construed to require or allow dangerously rapid changes in magnitudes of releases. Releases will be made in a manner consistent with requirements for protecting the dam and reservoir from major damage during passage of the maximum design flood for the project.

(iv) The project owner shall monitor current reservoir and hydro- meteorological conditions in and adjacent to the watershed and downstream of the damsite, as necessary. This and any other pertinent information shall be reported to the Corps of Engineers on a timely basis, in accordance with standing instructions to the damtender or other means requested by the Corps of Engineers.

(v) In all cases where the project owner retains responsibility for real-time implementation of the water control plan, he shall make current determinations of: Reservoir inflow, flood control storage utilized, and scheduled releases. He shall also determine storage space and releases required to comply with the water control plan prescribed by the Corps of Engineers. The owner shall report this information on a timely basis as requested by the Corps of Engineers.

(vi) The water control plan is subject to temporary modification by the Corps of Engineers if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be confirmed in writing the same day to the project owner and shall include justification for the action.

(vii) The project owner may temporarily deviate from the water control plan in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of the dam, or to avoid other serious hazards. Such actions shall be immediately reported by the fastest means of communication available. Actions shall be confirmed in writing the same day to the Corps of Engineers and shall include justification for the action. Continuation of the deviation will require the express approval of the Chief of Engineers, or his duly authorized representative.

(viii) Advance approval of the Chief of Engineers, or his duly authorized representative, is required prior to any deviation from the plan of regulation prescribed or approved by the Corps of Engineers in the interest of flood control and/or navigation, except in emergency situations provided for in paragraph (d)(9)(vii) of this section. When conditions appear to warrant a prolonged deviation from the approved plan, the project owner and the Corps of Engineers will jointly investigate and evaluate the proposed deviation to insure that the overall integrity of the plan would not be unduly compromised. Approval of prolonged deviations will not be granted unless such investigations and evaluations have been conducted to the extent deemed necessary by the Chief of Engineers, or his designated representatives, to fully substantiate the deviation.

(10) *Revisions.* The water control plan and all associated documents will be revised by the Corps of Engineers as necessary, to reflect changed conditions that come to bear upon flood control and

navigation, e.g., reallocation of reservoir storage space due to sedimentation or transfer of storage space to a neighboring project. Revision of the water control plan, water control agreement, water control diagram, or release schedule requires approval of the Chief of Engineers or his duly authorized representative. Each such revision shall be effective upon the date specified in the approval. The original (signed document) water control agreement shall be kept on file in the respective Office the Division Engineer, Corps of Engineers, Department of the Army, located at division offices throughout the continental USA. Copies of these agreements may be obtained from the office of the project owner, or from the office of the appropriate Division Engineer, Corps of Engineers.

(11) *Federal Register*. The following information for each project subject to section 7 of the 1944 Flood Control Act and other applicable congressional acts shall be published in the FEDERAL REGISTER prior to the time the projects becomes operational and prior to any significant impoundment before project completion or * * * at such time as the responsibility for physical operation and maintenance of the Corps of Engineers owned projects is transferred to another entity:

(i) Reservoir, dam, and lake names,

(ii) Stream, county, and State corresponding to the damsite location,

(iii) The maximum current storage space in acre-feet to be reserved exclusively for flood control and/or navigation purposes, or any multiple-use space (intermingled) when flood control or navigation is one of the purposes, with corresponding elevations in feet above mean sea level, and area in acres, at the upper and lower limits of said space,

(iv) The name of the project owner, and (v) Congressional legislation authorizing the project for Federal participation.

(e) *List of projects.* The following tables, ‘‘Pertinent Project Data—Section 208.11 Regulation,’’ show the pertinent data for projects which are subject to this regulation. Note that the following tables were condensed to show only those projects within the Missouri River basin, which includes the Omaha District and Kansas City District of the Northwestern Division, Corps of Engineers.

LIST OF PROJECTS

[Missouri River Basin Non-Corps projects with Corps Regulation Requirements]

Project name[1] (1)	State (2)	County (3)	Stream[1] (4)	Project purpose[2] (5)	Storage 1000 AF (6)	Elev limits feet M.S.L.		Area in acres		Authorizing legis.[3] (11)	Proj. owner[4] (12)
						Upper (7)	Lower (8)	Upper (9)	Lower (10)		
Omaha District Projects											
Boysen Dam & Res	WY	Fremont	Wind R	F FEIQ EIQ	150.4 146.1 403.8	4732.2 4725.0 4717.0	4725.0 4717.0 4685.0	22170 19560 16960	19560 16960 9280	PL 78–534	USBR.
Canyon Ferry Dam & Lk	MT	Lewis Clark	Missouri R	F FEI EI	99.5 795.1 711.5	3800.0 3797.0 3770.0	3797.0 3770.0 3728.0	33535 32800 24125	32800 24125 11480	PL 78–534	USBR.
Clark Canyon Dam & Res	MT	Beaverhead	Beaverhead R	F FI I	79.1 50.4 126.1	5560.4 5546.1 5535.7	5546.1 5535.7 5470.6	5900 5160 4495	5160 4495 220	PL 78–534	USBR.
Glendo Dam & Res	WY	Platte	N Platte R	F EIM	271.9 454.3	4653.0 4635.0	4635.0 4570.0	17990 12370	12370 3130	PL 78–534	USBR.
Heart Butte Dm & Lk Tschida	ND	Grant	Heart R	F IQ	147.9 69.0	2094.5 2064.5	2064.5 2030.0	6580 3400	3400 810	PL 78–534	USBR.
Jamestown Dam & Res	ND	Stutsman	James R	F IQ	185.4 28.1	1454.0 1429.8	1429.8 1400.0	13210 2090	2090 160	PL 78–534	USBR.
Keyhole Dam & Res	WY	Crook	Belle Fourche R	F IQ	140.5 185.8	4111.5 4099.3	4099.3 4051.0	13730 9410	9410 820	PL 78–534	USBR.
Pactola Dam & Res	SD	Pennington	Rapid Cr	F IM	43.1 55.0	4621.5 4580.2	4580.2 4456.1	1230 860	860 100	PL 78–534	USBR.
Shadehill Dam & Res	SD	Perkins	Grand R	F IQ	218.3 80.9	2302.0 2271.9	2271.9 2250.8	9900 4800	4800 2800	PL 78–534	USBR.
Tiber Dam & Res	MT	Libert Toole	Marias R	F FIQ IQ	400.9 268.0 121.7	3012.5 2993.0 2976.0	2993.0 2976.0 2966.4	23150 17890 13790	17890 13790 11710	PL 78–534	USBR.
Yellowtail Dam & Bighorn Lk	MT	Big Horn	Bighorn R	F FEIQ EIQ	258.3 240.3 336.1	3657.0 3640.0 3614.0	3640.0 3614.0 3547.0	17280 12600 6915	12600 6915 4150	PL 78–534	USBR PUD
Kansas City District Projects											
Bonny Dam & Res	CO	Yuma	S Fork Republic R	F ICR	128.2 39.2	3710.0 3672.0	3672.0 3638.0	5036 2042	2042 331	PL 78–534 PL 79–732	USBR.
Cedar Bluff Dam & Res	KS	Trego	Smoky Hill R	F IMCR	191.9 149.8	2166.0 2144.0	2144.0 2107.8	10790 6869	6869 2086	PL 78–534	USBR.
Enders Dam & Res	NE	Chase	Frenchman Cr	F ICR	30.0 34.5	3127.0 3112.3	3112.3 3082.4	2405 1707	1707 658	PL 78–534 PL 84–505	USBR.
Glen Elder Dam & Waconda Lk	KS	Mitchel	Solomon R	F IM	722.3 204.8	1488.3 1455.6	1455.6 1428.0	33682 12602	12602 3341	PL 78–534 PL 79–526	USBR.
Kirwin Dam & Res	KS	Phillips	N Fork Solomon R	F ICR	215.1 89.6	1757.3 1729.2	1729.3 1697.0	10640 5080	5080 1010	PL 78–534 PL 79–732; PL 79–526	USBR.
Lovewell Dam & Res	KS	Jewell	White Rock Cr	F ICR	50.5 24.9	1595.3 1582.6	1582.6 1571.7	5025 2986	2986 1704	PL 78–534 PL 79–732	USBR.
Medicine Cr Dam Harry Strunk Lk	NE	Frontier	Medicine Cr	F ICR	52.7 26.8	2386.2 2366.1	2366.1 2343.0	3483 1840	1840 701	PL 78–534 PL 84–505	USBR.
Norton Dam & Kieth Sebelius Lk	KS	Norton	Prairie Dog Cr	F IMRC	98.8 30.7	2331.4 2304.3	2304.3 2280.4	5316 2181	2181 587	PL 78–534 PL 79–526 PL 79–732	USBR.
Red Willow Dam Hugh Butler Lk	NE	Frontier	Red Willow Cr	F IRC	48.9 27.3	2604.9 2581.8	2581.8 2558.0	2682 1629	1629 787	PL 78–534 PL 85–783 PL 84–505	USBR.
Trenton Dam & Res	NB	Hitchcock	Republican R	F IRC	134.1 99.8	2773.0 2752.0	2752.0 2720.0	7940 4922	4922 1572	PL 78–534 PL 84–505	USBR.
Webster Dam & Res	KS	Rocks	S Fork Solomon R	F IRC	183.4 72.1	1923.7 1892.5	1892.5 1860.0	8480 3772	3772 906	PL 78–534 PL 79–526 PL 79–732	USBR

[1]Cr—Creek; CS—Control Structure; Div—Diversion; DS—Drainage Structure; FG—Floodgate; Fk—Fork; GIWW—Gulf Intercoastal Waterway; Lk—Lake; L&D—Lock & Dam; PS—Pump Station; R—River; Res—Reservoir
[2]F—Flood Control; N—Navigation; P—Corps Hydropower; E—Non Corps Hydropower; I—Irrigation; M—Municipal and/or Industrial Water Supply; C—Fish and Wildlife Conservation; A—Low Flow Augmentation or Pollution Abatement; R—Recreation; Q—Water Quality or Silt Control
[3]FCA—Flood Control Act; FERC—Federal Energy Regulatory Comm; HD—House Document; PL—Public Law; PW—Public Works; RHA—River & Harbor Act; SD—Senate Document; WSA—Water Supply Act
[4]Appl Pwr—Appalachian Power; Chln PUD—Chelan Cnty PUD 1; CLPC—CT Light & Power Co; Dgls PUD—Douglas Cnty PUD 1; DWR—Department of Water Resources; EB-MUD—East Bay Municipal Utility Dist; GRD—Grand River Dam Auth; Grnt PUD—Grant Cnty PUD 2; Hnbl—city of Hannibal; M&T Irr—Modesto & Turlock Irr; Mrcd Irr—Merced Irr; NEPC—New England Power Co; Pgnt P&L—Pugent Sound Power & Light; Ptmc Comm—Upper Potomac R Comm; Rclm B—Reclamation Board; Rkfd—city of Rockford; Sttl—city of Seattle; Tac—City of Tacoma; Vale USBR—50% Vale Irr 50% USBR; WF&CWID—City of Wichita Falls and Wichita Cnty Water Improvement District No. 2; WMEC—Western MA Electric Co; YCWA—Yuba City Water Auth; Yolo FC&W—Yolo Flood Control & Water Conserv Dist

(Sec. 7, Pub. L. 78–534, 58 Stat. 890 (33 U.S.C. 709); the Federal Power Act, 41 Stat. 1063 (16 U.S.C. 791(A)); and sec. 9, Pub. L. 83–436, 68 Stat. 303)

[43 FR 47184, Oct. 13, 1978, as amended at 46 FR 58075, Nov. 30, 1981; 55 FR 21508, May 24, 1990]

EXHIBIT 2

FIELD WORKING AGREEMENT

United States Department of the Interior

BUREAU OF RECLAMATION
Great Plains Regional Office
P.O. Box 36900
Billings, MT 59107-6900

IN REPLY REFER TO:
GP-4600
ADM-13.00

DEC 14 2015

Ms. Jessica Batterman
US Army Corps of Engineers, Omaha
1616 Capitol Avenue, Suite 9000
Omaha, NE 68102

Subject: Transmittal of the Field Working Agreement for Jamestown Dam, Garrison Diversion Unit, Pick Sloan Missouri Basin Program

Dear Ms. Batterman:

Enclosed please find the signed Memorandum of Field Working Agreement for Jamestown Dam. We have retained a copy for our records.

If you have any questions regarding this agreement or need additional information, please contact Mr. Jeff Nettleton of the Bureau of Reclamation's Dakotas Area Office at 605-394-9757 Ext 3015 or jnettleton@usbr.gov.

Sincerely,

[redacted]

Regional Director

Enclosure

MEMORANDUM OF AGREEMENT
BETWEEN
U.S. ARMY CORPS OF ENGINEERS, OMAHA DISTRICT
AND
U.S. BUREAU OF RECLAMATION

SUBJECT: Memorandum of Field Working Agreement

1. The Bureau of Reclamation (Reclamation) constructed Jamestown Dam and Reservoir and is responsible for operation and management of the dam and reservoir. The dam and reservoir were constructed under authorization of Section 9 of the Flood Control Act of 1944. Under Section 7 of the Flood Control Act of 1944, the Corps of Engineers (Corps) is directed to regulate all federally constructed projects when water is in the flood control zone. Flood control regulation of Jamestown Reservoir during periods when the reservoir water surface is within the exclusive flood control pool, between elevation 1431.0 and 1454.0 feet, and within the flood control portion of joint-use pool between 1429.8 and 1431.0 feet is the responsibility of the Department of the Army, acting through the Corps, represented by the Division Commander, Northwestern Division, who is in turn represented by the District Commander, Omaha District, hereinafter referred to as "District Commander". The Department of the Interior, acting through Reclamation, represented by the Regional Director, who in turn is represented by the Area Manager, Dakotas Area Office, hereinafter is referred to as the "Area Manager".

2. This letter supersedes the previously signed Field Working Agreement dated July 25, 1975. Flood Control Regulations governing the operation of Jamestown Dam and Reservoir, James River, ND were originally published in the Federal Register, at Page 864, Volume 22, issue of February 12, 1957, as amended at Page 7571, Volume 33, issue of May 22, 1969, and are superseded by regulations published in the Federal Register at 33 CFR Chapter II Part 208, Flood Control Regulations, Section 208.11 (a copy of these regulations is enclosed hereto as Exhibit 1). Per these regulations, it is agreed that the dam and reservoir will be operated under the following rules, unless and until such rules shall be amended by mutual agreement.

3. Storage Capacity Allocations. The storage capacity allocations of Jamestown Reservoir are defined in the following subparagraphs:

a. Surcharge Storage. Surcharge storage capacity allocation shall include the storage capacity between elevations 1454.0 and 1464.4 feet. The surcharge storage zone is provided in combination with spillway capacity to ensure safety of the structure. The storage in this zone, based on 2009 surveys, amounts to 158,917 acre-feet.

b. Exclusive Flood Control Storage. Flood control storage capacity allocation shall include the storage capacity between elevations 1431.0 and 1454.0 feet, for which there have been constructed suitable outlet works to provide discharges as expressly indicated herein. Based on 2009 surveys, storage in this zone amounts to 190,502 acre-feet.

c. Joint Use Storage. Joint use storage capacity allocation in Jamestown Reservoir shall include the storage capacity between elevations 1428.0 and 1431.0 feet. This storage is used for project purposes such as irrigation, municipal water supply, stream pollution abatement, recreation and wildlife, and potential power generation. In addition to these project purposes, the portion of the joint use zone between elevations 1429.8 and 1431.0 feet is also used for flood control storage. Based on 2009 surveys, this portion of the joint use storage includes 2,680 acre-feet of storage. The remaining portion of the joint use zone, between elevations 1428.0 and 1429.8 feet, includes 3,582 acre-feet of storage. The target pool levels in the overall joint use zone vary seasonally based on mutual agreement between agencies for conservation purposes.

d. Conservation Storage. Conservation storage capacity allocation shall include the storage capacity between elevations 1400.0 and 1428.0 feet. Storage in this zone initially amounted to 28,088 acre-feet, of which 9,178 acre-feet was provided for the accumulation of sediment, leaving a net planned conservation storage capacity allocation of 18,910 acre-feet. Current conservation storage based on 2009 surveys amounts to 23,934 acre-feet.

e. Dead Storage. Dead storage capacity allocation shall include the storage capacity between the streambed elevation and elevation 1400.0 feet, initially amounting to 822 acre-feet. This capacity is established by the elevation of the outlet works and provides for the accumulation of sediment in addition to the 9,178 acre-feet provided in the conservation storage. Current dead pool storage based on 2009 surveys amounts to 292 acre-feet.

4. Storage Reallocations. The Area Manager shall at reasonable intervals make necessary field surveys and office studies to prepare estimates of the volume and location of sediment deposits in the reservoir. If the results of these studies show that the storage available for flood control and conservation, respectively, is reduced by an amount exceeding 10 percent of the allocation for either purpose, the operating plan described herein with respect to the elevation limits of the storage allocations shall be reviewed with the view of equitably distributing the loss of reservoir capacity between the primary reservoir uses.

In the event of channel improvements downstream from Jamestown Dam associated with development of the James River valley for irrigation, review will be made of the operating plan described herein with respect to the elevation limits of the storage allocations with the view of increasing the storage allocated for conservation purposes commensurate with a decrease in allocated flood control storage capacity made possible by the improved downstream conditions. Any redistribution of storage capacity allocations is to be contingent on paragraph 10.

5. Plan of Flood Control Operation. The Area Manager shall operate Jamestown Dam and Reservoir in the interest of flood control in accordance with the published regulations described in Chapter 7 of the Jamestown Dam and Reservoir Water Control Manual. Operation of the reservoir with water surface between elevations 1429.8 and 1454.0 feet, except as provided in paragraph 5b and except for releases needed for downstream conservation requirements, shall be construed as a flood control operation and releases will be determined by the District Commander. Instructions issued by the District Commander for such flood control operation may be issued simultaneously to operating personnel and the Area Manager or the authorized representative; however, they normally will be issued to operating personnel through the Area Manager or the authorized representative.

a. Flood Control Regulation. Jamestown Dam will be operated in coordination with the Corps of Engineers' Pipestem Dam by the District Commander for flood control as explained in Chapter 7 of the Jamestown Dam and Reservoir Water Control Manual. The flood control plan for the joint regulation of Pipestem and Jamestown Reservoirs was developed according to Flexible Plan B, which was the preferred regulation plan as outlined in the report Jamestown Reservoir and Pipestem Reservoir, Water Control Plan Review and Update, dated July 2000. This plan is flexible and is designed to allow the water control managers to make adjustments based on hydrologic

conditions in the James River Basin both upstream and downstream of the reservoirs.

Specific objectives in close proximity to the dams and reservoirs include: reducing flood damages in the city of Jamestown, minimizing impacts at Arrowwood National Wildlife Refuge, and maintaining dam safety at Jamestown and Pipestem Dams. Downstream objectives include: reducing agricultural flood damages downstream from the city of Jamestown and reducing the adverse effects of high downstream flows in the states of North Dakota and South Dakota and on the refuges at Dakota Lake and Sand Lake. Achieving these objectives is accomplished by evaluating conditions both upstream and downstream of the reservoirs, determining a total release rate, and giving priority to releasing water to one reservoir or the other depending on this evaluation. Conditions each year will be evaluated in the spring and agency meetings conducted. The plan selected for that particular year will be dependent primarily on the amount of the forecasted runoff volume into the reservoirs and on the stated objectives of the agencies for that year. As the year progresses the selected regulation plan can be modified to meet the management objectives and considerations described in the Jamestown Dam and Reservoir Water Control Manual and changing basin hydrologic conditions.

In order to meet the management objectives and considerations, regulation guidelines have been developed for the type of flow year (calendar year) that is forecasted to assist in preparing an annual operating plan. The type of flow year is classified into one of three categories: low flow years, medium flow years, and high flow years. The flow category is based on the total combined forecasted annual inflow volume for both Jamestown and Pipestem Reservoirs for the calendar year. The forecasted annual inflow volume is normally prepared in the late February to late March time frame just prior to snowmelt beginning in the Northern Great Plains. This forecast represents the spring snowmelt volume plus average rainfall runoff volume for the remainder of the year.

Arrowwood National Wildlife Refuge (NWR), constructed prior to Jamestown Dam, is located just upstream of the permanent pool at Jamestown Reservoir and within the flood control pool. When pool elevations in Jamestown Reservoir exceed 1431.0 feet, the ability to manage the water levels at Arrowwood NWR and meet habitat management objectives is adversely affected. As part of the Arrowwood National Wildlife Refuge Final Environmental Impact Statement, September 1997, a bypass

channel was constructed to allow water to bypass lakes or be moved from lake to lake within the refuge, but the ability to move water within the bypass channel is heavily impacted by flood storage in Jamestown Reservoir. By maintaining a pool level at or below elevation 1431.0 feet by June 1, Arrowwood NWR has the ability to manage the four refuge pools at target levels and pass minor inflows into the refuge downstream to Jamestown Reservoir. During years when forecasted inflow volumes are in the low and medium flow year category, flood control releases from Jamestown Reservoir shall be made with an objective to attain a reservoir pool level of 1431.0 feet by June 1.

A summary of the range of releases that can be expected for flood control regulation is shown on Table 1 (attached). This table is not to be used as the final guide in determining releases under real time conditions. Additional guidance in determining releases for each type of flow year is contained in Chapter 7 of the Jamestown Dam and Reservoir Water Control Manual.

b. Joint Use Storage Regulations. This plan of regulation contemplates that the entire flood control portion of the joint use storage zone (1429.8 to 1431.0 feet) will be available at the beginning of the spring runoff period for storage and regulation of flood inflows. In those years when the reservoir level rises above elevation 1429.8 feet as a result of spring runoff or summer rainstorms, reservoir regulation and subsequent evacuation of accumulated flood storage down to elevation 1431.0 feet will be governed by paragraph 5a. When storage is in the joint use zone, the Area Manager will be responsible for coordination of Arrowwood NWR interests with other conservation uses of the reservoir. Following the occurrence of the spring runoff until September 1, the joint use storage zone may be regulated by the Area Manager as necessary for conservation uses and to prevent adverse effects on Arrowwood Refuge. Releases determined by the Area Manager while storage is within the joint use zone shall not exceed the schedule specified in Chapter 7 of the Jamestown Dam and Reservoir Water Control Manual for flood storage regulation. The joint use space will be evacuated by the District Commander after September 1 in accordance with the schedule specified in Chapter 7 of the Jamestown Dam and Reservoir Water Control Manual.

6. When the reservoir level is in the surcharge or conservation pools, the District Commander may make recommendations to the Area Manager for regulation in the interest of flood control, but such recommendations shall not be considered mandatory.

7. Integrated Regulation of All Flood Control Reservoirs in Missouri River Basin. Releases from Jamestown Reservoir eventually flow into the Missouri River just downstream of Gavins Point Reservoir, one of six Missouri River mainstem reservoirs. As per the Missouri River Mainstem Reservoir System Master Water Control Manual, Revised March, 2006, paragraph 7-04.23, "When tributary reservoir regulation affects Missouri River flood flows or navigation on the Missouri River, tributary reservoir regulation will, however, become a direct concern of the RCC [now known as Missouri River Basin Water Management, formerly known as the Reservoir Control Center]. During such periods, the RCC will issue pertinent tributary reservoir regulating instructions so that flood damages may be held to a minimum through integrated regulation of all flood control reservoirs in the Missouri River basin." Additionally, as per Section 208.11 of 33 CFR Chapter II, "The water control plan is subject to temporary modification by the Corps of Engineers if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be confirmed in writing the same day to the project owner and shall include justification for the action." As a result of these requirements, during large floods on the Missouri River mainstem reservoirs, releases of flood storage in Jamestown Reservoir may be adjusted in order to meet basin-wide flood control goals of the Missouri River system. In the case of Jamestown Reservoir, requests for modification will be made to the Reservoir and River Operations Branch, Great Plains Regional Office, Bureau of Reclamation in Billings, MT. Requests should be made via conference call or email, and confirmed via email the same day.

8. Collection and Assembly of Hydrologic Data and Reporting Arrangements. Available reports from precipitation and streamflow stations pertinent to the operation of Jamestown Reservoir which are collected by either party to this agreement will be relayed to the other by the most expeditious means of communications, under such detailed arrangements as may be made from time to time.

9. Elevation Datums. In this document, elevations for Jamestown Reservoir levels and project drawings are based on the Project Datum (PD), which for Jamestown Dam is close to the NGVD29 datum. See paragraph 1-03 of the Jamestown Dam and Reservoir Water Control Manual for additional information on elevation datums.

10. Design Limitations. It is recognized that any changes in the discharge characteristics of the outlet works resulting from reallocation of storage capacities, or for any other reason, which otherwise are mutually acceptable to the Corps of Engineers and the Bureau of Reclamation, must be approved by the Director of Design and Construction of the Bureau of Reclamation. It is further recognized, in connection with subparagraph d-9 of the Flood Control Regulations (Exhibit 1), that the upper half of the flood control storage capacity will be required for routing the inflow design flood. Hence, whenever less than 96,000 acre-feet of the flood storage capacity remains unfilled releases shall be made with the objective of evacuating this 96,000 acre-feet of capacity prior to July 1, or as soon thereafter as practicable. During this evacuation, releases will normally not exceed the rates specified in Table 1.

11. Gate Changes. Directives for flood control operations at Jamestown Dam are normally issued to the Bureau of Reclamation by the Omaha District Water Control and Water Quality Section. There may be times when communications may fail during a period of flood control operations and orders to make gate changes at Jamestown Dam cannot be issued by the Omaha District Water Control and Water Quality Section, and timely changes in release rates are essential for efficient flood control operations. Therefore, it is agreed that in times of emergency when the Omaha District Water Control and Water Quality Section in Omaha cannot be contacted and a gate change at Jamestown Dam is necessary, the dam tender at Pipestem Dam is authorized to instruct the Bureau of Reclamation to make the necessary gate changes at Jamestown Dam in accordance with schedules described in the Standing Instructions to Dam Tender of the Jamestown Dam and Reservoir Water Control Manual, and if the Bureau of Reclamation does not have personnel available or cannot be contacted, the Pipestem dam tender is authorized to make the gate changes.

[redacted]

Colonel, Corps of Engineers
District Commander

23 NOV 2015
(Date)

Regional Director
Great Plains Regions

DECEMBER 14, 2015
(Date)

Table 1
JAMESTOWN AND PIPESTEM RESERVOIRS
FLOOD CONTROL REGULATION
SUMMARY OF THE RANGE OF RELEASES FOR EACH TYPE OF FLOW YEAR

NOTE: This table is not to be used as the final guide in determining releases under real time conditions. For additional guidance in determining releases, consult the detailed discussion Chapter 7 of the *Jamestown Dam and Reservoir WCM.*

Footnote	Type of Flow Year	Forecasted Calendar Year Inflow Volume (af)	Typical Peak Annual Reservoir Levels		Normal Maximum Release		Normal Maximum Combined Release (cfs)
			Jamestown Pool Level (feet NGVD29)	Pipestem Pool Level (feet LPD)	Jamestown Reservoir (cfs)	Pipestem Reservoir (cfs)	
1.	High	>160,000	Above 1445.4	Above 1489.0	1,200-1,800	1,200-1,800	1,800
2.	High	>160,000	1440.0-1445.4	1478.2-1489.0	750-1,200	750-1,200	750-1,800
3.	High	>160,000	Below 1440.0	1478.2-1489.0	450-750	750-1,200	750-1,200
4.	Medium	160,000 – 90,000	Below 1440.0	Below 1478.2	450	450	450-750
5.	Low	90,000 - 0	Below 1433.0	Below 1460.0	200	120	200

Footnotes:

1. Combined release of 1,800 cfs. Release proportion coming out of Jamestown and Pipestem is based primarily on the percentage of flood control storage occupied at each reservoir.
2. Use 750 to 1,800 cfs release option. Release 750 to 1,800 cfs combined with Jamestown releasing from 750 cfs at the low end (1440.0 feet NGVD29) increasing to 1,200 cfs at the high end (1445.4 feet NGVD29). The release from Pipestem will depend on the release from Jamestown and also on the pool level at Pipestem. For example, if both Jamestown and Pipestem are near the upper end of the pool ranges specified, Jamestown release would be near 1,200 cfs and Pipestem would be near 600 cfs for a combined 1,800 cfs release. If both pools are near the low end of the specified pool range, the combined release would be near 750 cfs. If Pipestem is near the upper end (1489 feet LPD) and Jamestown is near the low end (1440 feet NGVD29), the combined release would be closer to 1,200 cfs with the greater part of the release coming from Pipestem.
3. Use 750 to 1,200 cfs release option. Release a combined total of 750 to 1,200 cfs distributed between both projects until the pool level at Pipestem is below 1478.2 feet LPD, then either maintain the higher release (see "ADDITIONAL NOTES" below) or reduce the combined release to a lesser discharge until Jamestown reaches 1431 feet NGVD29 and Pipestem reaches 1,450 feet LPD. Then evacuate the remainder of the storage by November 1.
4. Use 450 to 750 cfs release option. Release up to a combined 750 cfs until the 1431 feet NGVD29 target is met at Jamestown and until Pipestem reaches a level where a release of 50 cfs is sufficient to evacuate Pipestem to 1442.5 feet LPD by September 1. Then evacuate the remainder of storage in the flood control pool at Jamestown Reservoir to 1429.8 feet NGVD29 by November 1.
5. Use constant release option. Evacuate Jamestown first to 1431 feet NGVD29 by June 1, and then evacuate Pipestem to 1442.5 feet LPD by September 1, and then Jamestown to 1429.8 feet NGVD29 by November 1.

ADDITIONAL NOTES:

- The forecasted flow volume is the total combined forecasted annual inflow for both Jamestown and Pipestem for the calendar year. The forecasted inflow is derived from the spring snowmelt volume plus average rainfall runoff volume for the remainder of the year. If above normal runoff from rainfall occurs, releases may change from what are shown in the table.
- Once the maximum release for the year has been reached that release may be continued even as the pool drops through the different elevation zones indicated by the above table.
- During the winter season (November to beginning of spring runoff) releases should not cause the flow to exceed 100 cfs at Jamestown.

EXHIBIT 1

33 CFR Chapter II Part 208, Flood Control Regulations, Section 208.11

This exhibit contains text and table from 33 CFR Chapter II, Part 208, Flood Control Regulations, Section 208.11, Regulations for use of storage allocated for flood control or navigation and/or project operation at reservoirs subject to prescription of rules and regulations by the Secretary of the Army in the interest of flood control and navigation (7-1-12 Edition). In this document, the text of Section 208.11 has been reformatted (indented) for clarity, and the List of Projects table at the end of document has been shortened to only include reservoirs within the Missouri River basin. Section 208.11 should be reviewed on an annual basis to identify any changes and these changes should be included in an updated exhibit to this manual. Updated editions of Section 208.11 can be found at the following website: http://www.ecfr.gov.

Exhibit 1

33 CFR Chapter II Part 208 Flood Control Regulations, Section 208.11 (7-1-12 Edition), Regulations for use of storage allocated for flood control or navigation and/or project operation at reservoirs subject to prescription of rules and regulations by the Secretary of the Army in the interest of flood control and navigation.

(a) *Purpose.* This regulation prescribes the responsibilities and general procedures for regulating reservoir projects capable of regulation for flood control or navigation and the use of storage allocated for such purposes and provided on the basis of flood control and navigation, except projects owned and operated by the Corps of Engineers; the International Boundary and Water Commission, United States and Mexico; and those under the jurisdiction of the International Joint Commission, United States, and Canada, and the Columbia River Treaty. The intent of this regulation is to establish an understanding between project owners, operating agencies, and the Corps of Engineers.

(b) *Responsibilities.* The basic responsibilities of the Corps of Engineers regarding project operation are set out in the cited authority and described in the following paragraphs:

(1) Section 7 of the Flood Control Act of 1944 (58 Stat. 890, 33 U.S.C. 709) directs the Secretary of the Army to prescribe regulations for flood control and navigation in the following manner:

> Hereafter, it shall be the duty of the Secretary of War to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds provided on the basis of such purposes, and the operation of any such project shall be in accordance with such regulations: Provided, That this section shall not apply to the Tennessee Valley Authority, except that in case of danger from floods on the lower Ohio and Mississippi Rivers the Tennessee Valley Authority is directed to regulate the release of water from the Tennessee River into the Ohio River in accordance with such instructions as may be issued by the War Department

(2) Section 9 of Public Law 436–83d Congress (68 Stat. 303) provides for the development of the Coosa River, Alabama and Georgia, and directs the Secretary of the Army to prescribe rules and regulations for project operation in the interest of flood control and navigation as follows:

> The operation and maintenance of the dams shall be subject to reasonable rules and regulations of the Secretary of the Army in the interest of flood control and navigation. NOTE: This Regulation will also be applicable to dam and reservoir projects operated under provisions of future legislative acts wherein the Secretary of the Army is directed to prescribe rules and regulations in the interest of flood control and navigation. The Chief of Engineers, U.S. Army Corps of Engineers, is designated the duly authorized representative of the Secretary of the Army to exercise the authority set out in the Congressional Acts. This Regulation will normally be implemented by letters of understanding between the Corps of Engineers and project owner and will incorporate the provisions of such letters of understanding prior to the time construction renders the project capable of significant impoundment of water. A water control agreement signed by both parties will follow when deliberate impoundment first begins or at such time as the responsibilities of any Corps-owned projects may be transferred to another entity. Promulgation of this Regulation for a given project will occur at such time as the name of the project appears in the FEDERAL REGISTER in accordance with the requirements of paragraph 6k. When agreement on a water

control plan cannot be reached between the Corps and the project owner after coordination with all interested parties, the project name will be entered in the FEDERAL REGISTER and the Corps of Engineers plan will be the official water control plan until such time as differences can be resolved.

(3) Federal Energy Regulatory Commission (FERC), formerly Federal Power Commission (FPC), Licenses.

(i) Responsibilities of the Secretary of the Army and/or the Chief of Engineers in FERC licensing actions are set forth in reference 3c above and pertinent sections are cited herein. The Commission may further stipulate as a licensing condition, that a licensee enter into an agreement with the Department of the Army providing for operation of the project during flood times, in accordance with rules and regulations prescribed by the Secretary of the Army.

(A) Section 4(e) of the Federal Power Act requires approval by the Chief of Engineers and the Secretary of the Army of plans of dams or other structures affecting the navigable capacity of any navigable waters of the United States, prior to issuance of a license by the Commission as follows:

> The Commission is hereby authorized and empowered to issue licenses to citizens * * * for the purpose of constructing, operating and maintaining dams, water conduits, reservoirs, powerhouses, transmission lines, or other project works necessary or convenient for the development and improvement of navigation and for the development, transmission, and utilization of power across, along, from or in any of the streams or other bodies of water over which Congress has jurisdiction * * * Provided further, That no license affecting the navigable capacity of any navigable waters of the United States shall be issued until the plans of the dam or other structures affecting navigation have been approved by the Chief of Engineers and the Secretary of the Army.

(B) Sections 10(a) and 10(c) of the Federal Power Act specify conditions of project licenses including the following:

(1) Section 10(a). "That the project adopted * * * shall be such as in the judgment of the Commission will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of waterpower development, and for other beneficial public uses * * *."

(2) Section 10(c). "That the licensee shall * * * so maintain and operate said works as not to impair navigation, and shall conform to such rules and regulations as the Commission may from time to time prescribe for the protection of life, health, and property * * *."

(C) Section 18 of the Federal Power Act directs the operation of any navigation facilities built under the provision of that Act, be controlled by rules and regulations prescribed by the Secretary of the Army as follows:

> The operation of any navigation facilities which may be constructed as part of or in connection with any dam or diversion structure built under the provisions of this Act, whether at the expense of a licensee hereunder or of the United States, shall at all times be controlled by such reasonable rules and regulations in the interest of navigation; including the control of the pool caused by such dam or diversion structure as may be made from time to time by the Secretary of the Army, * * *.

(ii) Federal Power Commission Order No. 540 issued October 31, 1975, and published November 7, 1975 (40 FR 51998), amending § 2.9 of the Commission's General Policy and Interpretations prescribed Standardized Conditions (Forms) for Inclusion in Preliminary Permits and Licenses Issued Under part I of the Federal Power Act. As an example, Article 12 of Standard Form L–3, titled: ''Terms and Conditions of License for Constructed Major Projects Affecting Navigable Waters of the United States,'' sets forth the Commission's interpretation of appropriate sections of the Act, which deal with navigation aspects, and attendant responsibilities of the Secretary of the Army in licensing actions as follows:

> The United States specifically retains and safeguards the right to use water in such amount, to be determined by the Secretary of the Army, as may be necessary for the purposes of navigation on the navigable waterway affected; and the operations of the Licensee, so far as they affect the use, storage and discharge from storage of waters affected by the license, shall at all times be controlled by such reasonable rules and regulations as the Secretary of the Army may prescribe in the interest of navigation, and as the Commission may prescribe for the protection of life, health, and property, * * * and the Licensee shall release water from the project reservoir at such rate * * * as the Secretary of the Army may prescribe in the interest of navigation, or as the Commission may prescribe for the other purposes hereinbefore mentioned.

(c) *Scope and terminology.* This regulation applies to Federal authorized flood control and/or navigation storage projects, and to non-Federal projects which require the Secretary of the Army to prescribe regulations as a condition of the license, permit or legislation, during the planning, design and construction phases, and throughout the life of the project. In compliance with the authority cited above, this regulation defines certain activities and responsibilities concerning water control management throughout the Nation in the interest of flood control and navigation. In carrying out the conditions of this regulation, the owner and/or operating agency will comply with applicable provisions of Pub. L. 85–624, the Fish and Wildlife Coordination Act of 1958, and Pub. L. 92–500, the Federal Water Pollution Control Act Amendments of 1972. This regulation does not apply to local flood protection works governed by § 208.10, or to navigation facilities and associated structures which are otherwise covered by part 207 (Navigation Regulations) of title 33 of the code. Small reservoirs, containing less than 12,500 acre-feet of flood control or navigation storage, may be excluded from this regulation and covered under § 208.10, unless specifically required by law or conditions of the license or permit.

(1) The terms *reservoir* and *project* as used herein include all water resource impoundment projects constructed or modified, including natural lakes, that are subject to this regulation.

(2) The term *project owner* refers to the entity responsible for maintenance, physical operation, and safety of the project, and for carrying out the water control plan in the interest of flood control and/or navigation as prescribed by the Corps of Engineers. Special arrangements may be made by the project owner for ''operating agencies'' to perform these tasks.

(3) The term *letter of understanding* as used herein includes statements which consummate this regulation for any given project and define the general provisions or conditions of the local sponsor, or owner, cooperation agreed to in the authorizing legislative document, and the requirements for compliance with section 7 of the 1944 Flood Control Act, the Federal Power Act or other special congressional act. This information will be specified in the water control plan and manual. The letter of understanding will be signed by a duly authorized representative of the Chief of Engineers and the project owner. A ''field working agreement'' may be substituted for a letter of understanding, provided that the specified minimum requirements of the latter, as stated above, are met.

(4) The term *water control agreement* refers to a compilation of water control criteria, guidelines, diagrams, release schedules, rule curves and specifications that basically govern the use of reservoir storage space allocated for flood control or navigation and/or release functions of a water control project for these purposes. In general, they indicate controlling or limiting rates of discharge and storage space required for flood control and/or navigation, based on the runoff potential during various seasons of the year.

(5) For the purpose of this regulation, the term *water control plan* is limited to the plan of regulation for a water resources project in the interest of flood control and/or navigation. The water control plan must conform with proposed allocations of storage capacity and downstream conditions or other requirements to meet all functional objectives of the particular project, acting separately or in combination with other projects in a system.

(6) The term *real-time* denotes the processing of current information or data in a sufficiently timely manner to influence a physical response in the system being monitored and controlled. As used herein the term connotes * * * the analyses for and execution of water control decisions for both minor and major flood events and for navigation, based on prevailing hydrometeorological and other conditions and constraints, to achieve efficient management of water resource systems.

(d) *Procedures—*

(1) *Conditions during project formulation.* During the planning and design phases, the project owner should consult with the Corps of Engineers regarding the quantity and value of space to reserve in the reservoir for flood control and/or navigation purposes, and for utilization of the space, and other requirements of the license, permit or conditions of the law. Relevant matters that bear upon flood control and navigation accomplishment include: Runoff potential, reservoir discharge capability, downstream channel characteristics, hydrometeorological data collection, flood hazard, flood damage characteristics, real estate acquisition for flowage requirements (fee

and easement), and resources required to carry out the water control plan. Advice may also be sought on determination of and regulation for the probable maximum or other design flood under consideration by the project owner to establish the quantity of surcharge storage space, and freeboard elevation of top of dam or embankment for safety of the project.

(2) *Corps of Engineers involvement.* If the project owner is responsible for real-time implementation of the water control plan, consultation and assistance will be provided by the Corps of Engineers when appropriate and to the extent possible. During any emergency that affects flood control and/or navigation, the Corps of Engineers may temporarily prescribe regulation of flood control or navigation storage space on a day-to-day (real-time) basis without request of the project owner. Appropriate consideration will be given for other authorized project functions. Upon refusal of the project owner to comply with regulations prescribed by the Corps of Engineers, a letter will be sent to the project owner by the Chief of Engineers or his duly authorized representative describing the reason for the regulations prescribed, events that have transpired, and notification that the project owner is in violation of the Code of Federal Regulations. Should an impasse arise, in that the project owner or the designated operating entity persists in noncompliance with regulations prescribed by the Corps of Engineers, measures may be taken to assure compliance.

(3) *Corps of Engineers implementation of real-time water control decisions.* The Corps of Engineers may prescribe the continuing regulation of flood control storage space for any project subject to this regulation on a day-to-day (real-time) basis. When this is the case, consultation and assistance from the project owner to the extent possible will be expected. Special requests by the project owner, or appropriate operating entity, are preferred before the Corps of Engineers offers advice on real-time regulation during surcharge storage utilization.

(4) *Water control plan and manual.* Prior to project completion, water control managers from the Corps of Engineers will visit the project and the area served by the project to become familiar with the water control facilities, and to insure sound formulation of the water control plan. The formal plan of regulation for flood control and/or navigation, referred to herein as the water control plan, will be developed and documented in a water control manual prepared by the Corps of Engineers. Development of the manual will be coordinated with the project owner to obtain the necessary pertinent information, and to insure compatibility with other project purposes and with surcharge regulation. Major topics in the manual will include: Authorization and description of the project, hydrometeorology, data collection and communication networks, hydrologic forecasting, the water control plan, and water resource management functions, including responsibilities and coordination for water control decision-making. Special instructions to the dam tender or reservoir manager on data collection, reporting to higher Federal authority, and on procedures to be followed in the event of a communication outage under emergency conditions, will be prepared as an exhibit in the manual. Other exhibits will include copies of this regulation, letters of understanding consummating this regulation, and the water control agreements. After approval by the Chief of Engineers or his duly authorized representative, the manual will be furnished the project owner.

(5) *Water control agreement.*

(i) A water control diagram (graphical) will be prepared by the Corps of Engineers for each project having variable space reservation for flood control and/or navigation during the year; e.g., variable seasonal storage, joint-use space, or other rule curve designation. Reservoir inflow parameters will be included on the diagrams when appropriate. Concise notes will be included on the diagrams prescribing the use of storage space in terms of release schedules, runoff, nondamaging or other controlling flow rates downstream of the damsite, and other major factors as appropriate. A water control release schedule will be prepared in tabular form for projects that do not have variable space reservation for flood control and/or navigation. The water control diagram or release schedule will be signed by a duly authorized representative of the Chief of Engineers, the project owner, and the designated operating agency, and will be used as the basis for carrying out this regulation. Each diagram or schedule will contain a reference to this regulation.

(ii) When deemed necessary by the Corps of Engineers, information given on the water control diagram or release schedule will be supplemented by appropriate text to assure mutual understanding on certain details or other important aspects of the water control plan not covered in this regulation, on the water control diagram or in the release schedule. This material will include clarification of any aspects that might otherwise result in unsatisfactory project performance in the interest of flood control and/or navigation. Supplementation of the agreement will be necessary for each project where the Corps of Engineers exercises the discretionary authority to prescribe the flood control regulation on a day-today (real-time) basis. The agreement will include delegation of the responsibility. The document should also cite, as appropriate, section 7 of the 1944 Flood Control Act, the Federal Power Act and/or other congressional legislation authorizing construction and/or directing operation of the project.

(iii) All flood control regulations published in the FEDERAL REGISTER under this section (part 208) of the code prior to the date of this publication which are listed in § 208.11(e) are hereby superseded.

(iv) Nothing in this regulation prohibits the promulgation of specific regulations for a project in compliance with the authorizing acts, when agreement on acceptable regulations cannot be reached between the Corps of Engineers and the owner.

(6) *Hydrometeorological instrumentation.* The project owner will provide instrumentation in the vicinity of the damsite and will provide communication equipment necessary to record and transmit hydrometeorological and reservoir data to all appropriate Federal authorities on a real-time basis unless there are extenuating circumstances or are otherwise provided for as a condition of the license or permit. For those projects where the owner retains responsibility for real-time implementation of the water control plan, the owner will also provide or arrange for the measurement and reporting of hydrometeorological parameters required within and adjacent to the watershed and downstream of the damsite, sufficient to regulate the project for flood control and/or navigation in an efficient manner. When data collection stations outside the immediate vicinity of the damsite are required, and funds for installation, observation, and maintenance are

not available from other sources, the Corps of Engineers may agree to share the costs for such stations with the project owner. Availability of funds and urgency of data needs are factors which will be considered in reaching decisions on cost sharing.

(7) *Project safety.* The project owner is responsible for the safety of the dam and appurtenant facilities and for regulation of the project during surcharge storage utilization. Emphasis upon the safety of the dam is especially important in the event surcharge storage is utilized, which results when the total storage space reserved for flood control is exceeded. Any assistance provided by the Corps of Engineers concerning surcharge regulation is to be utilized at the discretion of the project owner, and does not relieve the owner of the responsibility for safety of the project.

(8) *Notification of the general public.* The Corps of Engineers and other interested Federal and State agencies, and the project owner will jointly sponsor public involvement activities, as appropriate, to fully apprise the general public of the water control plan. Public meetings or other effective means of notification and involvement will be held, with the initial meeting being conducted as early as practicable but not later than the time the project first becomes operational. Notice of the initial public meeting shall be published once a week for 3 consecutive weeks in one or more newspapers of general circulation published in each county covered by the water control plan. Such notice shall also be used when appropriate to inform the public of modifications in the water control plan. If no newspaper is published in a county, the notice shall be published in one or more newspapers of general circulation within that county. For the purposes of this section a newspaper is one qualified to publish public notices under applicable State law. Notice shall be given in the event significant problems are anticipated or experienced that will prevent carrying out the approved water control plan or in the event that an extreme water condition is expected that could produce severe damage to property or loss of life. The means for conveying this information shall be commensurate with the urgency of the situation. The water control manual will be made available for examination by the general public upon request at the appropriate office of the Corps of Engineers, project owner or designated operating agency.

(9) *Other generalized requirements for flood control and navigation.*

(i) Storage space in the reservoirs allocated for flood control and navigation purposes shall be kept available for those purposes in accordance with the water control agreement, and the plan of regulation in the water control manual.

(ii) Any water impounded in the flood control space defined by the water control agreement shall be evacuated as rapidly as can be safely accomplished without causing downstream flows to exceed the controlling rates; i.e., releases from reservoirs shall be restricted insofar as practicable to quantities which, in conjunction with uncontrolled runoff downstream of the dam, will not cause water levels to exceed the controlling stages currently in force. Although conflicts may arise with other purposes, such as hydropower, the plan or regulation may require releases to be completely curtailed in the interest of flood control or safety of the project.

(iii) Nothing in the plan of regulation for flood control shall be construed to require or allow dangerously rapid changes in magnitudes of releases. Releases will be made in a manner consistent with requirements for protecting the dam and reservoir from major damage during passage of the maximum design flood for the project.

(iv) The project owner shall monitor current reservoir and hydro- meteorological conditions in and adjacent to the watershed and downstream of the damsite, as necessary. This and any other pertinent information shall be reported to the Corps of Engineers on a timely basis, in accordance with standing instructions to the damtender or other means requested by the Corps of Engineers.

(v) In all cases where the project owner retains responsibility for real-time implementation of the water control plan, he shall make current determinations of: Reservoir inflow, flood control storage utilized, and scheduled releases. He shall also determine storage space and releases required to comply with the water control plan prescribed by the Corps of Engineers. The owner shall report this information on a timely basis as requested by the Corps of Engineers.

(vi) The water control plan is subject to temporary modification by the Corps of Engineers if found necessary in time of emergency. Requests for and action on such modifications may be made by the fastest means of communication available. The action taken shall be confirmed in writing the same day to the project owner and shall include justification for the action.

(vii) The project owner may temporarily deviate from the water control plan in the event an immediate short-term departure is deemed necessary for emergency reasons to protect the safety of the dam, or to avoid other serious hazards. Such actions shall be immediately reported by the fastest means of communication available. Actions shall be confirmed in writing the same day to the Corps of Engineers and shall include justification for the action. Continuation of the deviation will require the express approval of the Chief of Engineers, or his duly authorized representative.

(viii) Advance approval of the Chief of Engineers, or his duly authorized representative, is required prior to any deviation from the plan of regulation prescribed or approved by the Corps of Engineers in the interest of flood control and/or navigation, except in emergency situations provided for in paragraph (d)(9)(vii) of this section. When conditions appear to warrant a prolonged deviation from the approved plan, the project owner and the Corps of Engineers will jointly investigate and evaluate the proposed deviation to insure that the overall integrity of the plan would not be unduly compromised. Approval of prolonged deviations will not be granted unless such investigations and evaluations have been conducted to the extent deemed necessary by the Chief of Engineers, or his designated representatives, to fully substantiate the deviation.

(10) *Revisions.* The water control plan and all associated documents will be revised by the Corps of Engineers as necessary, to reflect changed conditions that come to bear upon flood control and

navigation, e.g., reallocation of reservoir storage space due to sedimentation or transfer of storage space to a neighboring project. Revision of the water control plan, water control agreement, water control diagram, or release schedule requires approval of the Chief of Engineers or his duly authorized representative. Each such revision shall be effective upon the date specified in the approval. The original (signed document) water control agreement shall be kept on file in the respective Office the Division Engineer, Corps of Engineers, Department of the Army, located at division offices throughout the continental USA. Copies of these agreements may be obtained from the office of the project owner, or from the office of the appropriate Division Engineer, Corps of Engineers.

(11) *Federal Register.* The following information for each project subject to section 7 of the 1944 Flood Control Act and other applicable congressional acts shall be published in the FEDERAL REGISTER prior to the time the projects becomes operational and prior to any significant impoundment before project completion or * * * at such time as the responsibility for physical operation and maintenance of the Corps of Engineers owned projects is transferred to another entity:

(i) Reservoir, dam, and lake names,

(ii) Stream, county, and State corresponding to the damsite location,

(iii) The maximum current storage space in acre-feet to be reserved exclusively for flood control and/or navigation purposes, or any multiple-use space (intermingled) when flood control or navigation is one of the purposes, with corresponding elevations in feet above mean sea level, and area in acres, at the upper and lower limits of said space,

(iv) The name of the project owner, and (v) Congressional legislation authorizing the project for Federal participation.

(e) *List of projects.* The following tables, "Pertinent Project Data—Section 208.11 Regulation," show the pertinent data for projects which are subject to this regulation. Note that the following tables were condensed to show only those projects within the Missouri River basin, which includes the Omaha District and Kansas City District of the Northwestern Division, Corps of Engineers.

LIST OF PROJECTS

[Missouri River Basin Non-Corps projects with Corps Regulation Requirements]

Project name[1] (1)	State (2)	County (3)	Stream[1] (4)	Project purpose[2] (5)	Storage 1000 AF (6)	Elev limits feet M.S.L. Upper (7)	Elev limits feet M.S.L. Lower (8)	Area in acres Upper (9)	Area in acres Lower (10)	Authorizing legis.[3] (11)	Proj. owner[4] (12)
Omaha District Projects											
Boysen Dam & Res	WY	Fremont	Wild R	F FEIQ EIQ	150.4 146.1 403.8	4732.2 4725.0 4717.0	4725.0 4717.0 4685.0	22170 19560 16960	19560 16960 9280	PL 78–534	USBR.
Canyon Ferry Dam & Lk	MT	Lewis Clark	Missouri R	F FEI EI	99.5 795.1 711.5	3800.0 3797.0 3770.0	3797.0 3770.0 3728.0	33535 32800 24125	32800 24125 11480	PL 78–534	USBR.
Clark Canyon Dam & Res	MT	Beaverhead	Beaverhead R	F FI I	79.1 50.4 126.1	5560.4 5546.1 5535.7	5546.1 5535.7 5470.6	5900 5160 4495	5160 4495 220	PL 78–534	USBR.
Glendo Dam & Res	WY	Platte	N Platte R	F EIM	271.9 454.3	4653.0 4635.0	4635.0 4570.0	17990 12370	12370 3130	PL 78–534	USBR.
Heart Butte Dm & Lk Tschida	ND	Grant	Heart R	F IQ	147.9 69.0	2094.5 2064.5	2064.5 2030.0	6580 3400	3400 810	PL 78–534	USBR.
Jamestown Dam & Res	ND	Stutsman	James R	F IQ	185.4 28.1	1454.0 1429.8	1429.8 1400.0	13210 2090	2090 160	PL 78–534	USBR.
Keyhole Dam & Res	WY	Crook	Belle Fourche R	F IQ	140.5 185.8	4111.5 4099.3	4099.3 4051.0	13730 9410	9410 820	PL 78–534	USBR.
Pactola Dam & Res	SD	Pennington	Rapid Cr	F IM	43.1 55.0	4621.5 4580.2	4580.2 4456.1	1230 860	860 100	PL 78–534	USBR.
Shadehill Dam & Res	SD	Perkins	Grand R	F IQ	218.3 80.9	2302.0 2271.9	2271.9 2250.8	9900 4800	4800 2800	PL 78–534	USBR.
Tiber Dam & Res	MT	Libert Toole	Marias R	F FIQ IQ	400.9 268.0 121.7	3012.5 2993.0 2976.0	2993.0 2976.0 2966.4	23150 17890 13790	17890 13790 11710	PL 78–534	USBR.
Yellowtail Dam & Bighorn Lk	MT	Big Horn	Bighorn R	F FEIQ EIQ	258.3 240.3 336.1	3657.0 3640.0 3614.0	3640.0 3614.0 3547.0	17280 12600 6915	12600 6915 4150	PL 78–534	USBR PUD
Kansas City District Projects											
Bonny Dam & Res	CO	Yuma	S Fork Republic R	F ICR	128.2 39.2	3710.0 3672.0	3672.0 3638.0	5036 2042	2042 331	PL 78–534 PL 79–732	USBR.
Cedar Bluff Dam & Res	KS	Trego	Smoky Hill R	F IMCR	191.9 149.8	2166.0 2144.0	2144.0 2107.8	10790 6869	6869 2086	PL 78–534	USBR.
Enders Dam & Res	NE	Chase	Frenchman Cr	F ICR	30.0 34.5	3127.0 3112.3	3112.3 3082.4	2405 1707	1707 658	PL 78–534 PL 84–505	USBR.
Glen Elder Dam & Waconda Lk	KS	Mitchel	Solomon R	F IM	722.3 204.8	1488.3 1455.6	1455.6 1428.0	33682 12602	12602 3341	PL 78–534 PL 79–526	USBR.
Kirwin Dam & Res	KS	Phillips	N Fork Solomon R	F ICR	215.1 89.6	1757.3 1729.2	1729.3 1697.0	10640 5080	5080 1010	PL 78–534 PL 79–732; PL 79–526	USBR.
Lovewell Dam & Res	KS	Jewell	White Rock Cr	F ICR	50.5 24.9	1595.3 1582.6	1582.6 1571.7	5025 2986	2986 1704	PL 78–534 PL 79–732	USBR.
Medicine Cr Dam Harry Strunk Lk	NE	Frontier	Medicine Cr	F ICR	52.7 26.8	2386.2 2366.1	2366.1 2343.0	3483 1840	1840 701	PL 78–534 PL 84–505	USBR.
Norton Dam & Kieth Sebelius Lk	KS	Norton	Prairie Dog Cr	F IMRC	98.8 30.7	2331.4 2304.3	2304.3 2280.4	5316 2181	2181 587	PL 78–534 PL 79–526 PL 79–732	USBR.
Red Willow Dam Hugh Butler Lk	NE	Frontier	Red Willow Cr	F IRC	48.9 27.3	2604.9 2581.8	2581.8 2558.0	2682 1629	1629 787	PL 78–534 PL 85–783 PL 84–505	USBR.
Trenton Dam & Res	NB	Hitchcock	Republican R	F IRC	134.1 99.8	2773.0 2752.0	2752.0 2720.0	7940 4922	4922 1572	PL 78–534 PL 84–505	USBR.
Webster Dam & Res	KS	Rocks	S Fork Solomon R	F IRC	183.4 72.1	1923.7 1892.5	1892.5 1860.0	8480 3772	3772 906	PL 78–534 PL 79–526 PL 79–732	USBR

[1]Cr—Creek; CS—Control Structure; Div—Diversion; DS—Drainage Structure; FG—Floodgate; Fk—Fork; GIWW—Gulf Intercoastal Waterway; Lk—Lake; L&D—Lock & Dam; PS—Pump Station; R—River; Res—Reservoir
[2]F—Flood Control; N—Navigation; P—Corps Hydropower; E—Non Corps Hydropower; I—Irrigation; M—Municipal and/or Industrial Water Supply; C—Fish and Wildlife Conservation; A—Low Flow Augmentation or Pollution Abatement; R—Recreation; Q—Water Quality or Silt Control
[3]FCA—Flood Control Act; FERC—Federal Energy Regulatory Comm; HD—House Document; PL—Public Law; PW—Public Works; RHA—River & Harbor Act; SD—Senate Document; WSA—Water Supply Act
[4]Appl Pwr—Appalachian Power; Chln PUD—Chelan Cnty PUD 1; CLPC—CT Light & Power Co; Dgls PUD—Douglas Cnty PUD 1; DWR—Department of Water Resources; EB-MUD—East Bay Municipal Utility Dist; GRD—Grand River Dam Auth; Grnt PUD—Grant Cnty PUD 2; Hnbl—city of Hannibal; M&T Irr—Modesto & Turlock Irr; Mrcd Irr—Merced Irr; NEPC—New England Power Co; Pgnt P&L—Pugent Sound Power & Light; Ptmc Comm—Upper Potomac R Comm; Rclm B—Reclamation Board; Rkfd—city of Rockford; Sttl—city of Seattle; Tac—City of Tacoma; Vale USBR—50% Vale Irr 50% USBR; WF&CWID—City of Wichita Falls and Wichita Cnty Water Improvement District No. 2; WMEC—Western MA Electric Co; YCWA—Yuba City Water Auth; Yolo FC&W—Yolo Flood Control & Water Conserv Dist

(Sec. 7, Pub. L. 78–534, 58 Stat. 890 (33 U.S.C. 709); the Federal Power Act, 41 Stat. 1063 (16 U.S.C. 791(A)); and sec. 9, Pub. L. 83–436, 68 Stat. 303)

[43 FR 47184, Oct. 13, 1978, as amended at 46 FR 58075, Nov. 30, 1981; 55 FR 21508, May 24, 1990]

EXHIBIT 3

JAMESTOWN DAM AND RESERVOIR

STANDING INSTRUCTIONS TO DAM TENDER

STANDING INSTRUCTIONS TO DAM TENDER
JAMESTOWN DAM WATER CONTROL MANUAL

TABLE OF CONTENTS

TABLES

SUPPORTING MATERIAL CONTAINED IN WATER CONTROL MANUAL

Directory of Regulation Personnel
Table 2-11. Outlet Works Discharge Tables
Table 5-3. Area in Acres
Table 5-4. Capacity in Acre-Feet
Exhibit 4. Area in Acres (Detailed)
Capacity in Acre-Feet (Detailed)
Plate 4-16. Rating Curve for Jamestown (James River)
Plate 4-19. Rating Curve for LaMoure (James River)

STANDING INSTRUCTIONS TO DAM TENDER FOR FLOOD CONTROL REGULATION OF JAMESTOWN DAM AND RESERVOIR

Section A. General / Introductory

A-1. Purpose of Instructions. It is the purpose of these instructions to set forth the responsibilities of the Dam Tender and procedures to be followed for flood control regulation of Jamestown Dam and Reservoir, located on the James River just upstream of the City of Jamestown, North Dakota. The Dam Tender and backups to the Dam Tender will familiarize themselves with these instructions and place them in a readily accessible place for reference and emergency use.

A-2. Purpose of Project. The Bureau of Reclamation (Reclamation) has constructed Jamestown Dam and Reservoir and is responsible for operation and management of the dam and reservoir. The dam and reservoir were constructed under authorization of Section 9 of the Flood Control Act of 1944. Under Section 7 of the Flood Control Act of 1944, the Corps of Engineers (Corps) is directed to regulate all federally constructed projects when water is in the flood control zone. Current storage allocations are shown in the following Table 1.

Table 1. Jamestown Reservoir Pool Elevations and Storage Allocations.

Zone	Pool Elevations (feet)	Storage Allocations (af)
Surcharge	1454.0 to 1464.4	158,860
Flood Control	1431.0 to 1454.0	189,468
Joint Use	1428.0 to 1431.0	6,262
Conservation	1400.0 to 1428.0	23,934
Dead Storage	1390.0 to 1400.0	292

A-3. Responsibilities. The Department of the Interior, acting through Reclamation, represented by the Regional Director, Billings, Montana, who in turn is represented by the Area Manager, Dakotas Area Office, Bismarck, North Dakota, hereinafter referred to as the “Area Manager”, is responsible for overall operation and management of Jamestown Dam and Reservoir. The Dam Tender for Jamestown Reservoir is a member of the Area Manager’s technical staff, with an office located at Reclamation’s Dakotas Area Office in Bismarck, North Dakota. Since Jamestown Reservoir is located approximately 100 miles east of Bismarck, Reclamation will also utilize two individuals that are located in the City of Jamestown for making gate changes during periods when the official Dam Tender is unable to make the gate change in a timely manner. The first point of contact, should the official Dam Tender not be available to make a gate change, is the staff member of the Stutsman County Park Board, who is responsible for overseeing operation of public facilities at Jamestown Reservoir. A secondary point of contact is the Corps’ Dam Tender for nearby Pipestem Dam. Both of these individuals are trained in the proper protocol for making changes in releases and both should be familiar with the water control plan and the standing instructions to Dam Tender for Jamestown Dam. While either of these individuals can execute a gate change at

Jamestown Dam, the primary point of contact responsible for on-site operation should always be Reclamation's official Dam Tender. Responsibilities of the Dam Tender and procedures to be followed for flood control regulation of Jamestown Reservoir are given in the following paragraphs. Flood control regulation of Jamestown Reservoir during periods when the reservoir water surface is within the exclusive flood control pool, between elevation 1431.0 and 1454.0 feet, and within the portion of joint-use pool between 1429.8 and 1431.0 feet is the responsibility of the Department of the Army, acting through the Corps, represented by the District Engineer, Omaha District, Omaha, Nebraska, who in turn is represented by the Chief of the Omaha District WCWQS, Hydrologic Engineering Branch, Omaha, Nebraska, hereinafter referred to as "Omaha District WCWQS".

The instructions given herein are to be followed at all times when the pool is within the flood control range unless otherwise directed by special instructions from the Omaha District WCWQS for flood control, or by special instructions from the Area Manager's office for conservation releases.

A-4. Telephone Directory. The directory of phone numbers taken from the Water Control Manual is attached at the back of this document as Table 4. A more extensive listing is shown on pages v and vi in the Water Control Manual.

Section B. Normal Conditions

B-1. Channels for Issuing Instructions. The Omaha District WCWQS is the designated unit of the District Engineer's office to prepare and issue directions concerning flood control regulation of Jamestown Reservoir. While the Field Working Agreement between the Corps and Reclamation allow the Corps to furnish simultaneous directives to the Dam Tender and the Area Manager, directives will usually be forwarded to the Dam Tender or the backups via the Area Manager's office. The Dam Tender will execute the directives upon receipt from the Area Manager, or the Omaha District WCWQS. During regular work hours, the directives will be prepared in the Omaha District WCWQS in writing and be phoned to the Area Manager's office (and the Dam Tender if appropriate). A follow-up written copy of the directives will be submitted to personnel of the Area Manager's and Regional Director's Office by email. When it becomes necessary to issue regulation directives during non-office hours, the directives will be issued by personnel of the Omaha District WCWQS designated for this purpose. During non-office hours, directives will be issued verbally by phone to personnel of the Area Manager's office. Directives issued verbally will be followed up in written form to the Area Manager's office and Regional Director's office at the earliest opportunity. When the Dam Tender has initiated execution of a directive, he will notify the Omaha District WCWQS directly or through the Area Manager's office to that effect. If conditions prevent the execution of a directive, the Omaha District WCWQS will be notified immediately and be informed of the corrective measures required before execution of the directive.

B-2. Communication Facilities. Phone calls will normally be used for communications with Jamestown Dam and Reservoir. Phone numbers of appropriate points of contact are shown in both the Communications Directory of the Standing Operating Procedures (SOP) prepared by the Great Plains Region of Reclamation and the Corps' Water Control Manual for Flood Control Regulation for Jamestown Dam Water Control Manual. The directory of phone numbers taken from the Water Control Manual is attached at the back of this document as Table 4. A more extensive listing is shown on pages v and vi in the Water Control Manual.

B-3. Gate Settings. All gate settings necessary to obtain releases required by directives from the Omaha District WCWQS or as required by the emergency instructions will be determined by the Dam Tender. Directives furnished to the Area Manager for transmission to the Dam Tender or transmitted to the Dam Tender directly will specify only the required discharges to be maintained from the reservoir. Tables of discharges for the two service gates as well as the discharge from the bypass valve are in the Jamestown Reservoir Water Control Manual (Plate 2-11).

B-4. Collection of Hydrologic Data, Reservoir Pool Readings and Reservoir Releases.

a. Hydrologic Data. The Dam Tender shall maintain surveillance of hydrologic conditions and convey information which may affect flood control operations to the Omaha District WCWQS. Information to be conveyed shall include: 1) large amounts of precipitation or forecasted precipitation in the James River drainage basin above Jamestown Dam, and 2) any flooding, heavy runoff or imminent heavy runoff into Jamestown Reservoir.

b. Jamestown Reservoir Pool Readings and Reservoir Releases. Data collection and remote monitoring equipment has been installed at Jamestown Dam as part of the Bureau of Reclamation's Hydromet System. The system consists of various sensors and satellite telemetry equipment that collect, record, and transmit data by way of GOES. The Data Collection Platform (DCP) at Jamestown Dam is also equipped with a telephone modem which enables collected data to be accessed by telephone. Whenever the reservoir is in the flood control zone, or such an occurrence appears imminent, the Dam Tender shall make reasonable effort to ensure that the DCP and Hydromet system are properly functioning. If the system is not functioning, the Dam Tender shall make manual readings, as requested by the Area Manager or Omaha District WCWQS.

B-5. Dam Tender Reports. The Jamestown Reservoir Dam Tender shall keep the Omaha District WCWQS and the Facilities and Engineering Manager for the Area Office informed of the Jamestown Reservoir pool levels, releases and other pertinent information which may affect flood control operations at Jamestown Dam and Reservoir. If the Facilities and Engineering Manager cannot be reached to receive the report(s), the Jamestown Reservoir Dam Tender will report to the Area Manager. Table 3 Dam Tenders Reservoir Regulation Log is attached to this document.

Section C Emergency Conditions

C-1. Purpose of Emergency Regulation. In the event of a communications failure with the Omaha District WCWQS or other emergency conditions, the Dam Tender shall make adjustments in reservoir flood control releases necessary for proper functioning and safety of Jamestown Dam.

C-2. Definition of Emergency. A communications failure will be considered of an emergency nature if the reservoir level is within the flood control pool and the Dam Tender is unable to convey information which may affect flood control operations to the Omaha District WCWQS.

C-3. Emergency Action to Reestablish Communications. When an emergency exists an all-out effort will be made by personnel at Jamestown Dam to re-establish communication with the Omaha District WCWQS during working hours and with either the Omaha District WCWQS or personnel at their homes during non-office hours. In the case of failure of the normal telephone communications system, use will be made of other available facilities which may include cell phones, satellite phones, email, or a combination of communication facilities.

C-4. Emergency Flood Control Operation of Jamestown Dam Outlet Works.

a. Pool Level below Elevation 1454.0. Under emergency conditions and a loss of communications with the Omaha District WCWQS, an immediate attempt should be made by the Dam Tender to establish communication with the Area Office. If this is not possible an attempt should be made to communicate with the Corps' Missouri River Basin Water Management office in Omaha or Reclamation's Regional Director's office in Billings. Communication should also be established with the Corps Pipestem Dam Tender located in the City of Jamestown. During such emergencies, the Pipestem Dam Tender is authorized to instruct Reclamation to make necessary gate changes at Jamestown Dam based on the Water Control Manual. Once contact is made with the Pipestem Dam Tender, the Jamestown Reservoir Dam Tender and Pipestem Reservoir Dam Tender will arrange for continued communication, and if necessary, periodic meetings to coordinate regulation of the two reservoirs. If communications cannot be established with the Omaha District WCWQS, the Pipestem Dam Tender, or Reclamation's Area Manager's Office, the Jamestown Reservoir Dam Tender has the authority to operate the reservoir in accordance with the water control manual. Before release changes are made, efforts will be made to contact the Jamestown City Engineer, Stutsman Count emergency manager, Arrowwood National Wildlife Refuge (NWR), and Sand Lake NWR concerning any proposed release rates. Table 2 shows a range of release rates for various ranges of reservoir pool zones. If pool levels are stable and increased inflows are not expected, the lower release rates for each zone should be used. If pool levels are increasing and the pool levels are expected to rise to the next higher zone, then the higher release rates should be used. If releases are going to be increased, if possible the City of Jamestown and Stutsman County should be given time to prepare for any high releases that may cause damages or urban

flooding in the City of Jamestown. If necessary, as explained in the FWA in Exhibit 2 of the water control manual, the Pipestem Dam Tender is authorized to make the gate changes at Jamestown Reservoir.

Table 2. Range of Release Rates for Emergency Flood Control Operations.

Typical Peak Annual Reservoir Levels		Normal Maximum Release		Normal Maximum Combined Release (cfs)
Jamestown Pool Level (ft)	Pipestem Pool Level (ft, PD)	**Jamestown Reservoir (cfs)**	Pipestem Reservoir (cfs)	
Above 1445.4	Above 1489.0	**1,200-1,800**	1,200-1,800	1,800
1440.0-1445.4	1478.2-1489.0	**750-1,200**	750-1,200	750-1,800
Below 1440.0	1478.2-1489.0	**450-750**	750-1,200	750-1,200
Below 1440.0	Below 1478.2	**450**	450	450-750
Below 1433.0	Below 1460.0	**200**	120	200

Note: This table is an abbreviated version of Table 7-2 from Chapter VII, Water Control Plan extracted from the Jamestown Dam Water Control Manual for Flood Control Regulation. It is not intended to be used as the final guide in determining releases under real time conditions but can be used for regulation in an emergency as defined in this paragraph (paragraph C-4a). For additional guidance in determining releases consult the detailed discussion in Chapter VII, Water Control Plan, of the Jamestown Dam Water Control Manual for Flood Control Regulation.

b. Pool Level above Elevation 1454.0. Operation of the reservoir when the pool is above elevation 1454.0 feet is under the direction of the Bureau of Reclamation and is outside the scope of these instructions. Regulation when the pool level is above elevation 1454.0 feet will follow the guidelines set forth in the EAP contained in Reclamation's SOP for Jamestown Dam and Reservoir. The maximum gate opening attained during the rising pool will be maintained until the pool drops to elevation 1454.0 feet, at which time releases will be set to the greater of inflows or the flood control release rates as specified in the Water Control Manual.

C-5. Time of Emergency Operation. The Dam Tender will continue to operate in accordance with this schedule until communication with the Omaha District WCWQS can be reestablished, after which the reservoir will be operated as directed by the Omaha District WCWQS while the pool is in the flood control zone.

C-6. Integrity of Dam. Nothing in these instructions shall be construed to require that releases shall be made at rates or in a manner that would be inconsistent with requirements for protecting the dam and its appurtenant facilities from damage.

C-7. Aids to Regulation. Copies of the following tables and plates are taken from the water control manual to aid in regulation of Jamestown Dam:

a. Gate Discharge Tables. The Jamestown Reservoir gate opening-discharge tables that are used to determine the proper gate opening are included as Plate 2-11 Outlet Works Discharge Tables in the Jamestown Reservoir water control manual.

b. Area Capacity Table. The Area-Capacity tables for Jamestown Reservoir are included in the following locations in the Jamestown Reservoir Water Control Manual:

- Table 5-3, Area in Acres.
- Table 5-4, Capacity in Acre-Feet.
- Exhibit 4, Area in Acres (detailed) and Capacity in Acre-Feet (detailed).

c. Discharge Rating Curves. Discharge rating curves for critical downstream gages along the James River included in the following locations in the Jamestown Reservoir Water Control Manual:

- Plate 4-15, Rating Curve for Jamestown (James River).
- Plate 4-16, Rating Curve for LaMoure (James River).

C-8. Posting of Emergency Instructions. A copy of these instructions and the names and telephone numbers of the Omaha District WCWQS personnel shall be posted in such a manner that they are readily accessible at all times and in usable form. The Dam Tender shall make certain that any other person temporarily charged with operation of Jamestown Dam is familiar with these instructions.

Table 3 JAMESTOWN DAM AND RESERVOIR DAM TENDERS RESERVOIR REGULATION LOG							
Date:							
RESERVOIR DATA							
Jamestown MN Pool Elevation							
Jamestown AM Pool Elevation							
Jamestown Precipitation							
Jamestown Evaporation							
Gate Openings in Feet:							
5'x6' High Pressure Slide Gate 1							
5'x6' High Pressure Slide Gate 2							
Time of Gate Change							
Pipestem AM Pool Elevation							
Pipestem Precipitation							
Gate Opening in Feet							
Time of Gate Change							
RIVER DATA							
Pipestem Creek @ Pingree							
Pipestem Creek below dam							
James River @ Grace City							
James River @ Jamestown							
James River @ LaMoure							

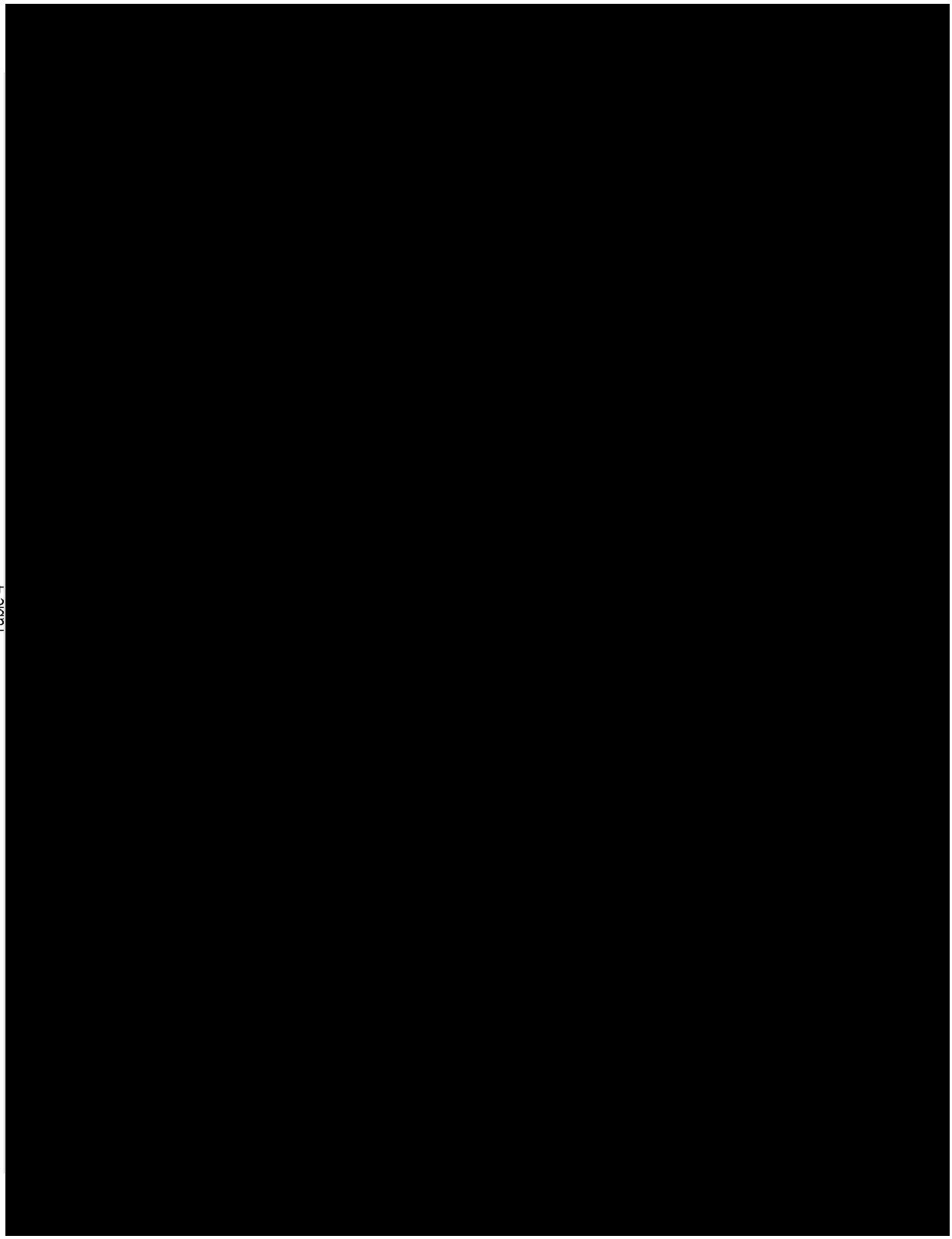


Table 4

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EXHIBIT 4

JAMESTOWN RESEVOIR

AREA AND CAPACITY TABLES

JAMESTOWN RESERVOIR
AREA IN ACRES
2009 SURVEY

ELEV	0	1	2	3	4	5	6	7	8	9
1390	0	0	0	2	3	11	23	38	63	91
1400	122	160	207	244	287	328	367	414	462	509
1410	552	604	657	706	757	809	869	949	1028	1109
1420	1200	1289	1376	1458	1529	1607	1685	1772	1875	1995
1430	2161	2342	2524	2705	2887	3068	3295	6917	7348	7719
1440	8090	8452	8813	9175	9536	9898	10260	10622	10983	11345
1450	11707	12084	12460	12837	13213	13590	13986	14382	14779	15175
1460	15571	15995	16418	16842	17265	17689	18143	18598	19052	19506
1470	19980									

JAMESTOWN RESERVOIR
CAPACITY IN ACRE-FEET
2009 SURVEY

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
1392.	0	0	0	0	0	0	0	0	0	0
.1	0	0	0	0	0	0	0	0	0	0
.2	0	0	0	0	0	0	0	0	0	0
.3	0	0	0	0	0	0	0	0	0	0
.4	0	0	0	0	0	0	0	0	0	0
.5	0	0	0	0	0	0	0	0	0	0
.6	0	0	0	0	0	0	0	0	0	0
.7	0	0	0	0	0	0	0	0	1	1
.8	1	1	1	1	1	1	1	1	1	1
.9	1	1	1	1	1	1	1	1	1	1
1393.	1	1	1	1	1	1	1	1	1	1
.1	1	1	1	1	1	1	1	1	1	1
.2	1	1	1	1	1	1	1	1	1	1
.3	1	1	1	1	1	2	2	2	2	2
.4	2	2	2	2	2	2	2	2	2	2
.5	2	2	2	2	2	2	2	2	2	2
.6	2	2	2	2	2	2	2	2	2	2
.7	2	2	2	2	2	3	3	3	3	3
.8	3	3	3	3	3	3	3	3	3	3
.9	3	3	3	3	3	3	3	3	3	3
1394.	3	3	3	3	3	3	4	4	4	4
.1	4	4	4	4	4	4	4	4	4	4
.2	4	4	4	4	4	4	4	4	5	5
.3	5	5	5	5	5	5	5	5	5	5
.4	5	5	5	5	5	6	6	6	6	6
.5	6	6	6	6	6	6	6	6	7	7

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.6	7	7	7	7	7	7	7	7	7	7
.7	7	8	8	8	8	8	8	8	8	8
.8	8	8	9	9	9	9	9	9	9	9
.9	9	9	10	10	10	10	10	10	10	10
1395.	10	11	11	11	11	11	11	11	11	11
.1	12	12	12	12	12	12	12	12	13	13
.2	13	13	13	13	13	14	14	14	14	14
.3	14	14	15	15	15	15	15	15	15	16
.4	16	16	16	16	16	17	17	17	17	17
.5	17	18	18	18	18	18	18	19	19	19
.6	19	19	19	20	20	20	20	20	21	21
.7	21	21	21	22	22	22	22	22	23	23
.8	23	23	23	24	24	24	24	24	25	25
.9	25	25	25	26	26	26	26	27	27	27
1396.	27	27	28	28	28	28	29	29	29	29
.1	30	30	30	30	31	30	31	31	32	32
.2	32	32	33	33	33	33	34	34	34	34
.3	35	35	35	36	36	36	36	37	37	37
.4	38	38	38	38	39	39	39	40	40	40
.5	40	41	41	41	42	42	42	43	43	43
.6	44	44	44	45	45	45	46	46	46	47
.7	47	47	48	48	48	49	49	49	50	50
.8	50	51	51	51	52	52	52	53	53	53
.9	54	54	55	55	55	56	56	56	57	57
1397.	58	58	58	59	59	59	60	60	61	61
.1	61	62	62	63	63	64	64	64	65	65
.2	66	66	67	67	67	68	68	69	69	70
.3	70	71	71	71	72	72	73	73	74	74
.4	75	75	76	76	77	77	78	78	79	79
.5	80	80	81	81	82	82	83	83	84	84
.6	85	85	86	86	87	88	88	89	89	90
.7	90	91	91	92	93	93	94	94	95	95
.8	96	97	97	98	98	99	100	100	101	101
.9	102	103	103	104	104	105	106	106	107	108
1398.	108	109	109	110	111	111	112	113	113	114
.1	115	115	116	117	117	118	119	119	120	121
.2	121	122	123	123	124	125	126	126	127	128
.3	128	129	130	131	131	132	133	133	134	135
.4	136	136	137	138	139	139	140	141	142	142
.5	143	144	145	146	146	147	148	149	149	150
.6	151	152	153	153	154	155	156	157	158	158
.7	159	160	161	162	163	163	164	165	166	167
.8	168	168	169	170	171	172	173	174	175	175
.9	176	177	178	179	180	181	182	183	183	184
1399.	185	186	187	188	189	190	191	192	193	194
.1	195	195	196	197	198	199	200	201	202	203

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.2	204	205	206	207	208	209	210	211	212	213
.3	214	215	216	217	218	219	220	221	222	223
.4	224	225	226	227	228	229	230	231	233	234
.5	235	236	237	238	239	240	241	242	243	244
.6	246	247	248	249	250	251	252	253	254	256
.7	257	258	259	260	261	262	263	265	266	267
.8	268	269	270	272	273	274	275	276	277	279
.9	280	280	282	283	285	286	287	288	290	291
1400.	292	293	294	296	297	298	299	301	302	303
.1	304	306	307	308	309	311	312	313	315	316
.2	317	318	320	321	322	324	325	326	328	329
.3	330	332	333	334	336	337	338	340	341	343
.4	344	345	347	348	349	351	352	354	355	356
.5	358	359	361	362	363	365	366	368	369	371
.6	372	374	375	376	378	379	381	382	384	385
.7	387	388	390	391	393	394	396	397	399	400
.8	402	403	405	406	408	409	411	413	414	416
.9	417	419	420	422	423	425	427	428	430	431
1401.	433	435	436	438	439	441	443	444	446	448
.1	449	451	452	454	456	457	459	461	462	464
.2	466	468	469	471	473	474	476	478	479	481
.3	483	485	486	488	490	492	493	495	497	499
.4	501	502	504	506	508	510	511	513	515	517
.5	519	520	522	524	526	528	530	532	533	535
.6	537	539	541	543	545	547	549	550	552	554
.7	556	558	560	562	564	566	568	570	572	574
.8	576	578	580	582	584	586	588	590	592	594
.9	596	598	600	602	604	606	608	610	612	614
1402.	616	618	620	622	625	627	629	631	633	635
.1	637	639	641	643	646	648	650	652	654	656
.2	658	660	663	665	667	669	671	673	676	678
.3	680	682	684	686	689	691	693	695	698	700
.4	702	704	706	709	711	713	715	718	720	722
.5	724	727	729	731	733	736	738	740	742	745
.6	747	749	752	754	756	759	761	763	765	768
.7	770	772	775	777	779	782	784	787	789	791
.8	794	796	798	801	803	805	808	810	813	815
.9	817	820	822	825	827	829	832	834	837	839
1403.	842	844	847	849	851	854	856	859	861	864
.1	866	869	871	874	876	879	881	884	886	889
.2	891	894	896	899	901	904	907	909	912	914
.3	917	919	922	924	927	930	932	935	937	940
.4	943	945	948	951	953	956	958	961	964	966
.5	969	972	974	977	980	982	985	988	990	993
.6	996	998	1001	1004	1007	1009	1012	1015	1017	1020

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.7	1023	1026	1028	1031	1034	1037	1039	1042	1045	1048
.8	1050	1053	1056	1059	1062	1064	1067	1070	1073	1076
.9	1079	1081	1084	1087	1090	1093	1096	1098	1101	1104
1404.	1107	1110	1113	1116	1118	1121	1124	1127	1130	1133
.1	1136	1139	1142	1145	1147	1150	1153	1156	1159	1162
.2	1165	1168	1171	1174	1177	1180	1183	1186	1189	1192
.3	1195	1198	1201	1204	1207	1210	1213	1216	1219	1222
.4	1225	1228	1231	1234	1237	1240	1243	1246	1249	1252
.5	1255	1259	1262	1265	1268	1271	1274	1277	1280	1283
.6	1286	1289	1293	1296	1299	1302	1305	1308	1311	1315
.7	1318	1321	1324	1327	1330	1334	1337	1340	1343	1346
.8	1349	1353	1356	1359	1362	1366	1369	1372	1375	1378
.9	1382	1385	1388	1391	1395	1398	1401	1404	1408	1411
1405.	1414	1418	1421	1424	1427	1431	1434	1437	1441	1444
.1	1447	1451	1454	1457	1461	1464	1467	1471	1474	1477
.2	1481	1484	1487	1491	1494	1497	1501	1504	1508	1511
.3	1514	1518	1521	1525	1528	1531	1535	1538	1542	1545
.4	1549	1552	1555	1559	1562	1566	1569	1573	1576	1580
.5	1583	1587	1590	1594	1597	1601	1604	1608	1611	1615
.6	1618	1622	1625	1629	1632	1636	1639	1643	1646	1650
.7	1654	1657	1661	1664	1668	1671	1675	1678	1682	1686
.8	1689	1693	1696	1700	1704	1707	1711	1715	1718	1722
.9	1725	1729	1733	1736	1740	1744	1747	1751	1755	1758
1406.	1762	1766	1769	1773	1777	1780	1784	1788	1791	1795
.1	1799	1803	1806	1810	1814	1818	1821	1825	1829	1833
.2	1836	1840	1844	1848	1851	1855	1859	1863	1867	1870
.3	1874	1878	1882	1886	1890	1893	1897	1901	1905	1909
.4	1913	1916	1920	1924	1928	1932	1936	1940	1944	1948
.5	1951	1955	1959	1963	1967	1971	1975	1979	1983	1987
.6	1991	1995	1999	2003	2007	2011	2014	2018	2022	2026
.7	2030	2034	2038	2042	2046	2050	2055	2059	2063	2067
.8	2071	2075	2079	2083	2087	2091	2095	2099	2103	2107
.9	2111	2115	2120	2124	2128	2132	2136	2140	2144	2148
1407.	2152	2157	2161	2165	2169	2173	2177	2182	2186	2190
.1	2194	2198	2202	2207	2211	2215	2219	2223	2228	2232
.2	2236	2240	2245	2249	2253	2257	2262	2266	2270	2274
.3	2279	2283	2287	2292	2296	2300	2304	2309	2313	2317
.4	2322	2326	2330	2335	2339	2343	2348	2352	2357	2361
.5	2365	2370	2374	2378	2383	2387	2392	2396	2400	2405
.6	2409	2414	2418	2423	2427	2431	2436	2440	2445	2449
.7	2454	2458	2463	2467	2472	2476	2481	2485	2490	2494
.8	2499	2503	2508	2512	2517	2521	2526	2531	2535	2540
.9	2544	2549	2553	2558	2563	2567	2572	2576	2581	2586
1408.	2590	2595	2599	2604	2609	2613	2618	2623	2627	2632
.1	2637	2641	2646	2651	2655	2660	2665	2669	2674	2679

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.2	2683	2688	2693	2698	2702	2707	2712	2717	2721	2726
.3	2731	2736	2740	2745	2750	2755	2759	2764	2769	2774
.4	2779	2783	2788	2793	2798	2803	2808	2812	2817	2822
.5	2827	2832	2837	2842	2846	2851	2856	2861	2866	2871
.6	2876	2881	2886	2890	2895	2900	2905	2910	2915	2920
.7	2925	2930	2935	2940	2945	2950	2955	2960	2965	2970
.8	2975	2980	2985	2990	2995	3000	3005	3010	3015	3020
.9	3025	3030	3035	3040	3045	3050	3055	3060	3065	3070
1409.	3076	3081	3086	3091	3096	3101	3106	3111	3116	3121
.1	3127	3132	3137	3142	3147	3152	3157	3163	3168	3173
.2	3178	3183	3189	3194	3199	3204	3209	3214	3220	3225
.3	3230	3235	3241	3246	3251	3256	3261	3267	3272	3277
.4	3283	3288	3293	3298	3304	3309	3314	3319	3325	3330
.5	3335	3341	3346	3351	3357	3362	3367	3373	3378	3383
.6	3389	3394	3399	3405	3410	3415	3421	3426	3432	3437
.7	3442	3448	3453	3458	3464	3469	3475	3480	3486	3491
.8	3496	3502	3507	3513	3518	3524	3529	3535	3540	3545
.9	3551	3556	3562	3567	3573	3578	3584	3589	3595	3600
1410.	3606	3611	3617	3623	3628	3634	3639	3645	3650	3656
.1	3661	3667	3673	3678	3684	3689	3695	3701	3706	3712
.2	3717	3723	3729	3734	3740	3746	3751	3757	3763	3768
.3	3774	3780	3785	3791	3797	3802	3808	3814	3819	3825
.4	3831	3837	3842	3848	3854	3860	3865	3871	3877	3883
.5	3888	3894	3900	3906	3912	3917	3923	3929	3935	3941
.6	3947	3952	3958	3964	3970	3976	3982	3988	3993	3999
.7	4005	4011	4017	4023	4029	4035	4041	4046	4052	4058
.8	4064	4070	4076	4082	4088	4094	4100	4106	4112	4118
.9	4124	4130	4136	4142	4148	4154	4160	4166	4172	4178
1411.	4184	4190	4196	4202	4208	4214	4220	4227	4233	4239
.1	4245	4251	4257	4263	4269	4275	4281	4288	4294	4300
.2	4306	4312	4318	4324	4331	4337	4343	4349	4355	4362
.3	4368	4374	4380	4386	4393	4399	4405	4411	4418	4424
.4	4430	4436	4443	4449	4455	4461	4468	4474	4480	4487
.5	4493	4499	4506	4512	4518	4524	4531	4537	4544	4550
.6	4556	4563	4569	4575	4582	4588	4595	4601	4607	4614
.7	4620	4627	4633	4639	4646	4652	4659	4665	4672	4678
.8	4685	4691	4697	4704	4710	4717	4723	4730	4736	4743
.9	4749	4756	4763	4769	4776	4782	4789	4795	4802	4808
1412.	4815	4822	4828	4835	4841	4848	4854	4861	4868	4874
.1	4881	4888	4894	4901	4907	4914	4921	4927	4934	4941
.2	4947	4954	4961	4967	4974	4981	4988	4994	5001	5008
.3	5014	5021	5028	5035	5041	5048	5055	5062	5068	5075
.4	5082	5089	5095	5102	5109	5116	5123	5129	5136	5143
.5	5150	5157	5163	5170	5177	5184	5191	5198	5204	5211

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.6	5218	5225	5232	5239	5246	5253	5259	5266	5273	5280
.7	5287	5294	5301	5308	5315	5322	5329	5336	5343	5350
.8	5356	5363	5370	5377	5384	5391	5398	5405	5412	5419
.9	5426	5433	5440	5447	5454	5462	5469	5476	5483	5490
1413.	5497	5504	5511	5518	5525	5532	5539	5546	5553	5561
.1	5568	5575	5582	5589	5596	5603	5610	5618	5625	5632
.2	5639	5646	5653	5661	5668	5675	5682	5689	5696	5704
.3	5711	5718	5725	5733	5740	5747	5754	5762	5769	5776
.4	5783	5791	5798	5805	5812	5820	5827	5834	5842	5849
.5	5856	5864	5871	5878	5886	5893	5900	5908	5915	5922
.6	5930	5937	5944	5952	5959	5967	5974	5981	5989	5996
.7	6004	6011	6018	6026	6033	6041	6048	6056	6063	6071
.8	6078	6086	6093	6100	6108	6115	6123	6130	6138	6145
.9	6153	6161	6168	6176	6183	6191	6198	6206	6213	6221
1414.	6228	6236	6244	6251	6259	6266	6274	6282	6289	6297
.1	6304	6312	6320	6327	6335	6343	6350	6358	6366	6373
.2	6381	6389	6396	6404	6412	6419	6427	6435	6443	6450
.3	6458	6466	6473	6481	6489	6497	6504	6512	6520	6528
.4	6535	6543	6551	6559	6567	6574	6582	6590	6598	6606
.5	6614	6621	6629	6637	6645	6653	6661	6669	6676	6684
.6	6692	6700	6708	6716	6724	6732	6740	6747	6755	6763
.7	6771	6779	6787	6795	6803	6811	6819	6827	6835	6843
.8	6851	6859	6867	6875	6883	6891	6899	6907	6915	6923
.9	6931	6939	6947	6955	6963	6971	6979	6987	6995	7004
1415.	7012	7020	7028	7036	7044	7052	7060	7068	7077	7085
.1	7093	7101	7109	7117	7126	7134	7142	7150	7158	7166
.2	7175	7183	7191	7199	7208	7216	7224	7232	7241	7249
.3	7257	7265	7274	7282	7290	7299	7307	7315	7323	7332
.4	7340	7348	7357	7365	7374	7382	7390	7399	7407	7415
.5	7424	7432	7441	7449	7457	7466	7474	7483	7491	7500
.6	7508	7516	7525	7533	7542	7550	7559	7567	7576	7584
.7	7593	7601	7610	7618	7627	7635	7644	7653	7661	7670
.8	7678	7687	7695	7704	7713	7721	7730	7738	7747	7756
.9	7764	7773	7782	7790	7799	7808	7816	7825	7834	7842
1416.	7851	7860	7868	7877	7886	7895	7903	7912	7921	7930
.1	7938	7947	7956	7965	7973	7982	7991	8000	8009	8018
.2	8026	8035	8044	8053	8062	8071	8080	8089	8097	8106
.3	8115	8124	8133	8142	8151	8160	8169	8178	8187	8196
.4	8205	8214	8223	8232	8241	8250	8259	8268	8277	8286
.5	8296	8305	8314	8323	8332	8341	8350	8359	8369	8378
.6	8387	8396	8405	8414	8424	8433	8442	8451	8460	8470
.7	8479	8488	8497	8507	8516	8525	8535	8544	8553	8563
.8	8572	8581	8591	8600	8609	8619	8628	8637	8647	8656
.9	8666	8675	8684	8694	8703	8713	8722	8732	8741	8751
1417.	8760	8769	8779	8788	8798	8808	8817	8827	8836	8846

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.1	8855	8865	8874	8884	8894	8903	8913	8922	8932	8942
.2	8951	8961	8971	8980	8990	9000	9009	9019	9029	9038
.3	9048	9058	9068	9077	9087	9097	9107	9116	9126	9136
.4	9146	9156	9165	9175	9185	9195	9205	9215	9225	9234
.5	9244	9254	9264	9274	9284	9294	9304	9314	9324	9334
.6	9344	9354	9363	9373	9383	9393	9403	9413	9424	9434
.7	9444	9454	9464	9474	9484	9494	9504	9514	9524	9534
.8	9544	9555	9565	9575	9585	9595	9605	9615	9626	9636
.9	9646	9656	9666	9677	9687	9697	9707	9718	9728	9738
1418.	9749	9759	9769	9779	9790	9800	9810	9821	9831	9841
.1	9852	9862	9872	9883	9893	9904	9914	9924	9935	9945
.2	9956	9966	9977	9987	9998	10008	10019	10029	10040	10050
.3	10061	10071	10082	10092	10103	10113	10124	10134	10145	10156
.4	10166	10177	10187	10198	10209	10219	10230	10241	10251	10262
.5	10273	10283	10294	10305	10316	10326	10337	10348	10358	10369
.6	10380	10391	10402	10412	10423	10434	10445	10456	10466	10477
.7	10488	10499	10510	10521	10532	10542	10553	10564	10575	10586
.8	10597	10608	10619	10630	10641	10652	10663	10674	10685	10696
.9	10707	10718	10729	10740	10751	10762	10773	10784	10795	10806
1419.	10817	10828	10839	10850	10862	10873	10884	10895	10906	10917
.1	10928	10940	10951	10962	10973	10984	10996	11007	11018	11029
.2	11041	11052	11063	11075	11086	11097	11108	11120	11131	11143
.3	11154	11165	11177	11188	11199	11211	11222	11234	11245	11256
.4	11268	11279	11291	11302	11314	11325	11337	11348	11360	11371
.5	11383	11394	11406	11418	11429	11441	11452	11464	11476	11487
.6	11499	11510	11522	11534	11545	11557	11569	11580	11592	11604
.7	11616	11627	11639	11651	11663	11674	11686	11698	11710	11721
.8	11733	11745	11757	11769	11781	11793	11804	11816	11828	11840
.9	11852	11864	11876	11888	11900	11912	11924	11935	11947	11959
1420.	11971	11983	11995	12007	12020	12032	12044	12056	12068	12080
.1	12092	12104	12116	12128	12140	12152	12165	12177	12189	12201
.2	12213	12225	12238	12250	12262	12274	12286	12299	12311	12323
.3	12335	12348	12360	12372	12385	12397	12409	12421	12434	12446
.4	12458	12471	12483	12496	12508	12520	12533	12545	12558	12570
.5	12582	12595	12607	12620	12632	12645	12657	12670	12682	12695
.6	12707	12720	12732	12745	12758	12770	12783	12795	12808	12821
.7	12833	12846	12858	12871	12884	12896	12909	12922	12934	12947
.8	12960	12973	12985	12998	13011	13023	13036	13049	13062	13075
.9	13087	13100	13113	13126	13139	13151	13164	13177	13190	13203
1421.	13216	13229	13242	13255	13267	13280	13293	13306	13319	13332
.1	13345	13358	13371	13384	13397	13410	13423	13436	13449	13462
.2	13475	13488	13501	13515	13528	13541	13554	13567	13580	13593
.3	13606	13620	13633	13646	13659	13672	13685	13699	13712	13725
.4	13738	13752	13765	13778	13791	13805	13818	13831	13845	13858
.5	13871	13884	13898	13911	13925	13938	13951	13965	13978	13991

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.6	14005	14018	14032	14045	14059	14072	14085	14099	14112	14126
.7	14139	14153	14166	14180	14193	14207	14221	14234	14248	14261
.8	14275	14288	14302	14316	14329	14343	14356	14370	14384	14397
.9	14411	14425	14438	14452	14466	14480	14493	14507	14521	14535
1422.	14548	14562	14576	14590	14603	14617	14631	14645	14659	14672
.1	14686	14700	14714	14728	14742	14756	14770	14783	14797	14811
.2	14825	14839	14853	14867	14881	14895	14909	14923	14937	14951
.3	14965	14979	14993	15007	15021	15035	15049	15063	15077	15091
.4	15105	15119	15134	15148	15162	15176	15190	15204	15218	15232
.5	15247	15261	15275	15289	15303	15318	15332	15346	15360	15375
.6	15389	15403	15417	15432	15446	15460	15474	15489	15503	15517
.7	15532	15546	15560	15575	15589	15604	15618	15632	15647	15661
.8	15676	15690	15704	15719	15733	15748	15762	15777	15791	15806
.9	15820	15835	15849	15864	15878	15893	15907	15922	15936	15951
1423.	15966	15980	15995	16009	16024	16039	16053	16068	16083	16097
.1	16112	16126	16141	16156	16170	16185	16200	16215	16229	16244
.2	16259	16273	16288	16303	16318	16332	16347	16362	16377	16392
.3	16406	16421	16436	16451	16466	16480	16495	16510	16525	16540
.4	16555	16570	16584	16599	16614	16629	16644	16659	16674	16689
.5	16704	16719	16734	16749	16764	16778	16793	16808	16823	16838
.6	16853	16868	16883	16899	16914	16929	16944	16959	16974	16989
.7	17004	17019	17034	17049	17064	17079	17095	17110	17125	17140
.8	17155	17170	17185	17201	17216	17231	17246	17261	17277	17292
.9	17307	17322	17337	17353	17368	17383	17398	17414	17429	17444
1424.	17460	17475	17490	17505	17521	17536	17551	17567	17582	17598
.1	17613	17628	17644	17659	17674	17690	17705	17721	17736	17752
.2	17767	17782	17798	17813	17829	17844	17860	17875	17891	17906
.3	17922	17937	17953	17968	17984	18000	18015	18031	18046	18062
.4	18078	18093	18109	18124	18140	18156	18171	18187	18203	18218
.5	18234	18250	18265	18281	18297	18312	18328	18344	18360	18375
.6	18391	18407	18423	18439	18454	18470	18486	18502	18518	18533
.7	18549	18565	18581	18597	18613	18628	18644	18660	18676	18692
.8	18708	18724	18740	18756	18772	18788	18804	18820	18836	18852
.9	18868	18884	18900	18916	18932	18948	18964	18980	18996	19012
1425.	19028	19044	19060	19076	19092	19108	19124	19141	19157	19173
.1	19189	19205	19221	19237	19254	19270	19286	19302	19318	19335
.2	19351	19367	19383	19400	19416	19432	19448	19465	19481	19497
.3	19514	19530	19546	19562	19579	19595	19612	19628	19644	19661
.4	19677	19693	19710	19726	19743	19759	19775	19792	19808	19825
.5	19841	19858	19874	19891	19907	19924	19940	19957	19973	19990
.6	20006	20023	20039	20056	20072	20089	20106	20122	20139	20155
.7	20172	20189	20205	20222	20239	20255	20272	20289	20305	20322
.8	20339	20355	20372	20389	20405	20422	20439	20456	20472	20489
.9	20506	20523	20540	20556	20573	20590	20607	20624	20640	20657
1426.	20674	20691	20708	20725	20742	20759	20775	20792	20809	20826

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.1	20843	20860	20877	20894	20911	20928	20945	20962	20979	20996
.2	21013	21030	21047	21064	21081	21098	21115	21132	21149	21167
.3	21184	21201	21218	21235	21252	21269	21286	21304	21321	21338
.4	21355	21372	21390	21407	21424	21441	21459	21476	21493	21510
.5	21528	21545	21562	21580	21597	21614	21632	21649	21666	21684
.6	21701	21718	21736	21753	21770	21788	21805	21823	21840	21858
.7	21875	21893	21910	21927	21945	21962	21980	21997	22015	22033
.8	22050	22068	22085	22103	22120	22138	22156	22173	22191	22208
.9	22226	22244	22261	22279	22297	22314	22332	22350	22367	22385
1427.	22403	22420	22438	22456	22474	22491	22509	22527	22545	22563
.1	22580	22598	22616	22634	22652	22670	22687	22705	22723	22741
.2	22759	22777	22795	22813	22831	22849	22867	22885	22903	22921
.3	22939	22957	22975	22993	23011	23029	23047	23065	23083	23101
.4	23120	23138	23156	23174	23192	23210	23229	23247	23265	23283
.5	23301	23320	23338	23356	23374	23393	23411	23429	23448	23466
.6	23484	23503	23521	23539	23558	23576	23594	23613	23631	23650
.7	23668	23687	23705	23723	23742	23760	23779	23797	23816	23834
.8	23853	23872	23890	23909	23927	23946	23964	23983	24002	24020
.9	24039	24058	24076	24095	24114	24132	24151	24170	24188	24207
1428.	24226	24245	24263	24282	24301	24320	24339	24357	24376	24395
.1	24414	24433	24452	24471	24490	24508	24527	24546	24565	24584
.2	24603	24622	24641	24660	24679	24698	24717	24736	24756	24775
.3	24794	24813	24832	24851	24870	24889	24909	24928	24947	24966
.4	24985	25005	25024	25043	25062	25082	25101	25120	25140	25159
.5	25178	25198	25217	25236	25256	25275	25295	25314	25333	25353
.6	25372	25392	25411	25431	25450	25470	25489	25509	25528	25548
.7	25568	25587	25607	25626	25646	25666	25685	25705	25725	25744
.8	25764	25784	25803	25823	25843	25863	25883	25902	25922	25942
.9	25962	25982	26001	26021	26041	26061	26081	26101	26121	26141
1429.	26161	26181	26201	26221	26241	26261	26281	26301	26321	26341
.1	26361	26381	26401	26421	26441	26462	26482	26502	26522	26543
.2	26563	26583	26603	26624	26644	26664	26685	26705	26725	26746
.3	26766	26787	26807	26828	26848	26869	26889	26910	26930	26951
.4	26971	26992	27013	27033	27054	27075	27095	27116	27137	27157
.5	27178	27199	27220	27241	27261	27282	27303	27324	27345	27366
.6	27387	27408	27429	27449	27470	27491	27512	27533	27555	27576
.7	27597	27618	27639	27660	27681	27702	27723	27745	27766	27787
.8	27808	27830	27851	27872	27893	27915	27936	27957	27979	28000
.9	28022	28043	28065	28086	28108	28129	28151	28172	28194	28215
1430.	28237	28258	28280	28302	28323	28345	28367	28389	28410	28432
.1	28454	28476	28497	28519	28541	28563	28585	28607	28629	28651
.2	28673	28695	28717	28739	28761	28783	28805	28827	28849	28871
.3	28893	28915	28938	28960	28982	29004	29027	29049	29071	29093
.4	29116	29138	29160	29183	29205	29228	29250	29273	29295	29317
.5	29340	29363	29385	29408	29430	29453	29475	29498	29521	29543

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.6	29566	29589	29611	29634	29657	29680	29703	29725	29748	29771
.7	29794	29817	29840	29863	29886	29909	29932	29955	29978	30001
.8	30024	30047	30070	30093	30116	30139	30162	30185	30209	30232
.9	30255	30278	30302	30325	30348	30372	30395	30418	30442	30465
1431.	30488	30512	30535	30559	30582	30606	30629	30653	30676	30700
.1	30724	30747	30771	30794	30818	30842	30866	30889	30913	30937
.2	30961	30984	31008	31032	31056	31080	31104	31128	31151	31175
.3	31199	31223	31247	31271	31295	31319	31343	31368	31392	31416
.4	31440	31464	31488	31512	31537	31561	31585	31609	31634	31658
.5	31682	31707	31731	31755	31780	31804	31829	31853	31878	31902
.6	31927	31951	31976	32000	32025	32049	32074	32099	32123	32148
.7	32173	32197	32222	32247	32271	32296	32321	32346	32371	32396
.8	32420	32445	32470	32495	32520	32545	32570	32595	32620	32645
.9	32670	32695	32720	32745	32770	32796	32821	32846	32871	32896
1432.	32921	32947	32972	32997	33023	33048	33073	33099	33124	33149
.1	33175	33200	33226	33251	33277	33302	33328	33353	33379	33404
.2	33430	33455	33481	33507	33532	33558	33584	33610	33635	33661
.3	33687	33713	33738	33764	33790	33816	33842	33868	33894	33920
.4	33945	33971	33997	34023	34049	34076	34102	34128	34154	34180
.5	34206	34232	34258	34285	34311	34337	34363	34389	34416	34442
.6	34468	34495	34521	34547	34574	34600	34627	34653	34680	34706
.7	34733	34759	34786	34812	34839	34865	34892	34919	34945	34972
.8	34999	35025	35052	35079	35105	35132	35159	35186	35213	35239
.9	35266	35293	35320	35347	35374	35401	35428	35455	35482	35509
1433.	35536	35563	35590	35617	35644	35671	35699	35726	35753	35780
.1	35807	35835	35862	35889	35916	35944	35971	35998	36026	36053
.2	36081	36108	36135	36163	36190	36218	36245	36273	36300	36328
.3	36356	36383	36411	36439	36466	36494	36522	36549	36577	36605
.4	36633	36660	36688	36716	36744	36772	36799	36827	36855	36883
.5	36911	36939	36967	36995	37023	37051	37079	37107	37135	37164
.6	37192	37220	37248	37276	37304	37333	37361	37389	37417	37446
.7	37474	37502	37531	37559	37587	37616	37644	37673	37701	37730
.8	37758	37787	37815	37844	37872	37901	37929	37958	37987	38015
.9	38044	38073	38101	38130	38159	38188	38216	38245	38274	38303
1434.	38332	38361	38390	38418	38447	38476	38505	38534	38563	38592
.1	38621	38650	38679	38709	38738	38767	38796	38825	38854	38884
.2	38913	38942	38971	39001	39030	39059	39088	39118	39147	39177
.3	39206	39235	39265	39294	39324	39353	39383	39412	39442	39471
.4	39501	39531	39560	39590	39619	39649	39679	39709	39738	39768
.5	39798	39828	39857	39887	39917	39947	39977	40007	40037	40066
.6	40096	40126	40156	40186	40216	40246	40276	40307	40337	40367
.7	40397	40427	40457	40487	40518	40548	40578	40608	40639	40669
.8	40699	40729	40760	40790	40821	40851	40881	40912	40942	40973
.9	41003	41034	41064	41095	41125	41156	41187	41217	41248	41278
1435.	41309	41340	41370	41401	41432	41463	41494	41524	41555	41586

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.1	41617	41648	41679	41710	41741	41772	41803	41834	41865	41896
.2	41927	41958	41990	42021	42052	42083	42114	42146	42177	42208
.3	42240	42271	42302	42334	42365	42397	42428	42460	42491	42523
.4	42554	42586	42618	42649	42681	42713	42744	42776	42808	42840
.5	42871	42903	42935	42967	42999	43031	43063	43095	43127	43159
.6	43191	43223	43255	43287	43319	43351	43383	43416	43448	43480
.7	43512	43545	43577	43609	43642	43674	43706	43739	43771	43804
.8	43836	43869	43901	43934	43966	43999	44032	44064	44097	44130
.9	44162	44195	44228	44260	44293	44326	44359	44392	44425	44458
1436.	44491	44524	44557	44591	44625	44660	44695	44730	44766	44802
.1	44838	44875	44912	44950	44987	45026	45064	45103	45142	45182
.2	45222	45262	45303	45344	45386	45428	45470	45512	45555	45598
.3	45642	45686	45730	45775	45820	45866	45911	45958	46004	46051
.4	46098	46146	46194	46242	46291	46340	46389	46439	46489	46540
.5	46591	46642	46694	46746	46798	46851	46904	46957	47011	47065
.6	47120	47174	47230	47285	47341	47397	47454	4751	47569	47626
.7	47684	47743	47802	47861	47921	47981	4804	48101	48162	48224
.8	48286	48348	48410	48473	48536	48600	48664	48728	48793	48858
.9	48923	48989	49055	49121	49188	49255	49323	49391	49459	49528
1437.	49597	49666	49735	49804	49874	49943	50012	50082	50151	50221
.1	50290	50360	50430	50499	50569	50639	50709	50779	50849	50919
.2	50989	51059	51129	51199	51269	51339	51410	51480	51550	5162
.3	5169	51762	51832	51903	51973	52044	52115	52185	52256	52327
.4	52398	52469	52540	52611	52682	52753	52824	52895	52966	53038
.5	53109	53180	53252	53323	53395	53466	53538	53609	53681	53753
.6	53824	53896	53968	54040	54112	54184	54256	54328	54400	54472
.7	54544	54616	54689	54761	54833	54906	54978	55050	55123	55196
.8	55268	55341	55413	55486	55559	55632	55705	55777	55850	55923
.9	55996	56070	56143	56216	56289	56362	56436	56509	56582	56656
1438.	56729	56803	56876	56950	57023	57097	5717	57244	57318	57392
.1	57466	57540	57614	57687	5776	57835	57910	57984	58058	58132
.2	58206	58280	58355	58429	58503	58578	58652	58727	58801	58876
.3	58950	59025	59099	59174	59249	59324	59398	59473	59548	59623
.4	59698	59773	59848	59923	59998	60073	60148	60224	60299	60374
.5	60449	60525	60600	60676	6075	60827	60902	60978	61053	61129
.6	61205	61280	61356	61432	61508	61584	61660	61736	61811	61888
.7	61964	62040	62116	62192	62268	62344	6242	62497	62573	62650
.8	62726	62803	62879	62956	63032	63109	63186	63262	63339	63416
.9	63493	63569	63646	63723	63800	63877	63954	64031	64108	64185
1439.	64263	64340	64417	64494	64572	64649	64726	64804	64881	64959
.1	65036	65114	65192	65269	65347	65425	65502	65580	65658	65736
.2	65814	65892	65970	66048	66126	66204	66282	66360	66438	66517
.3	66595	66673	66752	66830	66908	66987	67065	67144	67223	67301
.4	67380	67459	67537	67616	67695	67774	67853	67931	68010	68089
.5	68168	68248	68327	68406	68485	68564	68643	68723	68802	68881

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.6	68961	69040	69120	69199	69279	69358	69438	69518	69597	69677
.7	69757	69837	69916	69996	70076	70156	70236	70316	70396	70476
.8	70557	70637	70717	70797	70877	70958	71038	71119	71199	71279
.9	71360	71440	71521	71602	71682	71763	71844	71925	72005	72086
1440.	72167	72248	72329	72410	72491	72572	72653	72734	72815	72897
.1	72978	73059	73140	73222	73303	73385	73466	73548	73629	73711
.2	73792	73874	73956	74037	74119	74201	74283	74365	74446	74528
.3	74610	74692	74774	74856	74939	75021	75103	75185	75267	75350
.4	75432	75514	75597	75679	75762	75844	75927	76009	76092	76175
.5	76257	76340	76423	76506	76588	76671	76754	76837	76920	77003
.6	77086	77169	77252	77336	77419	77502	77585	77669	77752	77835
.7	77919	78002	78086	78169	78253	78336	78420	78504	78587	78671
.8	78755	78839	78922	79006	79090	79174	79258	79342	79426	79510
.9	79595	79679	79763	79847	79931	80016	80100	80184	80269	80353
1441.	80438	80522	80607	80692	80776	80861	80946	81030	81115	81200
.1	81285	81370	81455	81540	81625	81710	81795	81880	81965	82050
.2	82135	82221	82306	82391	82477	82562	82648	82733	82819	82904
.3	82990	83075	83161	83247	83332	83418	83504	83590	83676	83762
.4	83847	83933	84019	84105	84192	84278	84364	84450	84536	84623
.5	84709	84795	84882	84968	85054	85141	85227	85314	85401	85487
.6	85574	85661	85747	85834	85921	86008	86095	86182	86269	86356
.7	86443	86530	86617	86704	86791	86878	86966	87053	87140	87227
.8	87315	87402	87490	87577	87665	87752	87840	87928	88015	88103
.9	88191	88279	88366	88454	88542	88630	88718	88806	88894	88982
1442.	89070	89158	89247	89335	89423	89511	89600	89688	89776	89865
.1	89953	90042	90130	90219	90308	90396	90485	90574	90663	90751
.2	90840	90929	91018	91107	91196	91285	91374	91463	91552	91641
.3	91731	91820	91909	91998	92088	92177	92266	92356	92445	92535
.4	92624	92714	92804	92893	92983	93073	93163	93252	93342	93432
.5	93522	93612	93702	93792	93882	93972	94062	94153	94243	94333
.6	94423	94514	94604	94694	94785	94875	94966	95056	95147	95237
.7	95328	95419	95510	95600	95691	95782	95873	95964	96055	96146
.8	96237	96328	96419	96510	96601	96692	96783	96875	96966	97057
.9	97149	97240	97331	97423	97514	97606	97698	97789	97881	97973
1443.	98064	98156	98248	98340	98432	98523	98615	98707	98799	98891
.1	98984	99076	99168	99260	99352	99445	99537	99629	99722	99814
.2	99906	99999	100091	100184	100277	100369	100462	100555	100647	100740
.3	100833	100926	101019	101112	101205	101298	101391	101484	101577	101670
.4	101763	101856	101950	102043	102136	102230	102323	102416	102510	102603
.5	102697	102790	102884	102978	103071	103165	103259	103353	103446	103540
.6	103634	103728	103822	103916	104010	104104	104198	104293	104387	104481
.7	104575	104670	104764	104858	104953	105047	105142	105236	105331	105425
.8	105520	105614	105709	105804	105899	105993	106088	106183	106278	106373
.9	106468	106563	106658	106753	106848	106944	107039	107134	107229	107325
1444.	107420	107515	107611	107706	107802	107897	107993	108088	108184	108280

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.1	108375	108471	108567	108663	108759	108854	108950	109046	109142	109238
.2	109334	109430	109527	109623	109719	109815	109912	110008	110104	110201
.3	110297	110394	110490	110587	110683	110780	110876	110973	111070	111167
.4	111263	111360	111457	111554	111651	111748	111845	111942	112039	112136
.5	112233	112330	112428	112525	112622	112720	112817	112914	113012	113109
.6	113207	113304	113402	113500	113597	113695	113793	113890	113988	114086
.7	114184	114282	114380	114478	114576	114674	114772	114870	114968	115066
.8	115165	115263	115361	115460	115558	115656	115755	115853	115952	116050
.9	116149	116248	116346	116445	116544	116643	116741	116840	116939	117038
1445.	117137	117236	117335	117434	117533	117632	117732	117831	117930	118029
.1	118129	118228	118327	118427	118526	118626	118725	118825	118925	119024
.2	119124	119224	119323	119423	119523	119623	119723	119823	119923	120023
.3	120123	120223	120323	120423	120523	120624	120724	120824	120924	121025
.4	121125	121226	121326	121427	121527	121628	121728	121829	121930	122031
.5	122131	122232	122333	122434	122535	122636	122737	122838	122939	123040
.6	123141	123242	123343	123445	123546	123647	123749	123850	123951	124053
.7	124154	124256	124357	124459	124561	124662	124764	124866	124968	125069
.8	125171	125273	125375	125477	125579	125681	125783	125885	125987	126090
.9	126192	126294	126396	126499	126601	126703	126806	126908	127011	127113
1446.	127216	127319	127421	127524	127627	127729	127832	127935	128038	128141
.1	128244	128347	128450	128553	128656	128759	128862	128965	129069	129172
.2	129275	129379	129482	129585	129689	129792	129896	129999	130103	130207
.3	130310	130414	130518	130621	130725	130829	130933	131037	131141	131245
.4	131349	131453	131557	131661	131765	131870	131974	132078	132182	132287
.5	132391	132496	132600	132704	132809	132914	133018	133123	133228	133332
.6	133437	133542	133647	133751	133856	133961	134066	134171	134276	134381
.7	134486	134592	134697	134802	134907	135013	135118	135223	135329	135434
.8	135540	135645	135751	135856	135962	136068	136173	136279	136385	136490
.9	136596	136702	136808	136914	137020	137126	137232	137338	137444	137550
1447.	137657	137763	137869	137975	138082	138188	138295	138401	138508	138614
.1	138721	138827	138934	139041	139147	139254	139361	139468	139574	139681
.2	139788	139895	140002	140109	140216	140323	140431	140538	140645	140752
.3	140859	140967	141074	141182	141289	141396	141504	141611	141719	141827
.4	141934	142042	142150	142257	142365	142473	142581	142689	142797	142905
.5	143013	143121	143229	143337	143445	143553	143662	143770	143878	143986
.6	144095	144203	144312	144420	144529	144637	144746	144854	144963	145072
.7	145180	145289	145398	145507	145616	145725	145834	145943	146052	146161
.8	146270	146379	146488	146597	146706	146816	146925	147034	147144	147253
.9	147363	147472	147582	147691	147801	147910	148020	148130	148240	148349
1448.	148459	148569	148679	148789	148899	149009	149119	149229	149339	149449
.1	149559	149670	149780	149890	150000	150111	150221	150332	150442	150553
.2	150663	150774	150884	150995	151106	151216	151327	151438	151549	151660
.3	151770	151881	151992	152103	152214	152326	152437	152548	152659	152770
.4	152881	152993	153104	153215	153327	153438	153550	153661	153773	153884
.5	153996	154108	154219	154331	154443	154555	154667	154778	154890	155002

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.6	155114	155226	155338	155451	155563	155675	155787	155899	156012	156124
.7	156236	156349	156461	156573	156686	156798	156911	157024	157136	157249
.8	157362	157474	157587	157700	157813	157926	158039	158152	158265	158378
.9	158491	158604	158717	158830	158943	159057	159170	159283	159397	159510
1449.	159623	159737	159850	159964	160078	160191	160305	160419	160532	160646
.1	160760	160874	160988	161101	161215	161329	161443	161557	161671	161786
.2	161900	162014	162128	162242	162357	162471	162585	162700	162814	162929
.3	163043	163158	163272	163387	163502	163616	163731	163846	163961	164076
.4	164191	164305	164420	164535	164650	164765	164881	164996	165111	165226
.5	165341	165457	165572	165687	165803	165918	166034	166149	166265	166380
.6	166496	166611	166727	166843	166959	167074	167190	167306	167422	167538
.7	167654	167770	167886	168002	168118	168234	168350	168467	168583	168699
.8	168815	168932	169048	169165	169281	169398	169514	169631	169747	169864
.9	169981	170097	170214	170331	170448	170565	170682	170799	170916	171033
1450.	171150	171267	171384	171501	171618	171735	171853	171970	172087	172205
.1	172322	172440	172557	172675	172792	172910	173028	173145	173263	173381
.2	173499	173616	173734	173852	173970	174088	174206	174324	174442	174560
.3	174679	174797	174915	175033	175152	175270	175389	175507	175625	175744
.4	175863	175981	176100	176218	176337	176456	176575	176693	176812	176931
.5	177050	177169	177288	177407	177526	177645	177765	177884	178003	178122
.6	178242	178361	178480	178600	178719	178839	178958	179078	179197	179317
.7	179437	179556	179676	179796	179916	180036	180156	180276	180396	180516
.8	180636	180756	180876	180996	181116	181237	181357	181477	181598	181718
.9	181838	181959	182079	182200	182321	182441	182562	182683	182803	182924
1451.	183045	183166	183287	183408	183529	183650	183771	183892	184013	184134
.1	184255	184376	184498	184619	184740	184862	184983	185105	185226	185348
.2	185469	185591	185712	185834	185956	186078	186199	186321	186443	186565
.3	186687	186809	186931	187053	187175	187297	187419	187542	187664	187786
.4	187908	188031	188153	188276	188398	188521	188643	188766	188888	189011
.5	189134	189256	189379	189502	189625	189748	189871	189994	190117	190240
.6	190363	190486	190609	190732	190856	190979	191102	191225	191349	191472
.7	191596	191719	191843	191966	192090	192214	192337	192461	192585	192708
.8	192832	192956	193080	193204	193328	193452	193576	193700	193824	193948
.9	194073	194197	194321	194445	194570	194694	194819	194943	195068	195192
1452.	195317	195441	195566	195691	195815	195940	196065	196190	196315	196440
.1	196565	196690	196815	196940	197065	197190	197315	197440	197566	197691
.2	197816	197942	198067	198193	198318	198444	198569	198695	198820	198946
.3	199072	199198	199323	199449	199575	199701	199827	199953	200079	200205
.4	200331	200457	200583	200709	200836	200962	201088	201215	201341	201467
.5	201594	201720	201847	201974	202100	202227	202354	202480	202607	202734
.6	202861	202988	203114	203241	203368	203495	203623	203750	203877	204004
.7	204131	204258	204386	204513	204640	204768	204895	205023	205150	205278
.8	205405	205533	205661	205788	205916	206044	206172	206300	206428	206556
.9	206683	206811	206940	207068	207196	207324	207452	207580	207709	207837
1453.	207965	208094	208222	208351	208479	208608	208736	208865	208993	209122

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.1	209251	209380	209508	209637	209766	209895	210024	210153	210282	210411
.2	210540	210669	210798	210928	211057	211186	211316	211445	211574	211704
.3	211833	211963	212092	212222	212352	212481	212611	212741	212870	213000
.4	213130	213260	213390	213520	213650	213780	213910	214040	214170	214301
.5	214431	214561	214691	214822	214952	215082	215213	215343	215474	215605
.6	215735	215866	215996	216127	216258	216389	216520	216650	216781	216912
.7	217043	217174	217305	217436	217568	217699	217830	217961	218093	218224
.8	218355	218487	218618	218750	218881	219013	219144	219276	219407	219539
.9	219671	219803	219935	220066	220198	220330	220462	220594	220726	220858
1454.	220990	221123	221255	221387	221519	221652	221784	221916	222049	222181
.1	222314	222446	222579	222711	222844	222977	223109	223242	223375	223508
.2	223641	223774	223906	224039	224172	224306	224439	224572	224705	224838
.3	224971	225105	225238	225371	225505	225638	225772	225905	226039	226172
.4	226306	226440	226573	226707	226841	226975	227108	227242	227376	227510
.5	227644	227778	227912	228046	228181	228315	228449	228583	228718	228852
.6	228986	229121	229255	229390	229524	229659	229793	229928	230063	230197
.7	230332	230467	230602	230737	230871	231006	231141	231276	231411	231546
.8	231682	231817	231952	232087	232223	232358	232493	232629	232764	232899
.9	233035	233171	233306	233442	233577	233713	233849	233985	234120	234256
1455.	234392	234528	234664	234800	234936	235072	235208	235344	235481	235617
.1	235753	235889	236026	236162	236299	236435	236572	236708	236845	236981
.2	237118	237255	237391	237528	237665	237802	237939	238076	238213	238350
.3	238487	238624	238761	238898	239036	239173	239310	239448	239585	239722
.4	239860	239997	240135	240272	240410	240548	240685	240823	240961	241099
.5	241237	241375	241512	241650	241788	241927	242065	242203	242341	242479
.6	242617	242756	242894	243032	243171	243309	243448	243586	243725	243864
.7	244002	244141	244280	244418	244557	244696	244835	244974	245113	245252
.8	245391	245530	245669	245808	245947	246087	246226	246365	246505	246644
.9	246784	246923	247063	247202	247342	247481	247621	247761	247901	248040
1456.	248180	248320	248460	248600	248740	248880	249020	249160	249300	249441
.1	249581	249721	249861	250002	250142	250283	250423	250564	250704	250845
.2	250985	251126	251267	251407	251548	251689	251830	251971	252112	252253
.3	252394	252535	252676	252817	252958	253100	253241	253382	253524	253665
.4	253806	253948	254089	254231	254372	254514	254656	254797	254939	255081
.5	255223	255365	255507	255649	255790	255933	256075	256217	256359	256501
.6	256643	256785	256928	257070	257212	257355	257497	257640	257782	257925
.7	258068	258210	258353	258496	258638	258781	258924	259067	259210	259353
.8	259496	259639	259782	259925	260068	260212	260355	260498	260641	260785
.9	260928	261072	261215	261359	261502	261646	261790	261933	262077	262221
1457.	262364	262508	262652	262796	262940	263084	263228	263372	263516	263661
.1	263805	263949	264093	264238	264382	264526	264671	264815	264960	265104
.2	265249	265394	265538	265683	265828	265972	266117	266262	266407	266552
.3	266697	266842	266987	267132	267277	267423	267568	267713	267858	268004
.4	268149	268295	268440	268586	268731	268877	269022	269168	269314	269459
.5	269605	269751	269897	270043	270189	270335	270481	270627	270773	270919

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.6	271065	271211	271358	271504	271650	271797	271943	272090	272236	272383
.7	272529	272676	272823	272969	273116	273263	273410	273556	273703	273850
.8	273997	274144	274291	274438	274585	274733	274880	275027	275174	275322
.9	275469	275617	275764	275911	276059	276207	276354	276502	276649	276797
1458.	276945	277093	277241	277389	277536	277684	277832	277980	278129	278277
.1	278425	278573	278721	278870	279018	279166	279315	279463	279612	279760
.2	279909	280057	280206	280355	280503	280652	280801	280950	281099	281247
.3	281396	281545	281694	281844	281993	282142	282291	282440	282589	282739
.4	282888	283038	283187	283336	283486	283635	283785	283935	284084	284234
.5	284384	284534	284683	284833	284983	285133	285283	285433	285583	285733
.6	285883	286034	286184	286334	286484	286635	286785	286936	287086	287237
.7	287387	287538	287688	287839	287990	288140	288291	288442	288593	288744
.8	288895	289046	289197	289348	289499	289650	289801	289952	290104	290255
.9	290406	290558	290709	290860	291012	291163	291315	291467	291618	291770
1459.	291922	292073	292225	292377	292529	292681	292833	292985	293137	293289
.1	293441	293593	293746	293898	294050	294202	294355	294507	294660	294812
.2	294965	295117	295270	295422	295575	295728	295881	296033	296186	296339
.3	296492	296645	296798	296951	297104	297257	297410	297563	297717	297870
.4	298023	298177	298330	298483	298637	298790	298944	299098	299251	299405
.5	299559	299712	299866	300020	300174	300328	300482	300636	300790	300944
.6	301098	301252	301406	301560	301715	301869	302023	302178	302332	302487
.7	302641	302796	302950	303105	303260	303414	303569	303724	303879	304033
.8	304188	304343	304498	304653	304808	304963	305119	305274	305429	305584
.9	305739	305895	306050	306206	306361	306517	306672	306828	306983	307139
1460.	307295	307450	307606	307762	307918	308074	308230	308386	308542	308698
.1	308854	309010	309166	309322	309479	309635	309791	309948	310104	310261
.2	310417	310574	310730	310887	311044	311201	311357	311514	311671	311828
.3	311985	312142	312299	312456	312613	312770	312928	313085	313242	313399
.4	313557	313714	313872	314029	314187	314344	314502	314660	314817	314975
.5	315133	315291	315449	315607	315765	315923	316081	316239	316397	316555
.6	316713	316872	317030	317188	317347	317505	317664	317822	317981	318139
.7	318298	318457	318615	318774	318933	319092	319251	319410	319569	319728
.8	319887	320046	320205	320364	320524	320683	320842	321002	321161	321321
.9	321480	321640	321799	321959	322118	322278	322438	322598	322758	322917
1461.	323077	323237	323397	323557	323718	323878	324038	324198	324358	324519
.1	324679	324839	325000	325160	325321	325481	325642	325803	325963	326124
.2	326285	326446	326606	326767	326928	327089	327250	327411	327572	327734
.3	327895	328056	328217	328379	328540	328701	328863	329024	329186	329347
.4	329509	329671	329832	329994	330156	330318	330480	330642	330804	330966
.5	331128	331290	331452	331614	331776	331938	332101	332263	332425	332588
.6	332750	332913	333075	333238	333401	333563	333726	333889	334052	334214
.7	334377	334540	334703	334866	335029	335192	335356	335519	335682	335845
.8	336009	336172	336335	336499	336662	336826	336989	337153	337317	337480
.9	337644	337808	337972	338136	338299	338463	338627	338791	338955	339120
1462.	339284	339448	339612	339776	339941	340105	340270	340434	340599	340763

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.1	340928	341092	341257	341422	341586	341751	341916	342081	342246	342411
.2	342576	342741	342906	343071	343236	343402	343567	343732	343897	344063
.3	344228	344394	344559	344725	344890	345056	345222	345388	345553	345719
.4	345885	346051	346217	346383	346549	346715	346881	347047	347213	347380
.5	347546	347712	347878	348045	348211	348378	348544	348711	348878	349044
.6	349211	349378	349544	349711	349878	350045	350212	350379	350546	350713
.7	350880	351047	351215	351382	351549	351717	351884	352051	352219	352386
.8	352554	352721	352889	353057	353224	353392	353560	353728	353896	354064
.9	354232	354400	354568	354736	354904	355072	355240	355409	355577	355745
1463.	355914	356082	356251	356419	356588	356756	356925	357094	357262	357431
.1	357600	357769	357938	358107	358276	358445	358614	358783	358952	359121
.2	359291	359460	359629	359799	359968	360137	360307	360476	360646	360816
.3	360985	361155	361325	361495	361664	361834	362004	362174	362344	362514
.4	362684	362854	363025	363195	363365	363535	363706	363876	364047	364217
.5	364388	364558	364729	364899	365070	365241	365412	365582	365753	365924
.6	366095	366266	366437	366608	366779	366950	367122	367293	367464	367635
.7	367807	367978	368150	368321	368493	368664	368836	369008	369179	369351
.8	369523	369695	369866	370038	370210	370382	370554	370726	370899	371071
.9	371243	371415	371588	371760	371932	372105	372277	372450	372622	372795
1464.	372967	373140	373313	373486	373658	373831	374004	374177	374350	374523
.1	374696	374869	375042	375215	375389	375562	375735	375909	376082	376255
.2	376429	376602	376776	376950	377123	377297	377471	377644	377818	377992
.3	378166	378340	378514	378688	378862	379036	379210	379385	379559	379733
.4	379907	380082	380256	380431	380605	380780	380954	381129	381304	381478
.5	381653	381828	382003	382178	382352	382527	382702	382877	383053	383228
.6	383403	383578	383753	383929	384104	384279	384455	384630	384806	384981
.7	385157	385333	385508	385684	385860	386036	386211	386387	386563	386739
.8	386915	387091	387267	387444	387620	387796	387972	388149	388325	388501
.9	388678	388854	389031	389207	389384	389561	389737	389914	390091	390268
1465.	390445	390621	390798	390975	391152	391330	391507	391684	391861	392038
.1	392216	392393	392570	392748	392925	393103	393281	393458	393636	393814
.2	393991	394169	394347	394525	394703	394881	395059	395237	395415	395593
.3	395772	395950	396128	396307	396485	396664	396842	397021	397199	397378
.4	397556	397735	397914	398093	398272	398451	398630	398809	398988	399167
.5	399346	399525	399704	399884	400063	400242	400422	400601	400781	400960
.6	401140	401319	401499	401679	401859	402038	402218	402398	402578	402758
.7	402938	403118	403298	403479	403659	403839	404019	404200	404380	404561
.8	404741	404922	405102	405283	405464	405644	405825	406006	406187	406368
.9	406549	406730	406911	407092	407273	407454	407635	407817	407998	408179
1466.	408361	408542	408724	408905	409087	409268	409450	409632	409814	409995
.1	410177	410359	410541	410723	410905	411087	411269	411452	411634	411816
.2	411998	412181	412363	412546	412728	412911	413093	413276	413459	413641
.3	413824	414007	414190	414373	414556	414739	414922	415105	415288	415471
.4	415654	415838	416021	416204	416388	416571	416755	416938	417122	417305

ELEV	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
.5	417489	417673	417857	418040	418224	418408	418592	418776	418960	419144
.6	419328	419513	419697	419881	420065	420250	420434	420619	420803	420988
.7	421172	421357	421542	421726	421911	422096	422281	422466	422651	422836
.8	423021	423206	423391	423576	423761	423947	424132	424317	424503	424688
.9	424874	425059	425245	425430	425616	425802	425988	426173	426359	426545
1467.	426731	-426917	427103	427289	427475	427662	427848	428034	428220	428407
.1	428593	428780	428966	429153	429339	429526	429712	429899	430086	430273
.2	430460	430647	430834	431020	431208	431395	431582	431769	431956	432143
.3	432331	432518	432706	432893	433080	433268	433456	433643	433831	434019
.4	434206	434394	434582	434770	434958	435146	435334	435522	435710	435898
.5	436087	436275	436463	436652	436840	437028	437217	437405	437594	437783
.6	437971	438160	438349	438538	438726	438915	439104	439293	439482	439671
.7	439861	-440050	440239	440428	440618	440807	440996	441186	441375	441565
.8	441754	441944	442134	442323	442513	442703	442893	443083	443273	443463
.9	443653	443843	444033	444223	444413	444604	444794	444984	445175	445365
1468.	445556	445746	445937	446127	446318	446509	446700	446890	447081	447272
.1	447463	447654	447845	448036	448227	448419	448610	448801	448992	449184
.2	449375	449567	449758	449950	450141	450333	450524	450716	450908	451100
.3	451292	451484	451676	451868	452060	452252	452444	452636	452828	453020
.4	453213	453405	453598	453790	453982	454175	454368	454560	454753	454946
.5	455138	455331	455524	455717	455910	456103	456296	456489	456682	456875
.6	457068	457262	457455	457648	457842	458035	458229	458422	458616	458810
.7	459003	459197	459391	459584	459778	459972	460166	460360	460554	460748
.8	460942	461137	461331	461525	461719	461914	462108	462303	462497	462692
.9	462886	463081	463276	463470	463665	463860	464055	464250	464445	464640
1469.	464835	465030	465225	465420	465615	465810	466006	466201	466397	466592
.1	466788	466983	467179	467374	467570	467766	467962	468157	468353	468549
.2	468745	468941	469137	469333	469530	469726	469922	470118	470315	470511
.3	470708	470904	471101	471297	471494	471691	471887	472084	472281	472478
.4	472675	472872	473069	473266	473463	473660	473857	474055	474252	474449
.5	474647	474844	475042	475239	475437	475635	475832	476030	476228	476426
.6	476623	476821	477019	477217	477415	477614	477812	478010	478208	478407
.7	478605	478803	479002	479200	479399	479597	479796	479995	480193	480392
.8	480591	480790	480989	481188	481387	481586	481785	481984	482183	482383
.9	482582	482781	482981	483180	483380	483579	483779	483978	484178	484378
1470.	484578									

EXHIBIT 5

ARROWWOOD NATIONAL WILDLIFE REFUGE

AREA AND CAPACITY TABLES

ARROWWOOD LAKE
AREA AND CAPACITY TABLES
1985 SURVEY

***Area-capacity table were computed prior to construction of the mitigation features and are not accurate.**

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1429	0	0	0	0	72	144	216	288	360	431
1430	503	567	630	693	757	820	883	946	1010	1073
1431	1136	1154	1171	1189	1207	1224	1242	1260	1277	1295
1432	1212	1321	1330	1338	1347	1356	1364	1373	1381	1390
1433	1399	1406	1414	1421	1429	1436	1444	1452	1459	1467
1434	1474	1482	1490	1498	1506	1514	1522	1530	1538	1546
1435	1554	1566	1578	1590	1602	1614	1626	1638	1650	1662
1436	1674	1678	1683	1688	1693	1697	1702	1707	1711	1716
1437	1721	1726	1730	1735	1740	1745	1749	1754	1759	1764
1438	1768	1773	1778	1782	1787	1792	1797	1801	1806	1811
1439	1816	1820	1825	1830	1835	1839	1844	1849	1853	1858
1440	1863									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1429	0	0	0	0	4	14	32	58	90	129
1430	176	230	290	356	428	507	592	684	781	886
1431	996	1110	1227	1345	1465	1586	1709	1835	1961	2090
1432	2220	2352	2485	2618	2752	2887	3023	3160	3298	3436
1433	3576	3716	3857	3999	4141	4285	4429	4573	4719	4865
1434	5012	5160	5309	5458	5608	5759	5911	6064	6217	6371
1435	6526	6682	6839	6998	7157	7318	7480	7643	7807	7973
1436	8140	8307	8475	8644	8813	8983	9152	9323	9494	9665
1437	9837	10009	10182	10355	10529	10703	10878	11053	11229	11405
1438	11582	11759	11936	12114	12293	12472	12651	12831	13011	13192
1439	13374	13555	13738	13920	14104	14287	14471	14656	14841	15027
1440	15213									

BYPASS CHANNEL
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1428	0.72	1.08	1.48	1.93	2.42	2.97	3.56	4.19	4.87	5.60
1429	8.88	10.11	11.37	12.65	13.97	15.32	16.70	18.11	19.55	21.02
1430	32.55	35.64	38.77	41.95	45.18	48.45	51.77	55.14	58.56	62.02
1431	68.48	70.26	72.05	73.86	75.70	77.55	79.43	81.32	83.24	85.18
1432	90.38	92.90	95.42	97.95	100.49	103.02	105.56	108.11	110.66	113.21
1433	116.87	119.12	121.36	123.58	125.79	127.99	130.17	132.35	134.51	136.65
1434	139.02	140.83	142.64	144.46	146.29	148.12	149.95	151.79	153.64	155.49
1435	160.62	162.39	164.16	165.92	167.68	169.44	171.20	172.94	174.69	176.43
1436	178.97	180.55	182.15	183.76	185.38	187.02	188.67	190.33	192.01	193.70
1437	197.07	198.87	200.68	202.50	204.34	206.20	208.07	209.95	211.85	213.76
1438	216.80	218.74	220.70	222.66	224.64	226.63	228.63	230.65	232.68	234.73
1439	237.40	239.43	241.46	243.50	245.55	247.59	249.65	251.70	253.76	255.83
1440	257.90									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1428	0.00	0.08	0.20	0.37	0.58	0.84	1.15	1.53	1.97	2.48
1429	3.15	4.08	5.14	6.32	7.62	9.07	10.64	12.36	14.22	16.22
1430	18.71	22.07	25.74	29.72	34.02	38.65	43.60	48.89	54.52	60.49
1431	66.91	73.82	80.90	88.17	95.62	103.25	111.07	119.07	127.27	135.66
1432	144.35	153.47	162.85	172.47	182.35	192.49	202.87	213.51	224.41	235.56
1433	247.00	258.77	270.75	282.96	295.40	308.05	320.92	334.01	347.32	360.84
1434	374.58	388.55	402.69	417.01	431.52	446.21	461.08	476.14	491.38	506.81
1435	522.53	538.65	554.95	571.42	588.07	604.90	621.91	639.08	656.44	673.96
1436	691.69	709.64	727.75	746.02	764.45	783.04	801.80	820.72	839.81	859.07
1437	878.55	898.32	918.27	938.40	958.71	979.21	999.89	1020.76	1041.82	1063.07
1438	1084.54	1106.29	1128.23	1150.36	1172.70	1195.23	1217.96	1240.89	1264.02	1287.36
1439	1310.92	1334.73	1358.74	1382.96	1407.38	1432.00	1456.83	1481.86	1507.10	1532.55
1440	1558.20									

DEPUY MARSH
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1430	0.96	1.01	1.07	1.12	1.17	1.22	1.26	1.31	1.35	1.39
1431	2.85	2.96	3.06	3.18	3.30	3.42	3.54	3.68	3.81	3.95
1432	10.73	13.31	16.36	19.87	23.84	28.27	33.17	38.52	44.34	50.61
1433	95.96	103.51	110.97	118.33	125.59	132.75	139.82	146.78	153.65	160.42
1434	174.75	177.29	180.26	183.20	186.10	188.95	191.77	194.55	197.29	199.99
1435	214.82	216.10	217.36	218.61	219.83	221.04	222.23	223.40	224.56	225.69
1436	227.39	228.44	229.24	230.03	230.82	231.60	232.37	233.14	233.90	234.65
1437	235.63	236.30	236.95	237.60	238.25	238.89	239.52	240.14	240.76	241.37
1438	242.08	242.64	243.20	243.75	244.27	244.82	245.36	245.90	246.43	230.82
1439	247.56									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1430	0.00	0.10	0.20	0.31	0.42	0.54	0.67	0.79	0.92	1.06
1431	1.25	1.54	1.84	2.14	2.47	2.80	3.15	3.51	3.88	4.26
1432	4.89	6.05	7.47	9.23	11.35	13.89	16.88	20.37	24.41	29.06
1433	35.64	45.48	56.08	67.42	79.49	92.29	105.81	120.02	134.92	150.52
1434	167.04	184.60	202.43	220.56	238.97	257.67	276.67	295.94	315.49	335.31
1435	355.79	377.32	398.97	420.76	442.65	464.68	486.83	509.09	531.46	553.96
1436	576.59	599.36	622.23	645.18	668.21	691.32	714.51	737.77	761.11	784.52
1437	808.02	831.60	855.26	878.98	902.76	926.61	950.52	974.49	998.52	1022.62
1438	1046.78	1071.01	1095.30	1119.63	1144.02	1168.47	1192.97	1217.53	1242.13	1266.26
1439	1281.64									

JIM LAKE
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1428	179.39	195.70	211.80	227.69	243.36	258.82	274.07	289.10	303.92	318.53
1429	333.82	345.13	356.78	368.76	381.07	393.71	406.68	419.98	433.62	447.58
1430	496.96	477.59	488.46	499.49	510.68	522.03	533.54	545.21	557.04	569.03
1431	593.01	596.55	600.07	603.59	607.10	610.59	614.08	617.56	621.03	624.48
1432	632.32	635.18	638.12	641.13	644.22	647.38	650.63	653.94	657.34	660.81
1433	665.10	667.35	669.59	671.83	674.06	676.29	678.52	680.73	682.95	685.16
1434	688.74	690.72	692.69	694.67	696.64	698.62	700.59	702.57	704.54	706.51
1435	709.58	711.50	713.38	715.24	717.07	718.87	720.64	722.37	724.08	725.76
1436	727.56	729.10	730.65	732.20	733.75	735.30	736.84	738.39	739.94	741.48
1437	746.33	747.53	748.73	749.91	751.09	752.26	753.42	754.58	755.73	756.87
1438	758.37	759.60	760.82	762.04	763.27	764.49	765.71	766.93	768.15	769.36
1439	770.54									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1428	0.00	18.48	38.59	60.30	83.59	108.44	134.83	162.74	192.14	223.03
1429	255.66	289.43	324.33	360.41	397.70	436.22	476.02	517.13	559.59	603.42
1430	649.93	699.42	747.54	796.75	847.08	898.54	951.11	1004.85	1059.78	1115.89
1431	1179.96	1239.38	1299.16	1359.27	1419.74	1480.59	1541.76	1603.29	1665.16	1727.38
1432	1809.51	1872.83	1936.46	2000.37	2064.58	2129.11	2193.96	2259.13	2324.64	2390.49
1433	2458.87	2525.45	2592.26	2659.30	2726.57	2794.04	2861.75	2929.68	2997.83	3066.20
1434	3134.83	3203.77	3272.92	3342.25	3411.78	3481.52	3551.44	3621.57	3691.90	3762.42
1435	3833.17	3904.20	3975.41	4046.81	4118.40	4190.17	4262.12	4334.24	4406.52	4479.00
1436	4551.63	4624.45	4697.41	4770.52	4843.80	4917.23	4990.81	5064.55	5138.43	5212.48
1437	5293.34	5368.02	5442.82	5517.72	5592.76	5667.91	5743.18	5818.56	5894.05	5969.66
1438	6045.41	6121.29	6197.29	6273.41	6349.66	6426.03	6502.52	6579.13	6655.86	6732.73
1439	6784.39									

MIDDLE MUD
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1433	27.82	28.65	29.49	30.34	31.21	32.10	33.00	33.92	34.86	35.81
1434	37.03	37.41	37.79	38.18	38.57	38.96	39.35	39.74	40.14	40.54
1435	41.62	42.25	42.90	43.57	44.26	44.98	45.71	46.47	47.25	48.05
1436	50.52	51.27	52.04	52.83	53.64	54.47	55.32	56.18	57.07	57.98
1437	60.10	60.94	61.76	62.57	63.35	64.12	64.87	65.61	66.32	67.02
1438	69.61	70.57	71.50	72.40	73.27	74.10	74.90	75.67	76.40	77.10
1439	79.85									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1433	0	2.81	5.71	8.68	11.75	14.9	18.13	21.46	24.89	28.41
1434	32.02	35.74	39.5	43.29	47.12	50.98	54.89	58.85	62.83	66.86
1435	70.95	75.13	79.38	83.69	88.07	92.52	97.04	101.64	106.31	111.07
1436	115.96	121.03	126.18	131.41	136.72	142.12	147.6	153.15	158.81	164.54
1437	170.41	176.45	182.56	188.77	195.05	201.41	207.85	214.37	220.95	227.6
1438	234.39	241.38	248.47	255.66	262.92	270.27	277.72	285.23	292.82	300.49
1439	305.24									

MUD LAKE
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1430	64.95	66.77	68.62	70.52	72.45	74.43	76.45	78.51	80.62	82.76
1431	87.40	89.05	90.72	92.38	94.06	95.74	97.43	99.12	100.82	102.53
1432	104.59	105.96	107.34	108.75	110.16	111.59	113.04	114.50	115.98	117.47
1433	119.63	122.63	125.72	128.90	132.18	135.56	139.02	142.58	146.24	149.98
1434	154.60	157.37	160.19	163.06	165.97	168.93	171.93	174.98	178.08	181.23
1435	204.39	206.36	208.48	210.73	213.13	215.68	218.36	221.19	224.16	227.27
1436	236.07	239.03	242.01	245.03	248.08	251.16	254.27	257.41	260.59	263.79
1437	268.98	272.41	275.84	279.29	282.74	286.20	289.67	293.15	296.64	300.13
1438	308.09	311.73	315.35	318.94	322.51	326.04	329.56	333.04	337.74	341.15
1439	348.87									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1430	0.00	6.56	13.29	20.22	27.34	34.65	42.16	49.87	57.79	65.93
1431	74.36	83.15	92.12	101.24	110.54	120.00	129.63	139.43	149.40	159.54
1432	169.86	180.36	191.00	201.79	212.71	223.77	234.98	246.33	257.83	269.48
1433	281.37	293.43	305.79	318.47	331.47	344.80	358.48	372.50	386.87	401.62
1434	416.79	432.34	448.17	464.29	480.69	497.39	514.37	531.67	549.28	567.19
1435	586.23	606.74	627.45	648.37	669.52	690.92	712.57	734.51	756.72	779.25
1436	802.27	825.98	849.98	874.29	898.88	923.80	949.02	974.55	1000.40	1026.56
1437	1053.19	1080.20	1107.56	1135.26	1163.31	1191.69	1220.43	1249.52	1278.95	1308.73
1438	1339.20	1370.12	1401.42	1433.08	1465.09	1497.45	1530.19	1563.24	1596.71	1630.62
1439	1673.17									

NORTH DEPUY
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1432	3.81	3.94	4.07	4.22	4.38	4.55	4.74	4.93	5.14	5.36
1433	13.82	17.45	21.15	24.93	28.78	32.71	36.71	40.79	44.94	49.17
1434	58.59	59.63	60.67	61.72	62.76	63.79	64.83	65.87	66.90	67.94
1435	69.84	70.69	71.52	72.32	73.09	73.84	74.56	75.26	75.93	76.57
1436	79.72	79.93	80.13	80.33	80.54	80.75	80.95	81.16	81.38	81.59
1437	81.83	82.02	82.22	82.41	82.61	82.80	83.00	83.19	83.39	83.58
1438	83.80	83.95	84.11	84.26	84.41	84.56	84.72	84.87	85.02	85.17
1439	85.34	85.49	85.64	85.78	85.93	86.07	86.22	86.37	86.51	86.66
1440	86.81									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1432	0.00	0.39	0.78	1.20	1.62	2.07	2.53	3.01	3.51	4.03
1433	4.85	6.35	8.22	10.46	13.08	16.09	19.50	23.30	27.52	32.16
1434	37.39	43.28	49.28	55.38	61.59	67.90	74.31	80.83	87.45	94.18
1435	101.22	108.24	115.33	122.51	129.77	137.10	144.51	151.99	159.54	167.15
1436	174.92	182.90	190.90	198.91	206.95	215.02	223.10	231.20	239.33	247.47
1437	255.63	263.82	272.04	280.26	288.51	296.77	305.07	313.37	321.70	330.04
1438	338.41	346.80	355.19	363.61	372.04	380.49	388.95	397.42	405.92	414.43
1439	427.51	436.05	444.60	453.17	461.76	470.35	478.97	487.59	496.24	504.89
1440	513.56									

NORTH JIM
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1431	0.60	0.81	1.07	1.39	1.76	2.19	2.67	3.20	3.79	4.43
1432	12.89	15.66	18.47	21.33	24.23	27.18	30.17	33.20	36.28	39.40
1433	42.64	43.40	44.19	45.01	45.85	46.72	47.61	48.53	49.48	50.45
1434	51.57	52.18	52.79	53.41	54.04	54.67	55.31	55.95	56.61	57.26
1435	58.89	59.63	60.41	61.21	62.05	62.91	63.81	64.74	65.69	66.68
1436	68.54	69.34	70.17	71.01	71.88	72.77	73.68	74.62	75.58	76.56
1437	82.10	82.61	83.14	83.68	84.24	84.80	85.38	85.97	86.57	87.19
1438	88.67	89.94	91.16	92.33	93.46	94.53	95.55	96.52	97.45	98.32
1439	100.78									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1431	0.00	0.07	0.16	0.28	0.43	0.62	0.85	1.14	1.48	1.88
1432	2.60	3.98	5.64	7.59	9.82	12.34	15.15	18.27	21.70	25.43
1433	30.77	35.06	39.43	43.87	48.40	53.02	57.72	62.51	67.40	72.38
1434	77.46	82.63	87.88	93.18	98.54	103.96	109.45	115.00	120.62	126.30
1435	132.08	138.00	143.98	150.05	156.20	162.43	168.76	175.17	181.67	188.28
1436	194.17	201.05	208.00	215.05	222.18	229.40	236.70	244.11	251.60	259.19
1437	267.04	275.26	283.54	291.87	300.26	308.70	317.21	325.76	334.37	343.05
1438	351.82	360.74	369.77	378.92	388.20	397.57	407.06	416.65	426.33	436.11
1439	446.02									

NORTH MUD
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1432	14.01	14.81	15.59	16.36	17.12	17.86	18.58	19.29	19.98	20.66
1433	21.44	21.76	22.08	22.40	22.72	23.04	23.37	23.70	24.02	24.35
1434	24.97	25.30	25.63	25.96	26.31	26.65	27.00	27.36	27.72	28.09
1435	28.64	29.07	29.51	29.94	30.38	30.83	31.27	31.72	32.17	32.63
1436	33.67	34.51	35.37	36.23	37.11	37.99	38.88	39.78	40.68	41.60
1437	43.85	44.97	46.08	47.17	48.25	49.33	50.39	51.43	52.47	53.49
1438	56.52	57.63	58.74	59.85	60.96	62.07	63.19	64.31	65.44	66.57
1439	74.29									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1432	0.00	1.43	2.93	4.52	6.18	7.92	9.73	11.61	13.56	15.58
1433	19.48	21.63	23.81	26.04	28.29	30.57	32.89	35.23	37.62	40.03
1434	42.50	45.00	47.55	50.13	52.72	55.36	58.05	60.77	63.52	66.30
1435	68.81	71.69	74.61	77.58	80.58	83.64	86.73	89.88	93.06	96.30
1436	99.60	102.99	106.47	110.04	113.68	117.41	121.26	125.17	129.17	133.28
1437	137.52	141.93	146.46	151.12	155.85	160.72	165.69	170.76	175.93	181.22
1438	187.05	192.75	198.55	204.45	210.48	216.60	222.85	229.22	235.68	242.26
1439	248.31									

SOUTH ARROWWOOD
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1437	0.31	0.51	0.76	1.09	1.48	1.93	2.45	3.04	3.69	4.40
1438	7.30	7.54	7.78	8.02	8.27	8.52	8.77	9.03	9.28	9.55
1439	9.99	10.08	10.18	10.28	10.38	10.48	10.59	10.69	10.80	10.92
1440	11.07	11.14	11.21	11.28	11.35	11.42	11.49	11.56	11.62	11.69
1441	11.78	11.83	11.88	11.93	11.98	12.03	12.08	12.13	12.18	12.23
1442	12.29									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1437	0.00	0.04	0.10	0.18	0.31	0.47	0.68	0.94	1.27	1.66
1438	2.21	2.95	3.70	4.49	5.30	6.14	7.00	7.89	8.80	9.74
1439	10.71	11.71	12.73	13.74	14.77	15.81	16.86	17.94	19.00	20.08
1440	21.18	22.30	23.40	24.54	25.66	26.80	27.94	29.09	30.25	31.42
1441	32.59	33.76	34.95	36.14	37.34	38.54	39.75	40.95	42.16	43.38
1442	44.81									

SOUTH JIM
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1433	0.72	0.76	0.80	0.85	0.90	0.95	1.01	1.07	1.14	1.21
1434	7.94	9.18	10.43	11.68	12.94	14.20	15.46	16.73	18.00	19.28
1435	21.73	22.37	23.00	23.63	24.26	24.89	25.51	26.13	26.75	27.36
1436	28.68	29.30	29.92	30.54	31.16	31.79	32.42	33.04	33.68	34.31
1437	35.65	35.91	36.17	36.41	36.65	36.86	37.07	37.27	37.45	37.62
1438	38.06	38.17	38.28	38.39	38.50	38.61	38.71	38.82	38.92	39.02
1439	39.13	39.25	39.36	39.47	39.57	39.68	39.79	39.89	40.00	40.10
1440	40.24	40.33	40.42	40.51	40.60	40.69	40.78	40.87	40.96	41.05
1441	41.14									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1433	0.00	0.07	0.15	0.23	0.32	0.41	0.51	0.61	0.72	0.84
1434	1.18	2.02	2.98	4.06	5.27	6.61	8.07	9.66	11.37	13.22
1435	15.23	17.42	19.68	22.00	24.38	26.83	29.34	31.91	34.55	37.24
1436	40.02	42.91	45.86	48.87	51.95	55.08	58.28	61.55	64.87	68.26
1437	71.77	75.34	78.95	82.57	86.22	89.89	93.59	97.29	101.03	104.79
1438	109.06	112.87	116.69	120.53	124.37	128.22	132.09	135.96	139.85	143.74
1439	147.65	151.57	155.49	159.43	163.38	167.35	171.32	175.30	179.29	183.30
1440	187.31	191.34	195.37	199.42	203.47	207.54	211.61	215.69	219.78	223.88
1441	227.99									

SOUTH MUD
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1432	1.71	2.21	2.93	3.88	5.06	6.46	8.10	9.95	12.04	14.35
1433	24.79	25.48	26.16	26.84	27.51	28.16	28.82	29.46	30.09	30.72
1434	33.48	34.43	35.45	36.54	37.69	38.90	40.18	41.52	42.93	44.41
1435	51.80	53.84	55.92	58.04	60.21	62.43	64.68	66.98	69.32	71.71
1436	76.69	78.50	80.24	81.92	83.53	85.08	86.56	87.98	89.34	90.63
1437	94.35	95.28	96.17	97.01	97.82	98.58	99.30	99.98	100.63	101.23
1438	102.46	102.78	103.10	103.41	103.72	104.02	104.32	104.61	104.90	105.18
1439	105.46									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1432	0.00	0.19	0.43	0.76	1.18	1.74	2.44	3.31	4.37	5.66
1433	8.95	11.45	14.03	16.67	19.37	22.14	24.98	27.89	30.86	33.89
1434	37.03	40.41	43.88	47.47	51.15	54.98	58.90	62.97	67.16	71.50
1435	73.20	78.45	83.90	89.57	95.44	101.53	107.85	114.40	121.17	128.18
1436	135.52	143.25	151.16	159.24	167.49	175.89	184.45	193.15	202.00	210.98
1437	220.17	229.62	239.18	248.83	258.56	268.36	278.25	288.21	298.22	308.30
1438	318.47	328.73	339.02	349.34	359.69	370.07	380.48	390.92	401.40	411.89
1439	422.43									

SOUTHEAST ARROWWOOD
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1434	0.40	0.41	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49
1435	0.50	0.52	0.54	0.57	0.59	0.63	0.66	0.70	0.74	0.79
1436	1.04	1.09	1.14	1.20	1.25	1.31	1.36	1.41	1.47	1.53
1437	1.84	1.94	2.03	2.13	2.23	2.32	2.41	2.51	2.60	2.69
1438	2.93	3.01	3.08	3.16	3.23	3.31	3.39	3.46	3.54	3.62
1439	3.70									

Capacity in Acre-Feet

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1434	0.00	0.04	0.08	0.12	0.17	0.21	0.26	0.30	0.35	0.40
1435	0.45	0.50	0.55	0.61	0.66	0.72	0.79	0.86	0.93	1.00
1436	1.09	1.20	1.31	1.42	1.55	1.67	1.80	1.94	2.09	2.23
1437	2.40	2.58	2.78	2.99	3.20	3.43	3.66	3.91	4.16	4.43
1438	4.70	5.00	5.30	5.61	5.93	6.26	6.59	6.93	7.28	7.64
1439	8.00									

STONY BROOK
AREA AND CAPACITY TABLES
COMPUTED 2007

Area in Acres

Elev. (feet NGVD29)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1433	1.09	1.87	2.86	4.05	5.44	7.03	8.82	10.81	13.01	15.40
1434	20.62	20.77	20.92	21.08	21.24	21.40	21.57	21.73	21.90	22.07
1435	22.24	22.42	22.59	22.77	22.95	23.13	23.32	23.51	23.70	23.89
1436	85.51	85.41	85.53	85.87	86.45	87.25	88.28	89.54	91.02	92.73
1437	96.63	97.00	97.38	97.77	98.17	98.59	99.03	99.48	99.94	100.41
1438	103.02	104.97	106.93	108.89	110.84	112.80	114.76	116.72	118.67	120.63
1439	133.03	134.08	135.15	136.24	137.37	138.52	139.69	140.90	142.13	143.38
1440	148.32									

Capacity in Acre-Feet

Elev. Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1433	0.00	0.14	0.36	0.68	1.13	1.73	2.49	3.44	4.59	5.97
1434	7.69	9.76	11.84	13.93	16.05	18.18	20.32	22.49	24.66	26.86
1435	29.07	31.30	33.55	35.82	38.10	40.40	42.72	45.06	47.41	49.79
1436	54.23	62.78	71.33	79.89	88.50	97.17	105.93	114.80	123.80	132.96
1437	142.36	152.04	161.75	171.50	181.29	191.13	201.00	210.92	220.88	230.89
1438	241.07	251.44	262.01	272.77	283.72	294.86	306.21	317.76	329.49	341.42
1439	353.98	367.32	380.76	394.30	407.97	421.75	435.64	449.64	463.78	478.03
1440	492.54									