US Army Corps
of Engineers

Northwestern Division
Missouri River Region
Reservoir Control Center

Missouri River Region
RCC
Since 1953
Reservoir Control Center

Missouri River Main Stem Reservoirs

Summary of Actual 1998 - 1999 Operations

January 2000

MISSOURI RIVER MAIN STEM RESERVOIRS

Summary of Actual 1997-1998 Operations

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF ABBREVIATIONS

AOP -	annual operating plan
ac.ft. -	acre-feet
AF -	acre-feet
B -	Billion
cfs -	cubic feet per second
COE -	Corps of Engineers
CY -	calendar year (January 1 to December 31)
EA -	Environmental Assessment
EIS -	Environmental Impact Statement
elev -	elevation
ESA -	Endangered Species Act of 1978
ft -	feet
FWS -	U.S. Fish and Wildlife Service
FY -	fiscal year (October 1 to September 30)
GIS -	Geographic Information System
GWh -	gigawatt hour
KAF -	1,000 acre-feet
Kcfs -	1,000 cubic feet per second
kW -	kilowatt
kWh -	kilowatt hour
M -	million
MAF -	million acre-feet
MRBA -	Missouri River Basin Association
MRNRC -	Missouri River Natural Resources Committee
msl -	mean sea level
MW -	megawatt
MWh -	megawatt hour
NEPA -	National Environmental Policy Act
plover -	piping plover
pp -	powerplant
RCC -	Reservoir Control Center
RM -	river mile
tern -	interior least tern
tw -	tailwater
USGS -	United States Geological Survey
yr -	year

DEFINITION OF TERMS

Acre-foot (AF, ac-ft) is the quantity of water required to cover 1 acre to a depth of 1 foot and is equivalent to 43,560 cubic feet or 325,850 gallons.

Cubic foot per second (cfs) is the rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second and is equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute. The volume of water represented by a flow of 1 cubic foot per second for 24 hours is equivalent to 86,400 cubic feet, approximately 1.983 acre-feet, or 646,272 gallons.

Discharge is the volume of water (or more broadly, volume of fluid plus suspended sediment) that passes a given point within a given period of time.

Drainage area of a stream at a specific location is that area, measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the river above the specified point. Figures of drainage area given herein include all closed basins, or noncontributing areas, within the area unless otherwise noted.

Drainage basin is a part of the surface of the earth that is occupied by drainage system, which consists of a surface stream or body of impounded surface water together with all tributary surface streams and bodies of impounded water.

Gaging station is a particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained.

Runoff in inches shows the depth to which the drainage area would be covered if all the runoff for a given time period were uniformly distributed on it.

Streamflow is the discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" as streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

MISSOURI RIVER MAIN STEM RESERVOIRS

Summary of Actual 1998 – 1999 Operations

I. FOREWORD

This document contains a summary of the actual operation of the Missouri River main stem reservoirs for the 12-month period ending July 31, 1999. Previously, a comprehensive Annual Operating Plan document was prepared that contained three sections. The first section, the blue pages, contained a system description and a discussion of the typical operation to meet authorized purposes. The second section, which this document replaces, reviewed the actual operation for the previous 12 months, through July of the current year. The third section, the yellow pages, presented the tentative plan for operating the reservoirs for the remainder of the current year through December of the following year. For the past 2 years, in an attempt to reduce reproduction and mailing costs, the AOP has been divided into three separate documents based on the descriptions above. All three reports, "System Description and Operation," "Summary of Actual 1998-1999 Operation," and "Annual Operating Plan, 1999-2000," can be obtained from the Reservoir Control Center's website at **www.nwd-mr.usace.army.mil/rcc** or by contacting the Reservoir Control Center at 12565 West Center Road, Omaha, Nebraska 68144-3869, phone (402) 697-2676.

A basin map is presented on ***Plate 1*** and the pertinent data table for the Missouri River Main Stem System (System) is shown on ***Plate 2***.

II. REVIEW OF REGULATION FROM AUGUST 1998 THROUGH JULY 1999

A. General. During this period, the Missouri River main stem reservoirs were regulated in accordance with the applicable provisions of the 1998-1999 Annual Operating Plan (AOP), which was discussed and reviewed by representatives of state and Federal agencies as well as the general public and specific interest groups. A summary of the significant events during this past year is given in the following paragraphs.

B. Precipitation and Water Supply Available in 1998.

1. January - July 1998. Runoff during the first 7 months of 1998, as shown on ***Table I***, returned to more normal levels following the record-setting inflows of 1997. By late summer most of the basin had normal to moist soil conditions with the exception of eastern Montana, northeastern Wyoming, and western North Dakota where drought conditions had developed. See last year's AOP for a detailed description of precipitation, snowpack, and runoff patterns for the period January through July 1998.

Table I
Upper Missouri River Basin Runoff
For Calendar Year 1998

Reach Above	Fort Peck	Garrison	Oahe	Fort Randall	Gavins Point	Sioux City	Summation above Gavins Point	Summation above Sioux City	Accumulated Summation above Sioux City
				Values in 1000 Acre Feet					
	(Historic)								
JAN 98	278	157	-257	159	184	198	521	719	719
NORMAL	315	265	10	20	95	25	705	730	730
DEPARTURE	-37	-108	-267	139	89	173	-184	-11	-11
% OF NOR	88%	59%	-2570%	795%	194%	792%	74%	98%	98%
FEB 98	458	608	94	134	308	121	1,602	1,723	2,442
NORMAL	360	350	70	40	120	80	940	1,020	1,750
DEPARTURE	98	258	24	94	188	41	662	703	692
% OF NORM	127%	174%	134%	335%	257%	151%	170%	169%	140%
MAR 98	458	709	191	156	310	186	1,824	2,010	4,452
NORMAL	600	990	545	215	200	290	2,550	2,840	4,590
DEPARTURE	-142	-281	-354	-59	110	-104	-726	-830	-138
% OF NORM	76%	72%	35%	73%	155%	64%	72%	71%	97%
APR 98	528	898	217	105	369	584	2,117	2,701	7,153
NORMAL	670	1,120	480	140	170	300	2,580	2,880	7,470
DEPARTURE	-142	-222	-263	-35	199	284	-463	-179	-317
% OF NORM	79%	80%	45%	75%	217%	195%	82%	94%	96%
MAY 98	792	895	34	94	323	347	2,138	2,485	9,638
NORMAL	1,120	1,280	300	135	170	235	3,005	3,240	10,710
DEPARTURE	-328	-385	-266	-41	153	112	-867	-755	-1,072
% OF NORM	71%	70%	11%	70%	190%	148%	71%	77%	90%
JUN 98	1,300	1,722	272	259	373	349	3,926	4,275	13,913
NORMAL	1,645	2,710	435	150	170	240	5,110	5,350	16,060
DEPARTURE	-345	-988	-163	109	203	109	-1,184	-1,075	-2,147
% OF NORM	79%	64%	63%	173%	219%	145%	77%	80%	87%
JUL 98	1,447	2,431	220	120	332	208	4,550	4,758	18,671
NORMAL	820	1,790	165	60	125	180	2,960	3,140	19,200
DEPARTURE	627	641	55	60	207	28	1,590	1,618	-529
% OF NORM	176%	136%	133%	200%	266%	116%	154%	152%	97%
AUG 98	469	817	85	124	300	144	1,795	1,939	20,610
NORMAL	350	615	60	45	110	110	1,180	1,290	20,490
DEPARTURE	119	202	25	79	190	34	615	649	120
% OF NORM	134%	133%	142%	276%	273%	131%	152%	150%	101%
SEP 98	335	404	-15	24	208	61	956	1,017	21,627
NORMAL	340	480	115	45	105	85	1,085	1,170	21,660
DEPARTURE	-5	-76	-130	-21	103	-24	-129	-153	-33
% OF NORM	99%	84%	-13%	53%	198%	72%	88%	87%	100%
OCT 98	379	875	169	65	254	123	1,742	1,865	23,492
NORMAL	395	525	70	10	115	65	1,115	1,180	22,840
DEPARTURE	-16	350	99	55	139	58	627	685	652
% OF NORM	96%	167%	241%	650%	221%	189%	156%	158%	103%
NOV 98	413	642	72	-32	312	351	1,407	1,758	25,250
NORMAL	390	410	65	10	115	60	990	1,050	23,890
DEPARTURE	23	232	7	-42	197	291	417	708	1,360
% OF NORM	106%	157%	111%	-320%	271%	585%	142%	167%	106%
DEC 98	293	274	-2	41	228	328	834	1,162	26,412
NORMAL	330	250	-5	5	90	40	670	710	24,600
DEPARTURE	-37	24	3	36	138	288	164	452	1,812
% OF NORM	89%	110%	40%	820%	253%	820%	124%	164%	107%
				Calendar Year Totals					
	7,150	10,432	1,080	1,249	3,501	3,000	23,412	26,412	
NORMAL	7,335	10,785	2,310	875	1,585	1,710	22,890	24,600	
DEPARTURE	-185	-353	-1,230	374	1,916	1,290	522	1,812	
% OF NORM	97%	97%	47%	143%	221%	175%	102%	107%	

2. <u>August - December 1998</u>. Summer precipitation was above normal throughout the basin as shown in ***Figure 1***. Frequent rains fell across the Midwest in August easing some of the dryness in the upper basin. Bismarck, North Dakota had an August record rainfall of 9.29 inches or 540 percent of normal, including 4.64 inches that fell in a 24-hour period on August 21-22. Temperatures were generally 2 to 5 degrees above normal in the northern plains and within 2 degrees of normal in the lower basin.

September's temperatures averaged well above normal across the basin, setting several record highs. Some of the highest readings included: 101 degrees in Williston, North Dakota and a record 102 degrees in Scottsbluff, Nebraska on September 4; 100 degrees in Huron, South Dakota on September 10; and 98 degrees in Glasgow Montana on September 16, their highest reading on record that late in the year. Precipitation varied widely during September, from over 10 inches along the Kansas-Missouri border to less than half of normal in a wide stretch from eastern North Dakota to western Kansas.

A very wet weather pattern developed across the basin in October, eliminating soil moisture deficits that had accumulated during the summer and early fall. New monthly precipitation records were set in Mellette, South Dakota (8.68 inches); Aberdeen, South Dakota (7.29 inches); Rapid City, South Dakota (5.60 inches); and Glasgow, Montana (3.05 inches). Temperatures during October averaged within 2 degrees of normal, but varied widely throughout the month.

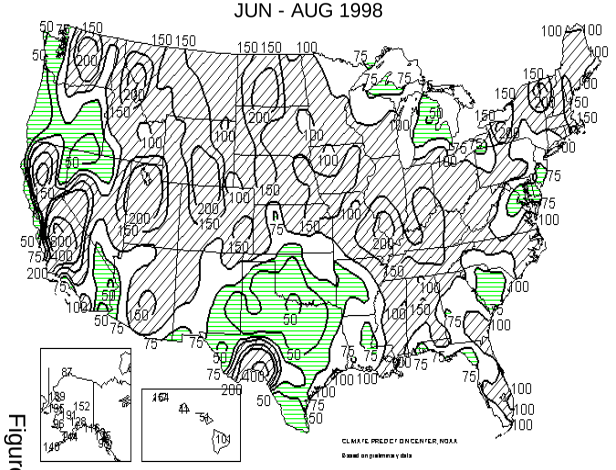
Late summer and early fall precipitation virtually wiped out drought conditions that had developed in the upper basin during the summer months. The last Palmer Drought Severity map for the 1998 growing season, dated October 24, 1998, ***Figure 2***, indicates normal to moist soil conditions throughout most of the basin with only a few pockets of dryness remaining in Montana, Wyoming, and Colorado.

The wet fall weather continued into the first half of November as a series of storms tracked across the basin. Rapid City secured its second snowiest November (21.3 inches) by November 10 but received no snow thereafter. Total precipitation for the month was more than 200 percent of normal from Montana and North Dakota southward through Kansas. After mid-month warm, dry weather was prevalent across the region.

Figure 1 shows the autumn precipitation distribution as a percent of normal.

Temperatures remained well above normal during the first half of December setting numerous record highs, but the month-long warm spell came to an abrupt end on December 19 as an arctic system crossed the basin. In South Dakota, Rapid City reported a 91-degree temperature drop in 4 days, from a high of 69 degrees on December 17 to a low of -22 degrees on December 21. Precipitation in December was generally well below normal except in Montana, where an early-month snowstorm dumped up to 21 inches of snow, and southeastern Kansas, which benefited from a southerly storm track.

Summer Percent of Normal Precipitation
JUN - AUG 1998



Autumn Percent of Normal Precipitation
SEP- NOV 1998

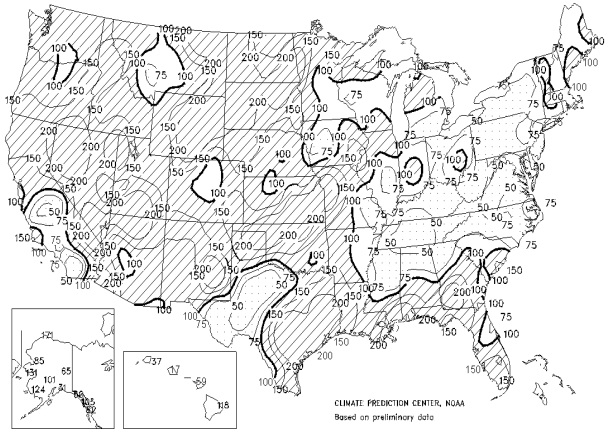
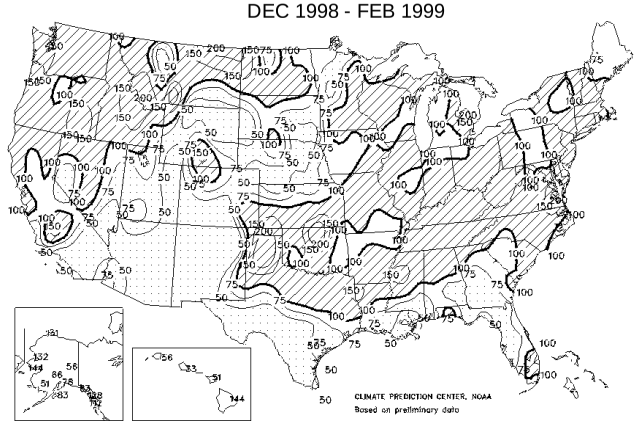
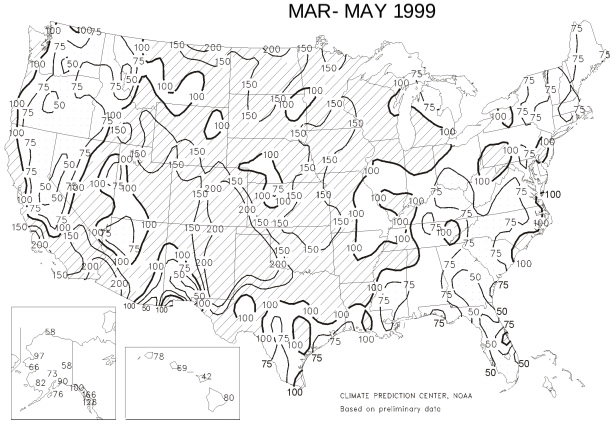


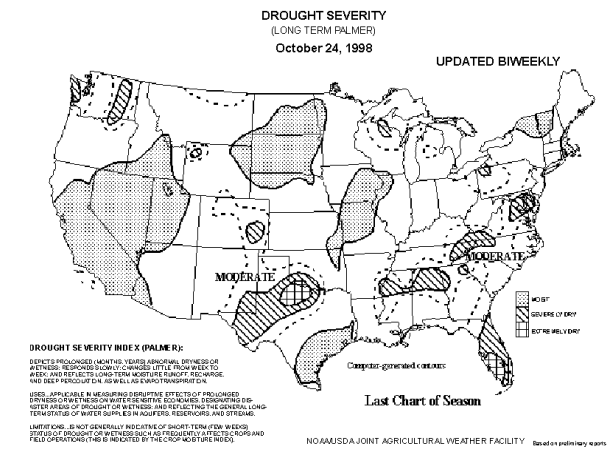
Figure 14

Winter Percent of Normal Precipitation
DEC 1998 - FEB 1999



Spring Percent of Normal Precipitation
MAR- MAY 1999




DROUGHT SEVERITY
(LONG TERM PALMER)
October 24, 1998
UPDATED BIWEEKLY
MODERATE
MODERATE
MOIST
SEVERE/DRY
EXTREMELY DRY
DROUGHT SEVERITY INDEX (PALMER):
Computer-generated contours
Last Chart of Season
NOAA/USDA JOINT AGRICULTURAL WEATHER FACILITY

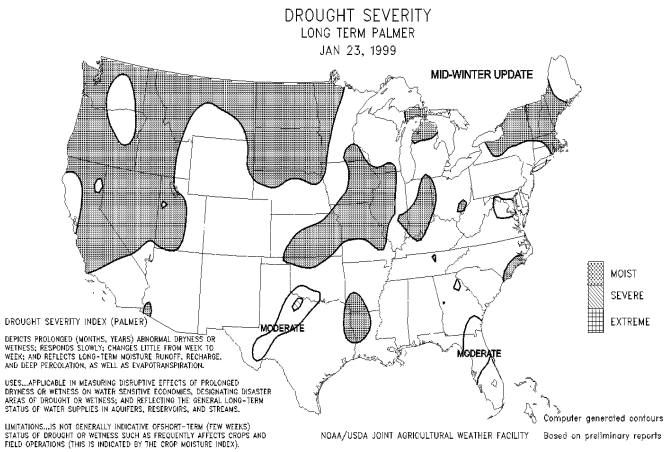
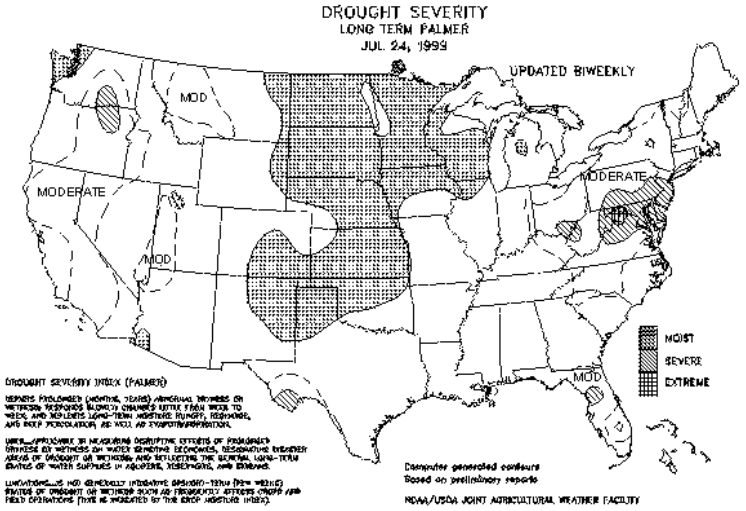

DROUGHT SEVERITY
LONG TERM PALMER
JAN 23, 1999
MID-WINTER UPDATE
MODERATE
MODERATE
MOIST
SEVERE
EXTREME
DROUGHT SEVERITY INDEX (PALMER)
Computer generated contours
NOAA/USDA JOINT AGRICULTURAL WEATHER FACILITY
Based on preliminary reports

Figure 2
5


DROUGHT SEVERITY
LONG TERM PALMER
APR 3, 1999
UPDATED BIWEEKLY
MOIST
SEVERE
EXTREME
Computer generated contours
NOAA/USDA JOINT AGRICULTURAL WEATHER FACILITY
Based on preliminary reports


DROUGHT SEVERITY
LONG TERM PALMER
JUL 24, 1999
UPDATED BIWEEKLY
MOD
MODERATE
MODERATE
MOD
MOD
MOIST
SEVERE
EXTREME
DROUGHT SEVERITY INDEX (PALMER)
Computer generated contours
Based on preliminary reports
NOAA/USDA JOINT AGRICULTURAL WEATHER FACILITY

3. 1998 Calendar Year Runoff. Despite a slow start the first half of 1998, runoff picked up as late summer and fall precipitation brought the yearly total to 26.4 MAF, 107 percent of the 1898-1992 average. Monthly runoff ranged from a low of 71 percent of normal in March to a high of 169 percent of normal in February and 167 percent of normal in November.

Following the record-setting runoff in 1997, the nearly normal runoff in 1998 was a welcome relief. The 1998 annual runoff at Sioux City is shown in historical perspective on ***Figure 3***.

Although the annual runoff above Sioux City was near normal, distribution in the six reaches varied from a low of 47 percent of normal in the Oahe reach, to a high of 221 percent of normal in the Gavins Point reach. Annual runoff in the upper two reaches, above Fort Peck and between Fort Peck and Garrison, was very near normal at 97 percent. As in the Gavins Point reach, runoff in the reaches above Fort Randall and Sioux City was well above normal with 143 percent of normal and 175 percent of normal, respectively. The 1998 annual reach runoff expressed as a percentage of the historic 1898-1992 average is presented in ***Table II***. The monthly reach runoff is shown on ***Table I***. This table is prepared on the first of each month to indicate the historic and forecast runoff for the year. ***Figure 4A*** displays the monthly distribution of runoff for 1998 and compares it with the 1898-1992 average.

TABLE II
1998 CALENDAR YEAR RUNOFF FOR SELECTED REACHES
(In 1,000 Acre-Feet)

Reach	1898-1992 Normal Runoff-Volume	Calendar Year 1998 Runoff-Volume	Percent of Normal Runoff
Above Fort Peck	7,335	7,150	97
Fort Peck to Garrison	10,785	10,432	97
Garrison to Oahe	2,310	1,080	47
Oahe to Fort Randall	875	1,249	143
Fort Randall to Gavins Point	1,585	3,501	221
Gavins Point to Sioux City	1,710	3,000	175
TOTAL ABOVE SIOUX CITY	24,600	26,412	107
Sioux City to Nebr. City	7,770	10,350	133
Nebr. City to Kansas City	12,560	20,450	163
Kansas City to Hermann	24,920	40,060	161
TOTAL BELOW SIOUX CITY*	45,250	70,860	157

* Reaches from Sioux City to Hermann are not adjusted to 1949 depletions. Averages are taken from USGS Water-Data Reports for the period 1967-1998.

Missouri River Main Stem
Annual Runoff at Sioux City, Iowa

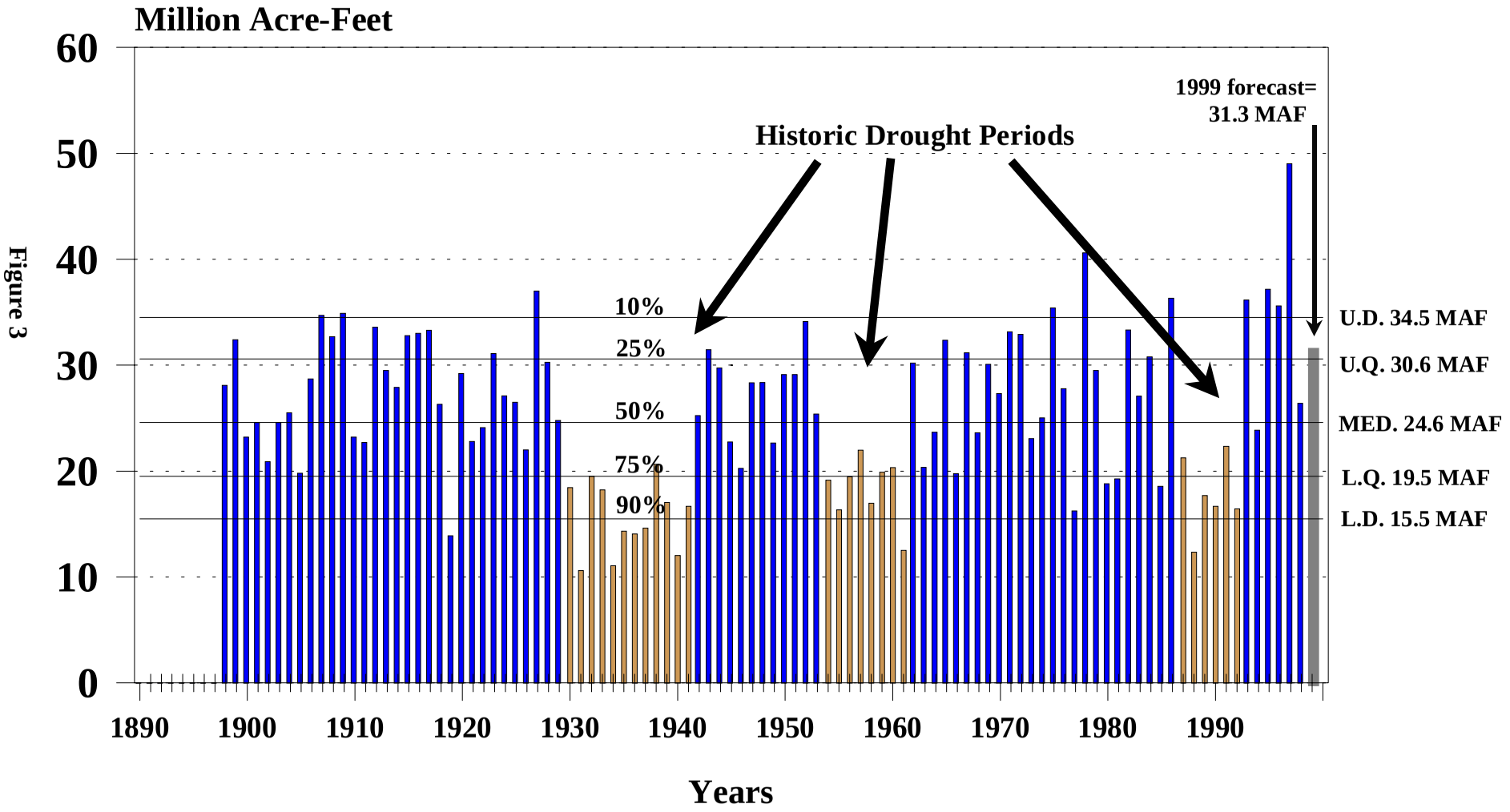


Figure 3
7

1998 Missouri River Runoff
Above Sioux City, Iowa

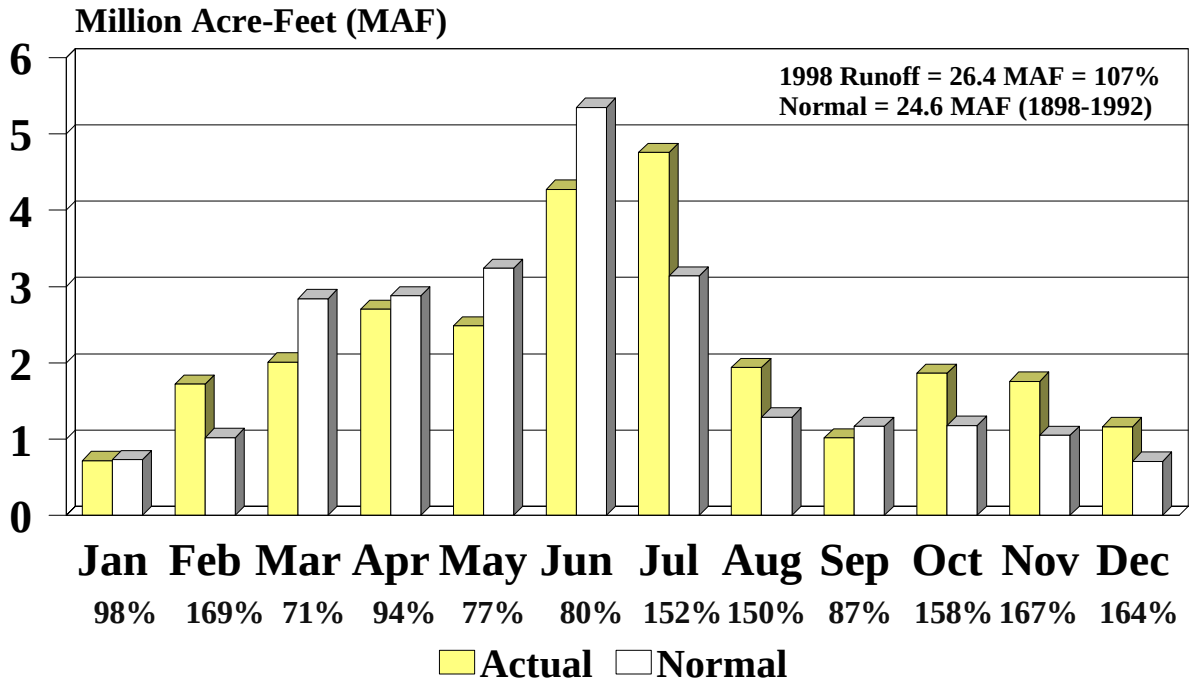


Figure 4A

1999 Missouri River Runoff
Above Sioux City, Iowa

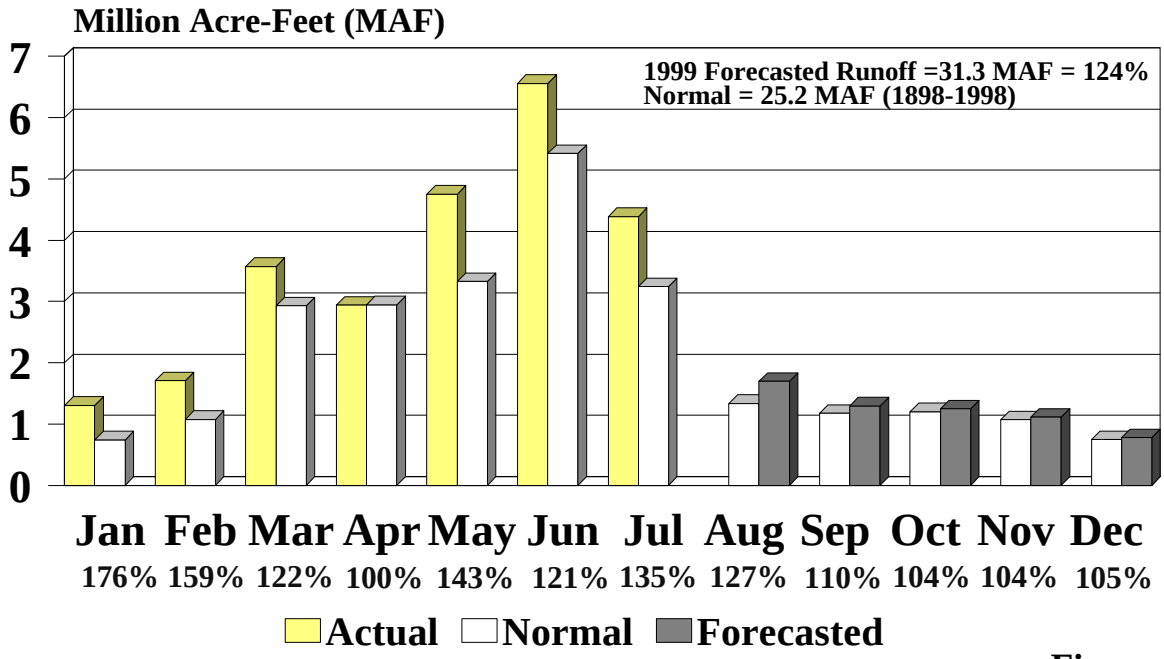


Figure 4B

C. Precipitation and Water Supply Available in 1999.

1. Plains Snowpack 1998-1999. Plains snowpack during the 1998-1999 season consisted of a series of winter storms and intermittent melt periods. The winter's only significant outbreak of cold weather lasted a month, from mid-December to mid-January.

The first significant snow of the 1998-1999 winter season came in mid-October when a strong low-pressure system moved across the central high plains dumping over 18 inches of snow in Casper, Wyoming and 6.2 inches in Lander, Wyoming. The same system brought heavy rain to much of South Dakota, including 2.68 inches in Rapid City and 3.5 inches in Aberdeen. The last half of October was much warmer and the remainder of the month's precipitation generally fell as rain.

Cold weather returned in early November on the heels of a "super storm" which developed into one the strongest storms on record in terms of minimum barometric pressure in Nebraska, South Dakota, Iowa, and Minnesota. Heavy snow accompanied the storm with over 13 inches recorded in Sioux Falls, South Dakota and 10 inches in Bismarck, North Dakota. During the first 10 days of November, 21.3 inches of snow fell in Rapid City securing their second snowiest November even though no additional snow fell after the tenth of the month.

Warm weather returned to the region the second half of November and by the first of December the plains snowpack was limited to 1 to 3 inches in the western half of Montana. Snow fell across the northern plains in early December with 3 to 7 inches across much of Montana.

In mid-December an arctic blast abruptly ended a month-long run of unseasonably warm weather. Light snow accompanied the cold weather and at the end of the year most of the northern plains, with the exception of South Dakota, was blanketed in several inches of snow.

The new year was ushered in by a fast moving storm that delivered snow to much of the basin. The upper basin generally picked up 4 to 6 inches of new snow while up to a foot fell in eastern Nebraska, western Iowa, and northern Missouri. Additional light snow fell across the northern plains the second week of January. Mild, breezy weather moved into the region mid-month melting much of the snowcover in the lower basin and in the southern half of South Dakota. In the northern plains, snow that was melted by the mid-month warm-up was replenished by month's end as wintry storms continued to cross the region. Williston, North Dakota received over three times its normal annual January snowfall; Bismarck, North Dakota experienced its second snowiest January on record.

In early February snow depths ranged from 10 to 12 inches in North Dakota, up to 7 inches in eastern Montana, and up to 3 inches in eastern South Dakota. Elsewhere in the basin there was little or no plains snowpack.

light, especially in Wyoming and South Dakota. Eastern Montana and North Dakota had heavier snow accumulations with fewer periods of intermittent melting. Winter precipitation in the lower basin was well below normal in Nebraska, Colorado, northern Kansas, and western Iowa while Missouri's winter precipitation was near normal. ***Figure 1*** shows the winter precipitation as a percent of normal.

March was warm and dry in the Missouri basin with less than half of normal precipitation falling over a large portion of the basin. Temperatures meanwhile averaged 4 to 6 degrees above normal in the upper basin and within 2 degrees of normal in the lower basin. The Palmer Drought Severity map dated April 3, 1999, ***Figure 2,*** indicates normal to moist soil conditions throughout the basin. The only region showing significant change since January was in northern and eastern Montana where excess soil moisture was eliminated.

Both April and May were cool and wet. In April over 8 inches of rain fell in eastern Kansas, western Missouri, eastern Nebraska, and western Iowa. Omaha, Nebraska received 8.47 inches, greater than 300 percent of normal. The remainder of the basin was also well above normal with the exception of North Dakota where less than half of normal April precipitation fell in the northern portion of the state. Significant snowfall occurred in portions of Wyoming between late March and the end of April. In Lander, where April is typically the snowiest month, a series of storms dropped 12 inches of snow on March 31 and another 70 inches during the month of April. Early April snowstorms also deposited over a foot of snow in portions of Colorado and North Dakota.

April's weather pattern carried through May with cool temperatures and heavy precipitation in much of the Missouri River basin. Bismarck, North Dakota, with 6.96 inches, recorded its second wettest May on record, while most of the eastern half of the basin received in excess of 4 inches. Drier conditions developed in the western half of the basin including the southern half of Montana, northern Wyoming, northeast Colorado, western Nebraska, and western Kansas. ***Figure 1*** shows the spring precipitation as a percent of normal.

June's precipitation was above normal over most of the basin although pockets of dryness developed in portions of the upper basin as the summer progressed. Typical summer-like thunderstorms dumped very heavy rain in portions of the lower basin including 8.67 inches in Kansas City, Missouri and 7.90 inches in Sioux City, Iowa. In contrast, precipitation was below normal in eastern Montana and the northwestern half of North Dakota as well as in the northeast corner of Wyoming. Temperatures for the month averaged about 2 degrees below normal.

Cool weather continued into the first half of July but was replaced with above normal temperatures near mid-month. A late-month surge of hot weather pushed temperatures to record or near-record levels the last couple days of the month. Pierre, South Dakota reached 111 degrees on July 28 and 29, surpassing daily records set in 1933. Miles City, Montana at 108 degrees on July 29 tied a record set for that date in 1947. Other highs included 105 degrees at Billings, Montana, 106 in Bismarck, North Dakota, and 103 degrees in St. Louis, Missouri. Precipitation was well below normal in the lower basin with less than half of normal falling in eastern Kansas and much of Missouri. Kansas City, Missouri had a monthly total of only 0.51 inches, 12 percent

Temperatures the first half of February averaged much above normal, including numerous record highs, melting the bulk of the plains snowpack. By mid-month snow depths had diminished to 1 to 3 inches in most of the upper basin except western North Dakota and northeastern Montana where 4 to 7 inches remained.

During the second half of February, a series of fast moving storms brought additional snow to the plains. While portions of the upper basin picked up 4 to 8 inches of new snow, Omaha, Nebraska received 8.6 inches on February 17-20 and an additional 7.2 inches on February 22-23.

Temperatures continued to average above normal through March, although two late winter snowstorms briefly interrupted the pattern. The first brought heavy snow to the Black Hills of South Dakota on March 5 when Rapid City received 12.0 inches of snow in 24 hours. The second hit western Kansas on March 12-13 leaving nearly 10 inches of snow in its wake. Elsewhere, though, very little precipitation fell during March, and the continued warmth melted virtually all of the plains snowpack by late March.

2. Mountain Snowpack 1998-1999. Mountain snowpack in the Missouri River basin was slightly above normal throughout the winter of 1998-1999. On December 1, the snowpack was 110 percent of normal in the reach above Fort Peck Dam and 104 percent of normal in the reach between Fort Peck and Garrison Dams.

On January 1, mountain snowpack in the Fort Peck reach was at 112 percent of normal, and the Garrison reach was down slightly at 100 percent of normal. Both reaches gained steadily during January and February, and by March 1 were at 119 and 118 percent, respectively. Drier conditions developed in the mountainous regions during March, resulting in below normal accumulation. By April 1 snowpack had declined to 108 percent of normal in the reach above Fort Peck and 109 percent of normal in the reach between Fort Peck and Garrison.

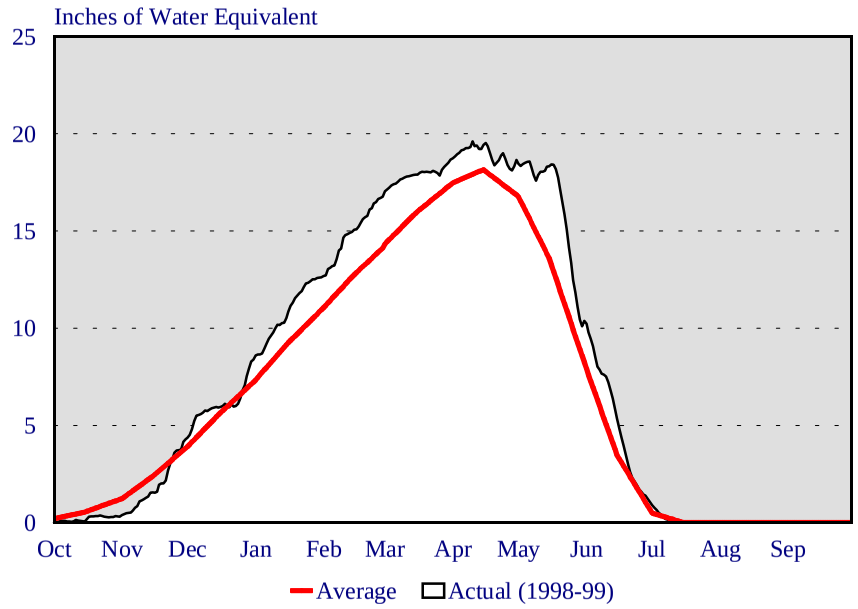
The mountain snowpack in the Fort Peck reach peaked at 107 percent of the normal peak accumulation on April 15 which, incidentally, is the usual date of peak accumulation. Additional snow during the second half of April delayed the peak in the reach between Fort Peck and Garrison until May 1 when it crested at 115 percent of the normal peak accumulation.

Cool temperatures delayed the start of the melt until late May, more than a month behind schedule. Once warm temperatures finally took hold, the melt proceeded rapidly and by July 1 was essentially complete. The 1998-1999 snow accumulation and melt are illustrated in ***Figure 5***.

3. January - July 1999. Runoff during the first 7 months of 1999 averaged well above normal due, in part, to high base flows resulting from the much above normal fall precipitation. In late January soil conditions were normal to moist throughout the basin as indicated on the Palmer Drought Index map dated January 23, 1999, ***Figure 2***. As discussed previously, the plains snowpack was intermittently melted during warm periods and was relatively

Mountain Snowpack Water Content
Missouri River Basin, Winter 1998 - 1999

Total Above Fort Peck



Total Fort Peck to Garrison

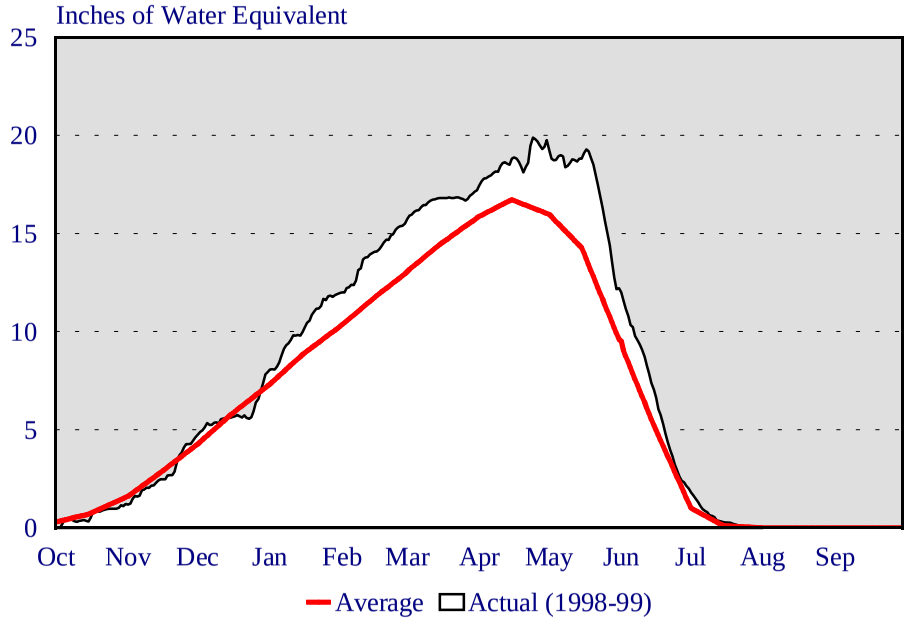


Figure 5
11

Snowpack peaked on April 15, 1999 at 107 percent of the normal peak in the reach above Fort Peck, and on May 1, 1999 at 115 percent of the normal peak in the reach between Fort Peck and Garrison

of normal. Precipitation in the upper basin was also generally below normal except in the western Dakotas where is was slightly above normal.

The Palmer Drought Severity map, dated July 24, 1999 is shown in ***Figure 2***. As indicated, moist conditions stretched from North Dakota to Kansas while normal conditions were found in eastern Montana, Wyoming, and Missouri. The only region in the Missouri River basin with moderate drought was western Montana.

4. 1999 Calendar Year Runoff. Runoff for the period January through July 1999 totaled 25.2 MAF, 128 percent of the updated 1898-1998 normal. Monthly runoff above Sioux City varied from a low of 100 percent of normal in April to 176 percent of normal in January. The August 1 forecast for CY 1999 runoff is 31.3 MAF, 124 percent of normal and 6.7 MAF above the 1898-1998 average, as shown in ***Figure 4B***.

The historic and forecasted monthly runoff for CY 1999 from Fort Peck downstream to Sioux City by major reach are presented in ***Table III***. The table describes the annual runoff by month and is the basic compilation of the month-by-month runoff in the upper basin by reach. This forecast forms a basis for intrasystem balancing of storage accumulated in the projects and is used by the RCC on the first of each month to forecast the runoff for the remainder of the year. The monthly accumulation of actual runoff through July and the forecasts through December are shown under the "Summation above Sioux City" column. As the season progresses and the actual runoff accumulates, the forecast becomes more reliable. The majority of the annual runoff has normally occurred by the end of July and the remainder of the year can be estimated with a fair degree of accuracy.

D. System Operations.

1. System Operational Objectives - August 1998 to July 1999. With near normal runoff during the first half of 1998, the July 1 System storage check was well above the level needed to provide a full length navigation season according to the guidelines in the Missouri River Main Stem Master Water Control Manual (Master Manual). The 1998 peak System storage, 62.5 MAF on July 23, was just under the average peak of 62.6 MAF but 9.2 MAF lower than 1997's peak storage. Runoff into the System during the late summer and fall was above average and, as a result, the 1998 navigation season was extended 10 days and the service level was adjusted to evacuate flood water stored in the System.

System storage declined to 61.8 MAF on September 1, 1998, still 3.8 MAF over the amount needed to provide full service support to the power function during the winter season. According to the guidelines in the Master Manual, above average winter releases from Fort Randall were required to continue the evacuation of flood control storage and to provide support for the extended navigation season. Gavins Point winter releases were scheduled to evacuate flood control storage while preventing downstream flooding. Runoff into the System averaged more than 160 percent of normal for the period October 1998 through January 1999. System storage

Table III
Upper Missouri River Basin Runoff
For Calendar Year 1999
Historic and Forecasted

Reach Above	Fort Peck	Garrison	Oahe	Fort Randall	Gavins Point	Sioux City	Summation above Gavins Point	Summation above Sioux City	Accumulated Summation above Sioux City
				Values in 1000 Acre Feet					
	(Historic)								
JAN 99	441	393	-35	158	215	134	1,172	1,306	1,306
NORMAL	315	260	10	20	100	35	705	740	740
DEPARTURE	126	133	-45	138	115	99	467	566	566
% OF NORM	140%	151%	-350%	790%	215%	383%	166%	176%	176%
FEB 99	418	506	208	78	317	178	1,527	1,705	3,011
NORMAL	365	360	90	50	125	85	990	1,075	1,815
DEPARTURE	53	146	118	28	192	93	537	630	1,196
% OF NORM	115%	141%	231%	156%	254%	209%	154%	159%	166%
MAR 99	504	1,669	687	44	308	359	3,212	3,571	6,582
NORMAL	610	1,010	580	220	205	300	2,625	2,925	4,740
DEPARTURE	-106	659	107	-176	103	59	587	646	1,842
% OF NORM	83%	165%	118%	20%	150%	120%	122%	122%	139%
APR 99	425	916	289	255	413	638	2,298	2,936	9,518
NORMAL	665	1,115	500	145	180	340	2,605	2,945	7,685
DEPARTURE	-240	-199	-211	110	233	298	-307	-9	1,833
% OF NORM	64%	82%	58%	176%	229%	188%	88%	100%	124%
MAY 99	789	1,448	820	746	360	589	4,163	4,752	14,270
NORMAL	1,120	1,280	320	145	185	275	3,050	3,325	11,010
DEPARTURE	-331	168	500	601	175	314	1,113	1,427	3,260
% OF NORM	70%	113%	256%	514%	195%	214%	136%	143%	130%
JUN 99	1,480	3,272	513	201	345	747	5,811	6,558	20,828
NORMAL	1,655	2,715	435	160	180	270	5,145	5,415	16,425
DEPARTURE	-175	557	78	41	165	477	666	1,143	4,403
% OF NORM	89%	121%	118%	126%	192%	277%	113%	121%	127%
JUL 99	724	2,160	291	121	431	658	3,727	4,385	25,213
NORMAL	835	1,815	180	60	135	215	3,025	3,240	19,665
DEPARTURE	-111	345	111	61	296	443	702	1,145	5,548
% OF NORM	87%	119%	162%	202%	319%	306%	123%	135%	128%
	(Forecast)								
AUG 99	340	700	80	90	225	260	1,435	1,695	26,908
NORMAL	360	625	65	40	115	130	1,205	1,335	21,000
DEPARTURE	-20	75	15	50	110	130	230	360	5,908
% OF NORM	94%	112%	123%	225%	196%	200%	119%	127%	128%
SEP 99	345	470	125	80	145	130	1,165	1,295	28,203
NORMAL	345	470	115	40	110	95	1,080	1,175	22,175
DEPARTURE	0	0	10	40	35	35	85	120	6,028
% OF NORM	100%	100%	109%	200%	132%	137%	108%	110%	127%
OCT 99	400	525	70	10	150	90	1,155	1,245	29,448
NORMAL	400	525	70	10	120	75	1,125	1,200	23,375
DEPARTURE	0	0	0	0	30	15	30	45	6,073
% OF NORM	100%	100%	100%	100%	125%	120%	103%	104%	126%
NOV 99	390	410	65	10	145	90	1,020	1,110	30,558
NORMAL	390	410	65	10	120	75	995	1,070	24,445
DEPARTURE	0	0	0	0	25	15	25	40	6,113
% OF NORM	100%	100%	100%	100%	121%	120%	103%	104%	125%
DEC 99	335	255	0	10	120	60	720	780	31,338
NORMAL	335	255	0	10	100	45	700	745	25,190
DEPARTURE	0	0	0	0	20	15	20	35	6,148
% OF NORM	100%	100%	0%	100%	120%	133%	103%	105%	124%
				Calendar Year Totals					
	6,591	12,724	3,113	1,803	3,174	3,933	27,405	31,338	
NORMAL	7,395	10,840	2,430	910	1,675	1,940	23,250	25,190	
DEPARTURE	-804	1,884	683	893	1,499	1,993	4,155	6,148	
% OF NORM	89%	117%	128%	198%	189%	203%	118%	124%	

was reduced from 60.2 MAF on November 1, 1998, to 57.8 MAF on January 31, 1999. With February runoff at 159 percent of normal, storage increased to 58.0 MAF on March 1, 1999, 0.9 MAF above the desired 57.1 MAF level, the top of the carryover multiple use zone.

Support for the 1999 navigation season was in accordance with the plan presented in the 1998-1999 AOP. The plan included a normal season opening date with full service flows for the fifth consecutive year and a season length based on July 1 System storage. Flow support for the 1999 navigation season began on March 23 at Sioux City, March 25 at Omaha, March 26 at Nebraska City, March 28 at Kansas City, and April 1 at the mouth of the Missouri River near St. Louis.

On April 1, System storage stood at 59.5 MAF, 0.9 MAF higher than the previous year. It made moderate gains during two runoff periods in 1999. The plains snowmelt produced a March-April runoff of 6.5 MAF, higher than the normal 5.9 MAF inflow. Runoff from May, June, and July was 4.8 MAF, 6.6 MAF, and 4.4 MAF, respectively. Normal for that same time period is 3.3 MAF, 5.4 MAF, and 3.2 MAF, respectively. End-of-month System storage was 62.6 MAF for May, 65.0 MAF for June, and 65.2 MAF for July. System storage peaked at 65.4 MAF on July 23, 1999, 2.9 MAF higher than the 1998 peak. The 65.2 MAF storage ending in July was 3.3 MAF above average.

In accordance with the 1998-1999 AOP and based on the actual 65.0 MAF July 1 System storage, a full 8-month navigation season with a 10-day extension and full service flows was scheduled for the remainder of the 1999 navigation season.

Energy generation at the six main stem powerplants totaled 10.8 billion kilowatt hours (kWh) for the period August 1, 1998, to July 31, 1999, 0.6 billion kWh above the average since the System first filled in 1967. The above normal generation was due to the evacuation of excess flood storage.

2. <u>Fort Peck Operation - August 1998 to July 1999</u>. Fort Peck Reservoir, the third largest Corps of Engineers storage reservoir, serves all authorized purposes. Fort Peck's primary functions are: (1) to capture the mountain and plains snow and localized rainfall runoffs from the large drainage area above Fort Peck Dam. Captured floodwaters are metered out at controlled release rates to meet the main stem authorized purposes while reducing flood damages in the Fort Peck to Garrison reach; (2) to serve as a secondary storage location for water accumulated in the System from reduced System releases due to major downstream flood control operations, thus helping to alleviate large pool increases in Garrison, Oahe, and Fort Randall projects; and (3) to provide the extra water needed to meet all main stem authorized purposes which draft storage during low water years.

Late Summer and Fall 1998. Fort Peck releases were below normal levels during the period, averaging 10,500 cubic feet per second (cfs) in August, 8,500 cfs in September, 7,600 in October, and 7,900 cfs in November. The releases for August through November were 300, 1,300, 1,600, and 1,600 cfs below average, respectively. Fort Peck pool elevation started the period 6 feet into the annual flood control and multiple use zone at 2240.1 feet above mean sea level (msl), 10 feet

lower than a year earlier. The pool declined to elevation 2237.8 by the end of November, 3.8 feet into the annual flood control and multiple use zone and 0.5 foot above the previous year.

Winter 1998-1999. Fort Peck releases averaged 9,900 cfs for December, 11,400 cfs for January and 11,900 cfs for February. The project releases were held at 10,000 cfs to prevent ice jam flooding during the winter freeze-in period on the Missouri River downstream from Fort Peck Dam. The freeze-in occurred around December 22, 1998, and once the ice conditions downstream stabilized the releases were increased from 10,000 cfs in early January to 12,000 cfs on January 14, 1999 where they remained until the end of February. Beginning on February 28, 1999, the releases were reduced from 12,000 cfs to 9,000 cfs by March 2, 1999. This past winter season the daily releases varied only slightly from the monthly average. This was required for intrasystem storage balance and downstream flood control. December, January, and February average daily releases were 300, 200, and 300 cfs below average, respectively.

The Fort Peck Lake level began the winter season at elevation 2237.8 feet msl, 3.8 feet into the annual flood control zone and 0.5 foot above the previous year. The lake fell to the season low of 2234.9 feet msl on February 24, 1999. At the end of February the lake was at elevation 2235.0 feet msl, 1.0 foot above the base of the annual flood control zone.

Winter River and Ice Conditions Below Fort Peck Dam. Ice formation on the Missouri River below Fort Peck Dam began on December 22 and 23, 1998 when the stage rose over 1.5 feet in the Wolf Point area and 2 feet in the Culbertson area. The Fort Peck releases were held at 10,000 cfs until the ice conditions and stages on the Missouri River stabilized. The releases were then increased to 12,000 cfs by January 14, 1999. No reports of ice-affected flooding on the Missouri River below Fort Peck Dam were recorded during this winter season.

Spring and Summer 1999. Releases from Fort Peck averaged 8,900 cfs in March and 7,900 cfs in April, above the 6,000 cfs recommended to support fish spawning below the dam. In May, releases from Fort Peck averaged below normal at 8,000 cfs. Summer releases from Fort Peck were reduced from 9,000 cfs to 8,000 cfs on June 21, but numerous irrigators experienced difficulty with their intakes at the lower release rate. Dry conditions coupled with changed channel geometry after the 1997 high releases made irrigation difficult at 8,000 cfs. Fort Peck releases were returned to 9,000 cfs on June 28 and remained at that rate through Labor Day. June and July's release averages were slightly below normal at 8,700 and 9,000 cfs, respectively.

The elevation of Fort Peck Lake was at 2235.2 feet msl at the beginning of the 1999 navigation season, the same as at the beginning of the 1998 navigation season. The pool rose moderately through the period, peaking on July 4 at 2238.3 feet msl, 2.1 feet lower than the 1998 peak. Fort Peck Lake in 1999 occupied 4.3 feet of the annual flood control storage zone, which extends from 2234 to 2250 feet msl. By the end of July the pool had fallen to 2237.6 feet msl, 2.6 feet above the base of the annual flood control pool.

3. Garrison Operation - August 1998 to July 1999. Garrison, as the largest Corps of Engineers storage reservoir, is another key player in the operation of the main stem system. Its primary functions are (1) to capture the snowmelt runoff and localized rainfall runoffs

from the large drainage area between Fort Peck and Garrison Dam. Captured floodwaters are metered out at controlled release rates to meet the main stem authorized purposes while reducing flood damages in the Garrison to Oahe reach, particularly the urban Bismarck area; (2) to serve as a secondary storage location for water accumulated in the System from reduced System releases due to major downstream flood control operations, thus helping to alleviate large pool increases in Oahe and Fort Randall projects; and (3) to provide the extra water needed to meet all main stem authorized purposes which draft storage during low water years.

Late Summer and Fall 1998. Daily releases from Garrison varied between 15,700 cfs and 24,800 cfs with monthly average releases of 24,000, 21,200, 17,100, and 20,500 cfs for August through November. The releases were 1,600, 700, 3,700, and 1,000 cfs below average from August through November, respectively. Lake Sakakawea began the period at elevation 1843.0 feet msl, 5.5 feet into the base flood control pool and 9.2 feet lower than at the same time a year earlier. By the end of November it was at 1841.8 feet msl, 0.4 foot higher than a year earlier.

Winter 1998-1999. Releases from Garrison were below normal in December and slightly above normal in January and February. The releases, which were 21,000 cfs on December 1, 1998 were reduced to 20,000 cfs on December 17, 1998 as a precaution against ice-affected flooding in the Bismarck area as colder weather arrived. Beginning on January 1, 1999, the Garrison releases were gradually increased from 20,000 to 24,000 cfs on January 5, 1999, then up an additional 1,000 cfs on both January 11 and 20, 1999. Garrison releases remained at 26,000 cfs from January 20 through February 2, 1999 when they were increased to 27,000 cfs and held through the end of February. Releases, which had been reduced to 23,000 cfs in early March, were increased to 24,000 cfs on March 17, 1999 to meet both power demands and intrasystem storage balance.

Lake Sakakawea began the season near elevation 1841.8 feet msl, 4.3 feet into the annual flood control zone. The lake declined throughout the winter season to an elevation of 1838.8 feet msl by February 21, 1999, 1.3 feet above the top of the carryover multiple use zone. By the end of March, Lake Sakakawea pool was at an elevation of 1841.7 feet msl, 2.3 feet higher than March 1998.

Winter River and Ice Conditions Below Garrison Dam. As a precaution, Garrison releases were reduced in mid-December from 21,000 cfs to 20,000 to prevent the Missouri River at Bismarck, North Dakota from exceeding the critical 14.0-foot stage during freeze-in. On December 21, 1999, the stage, which had been near 6.5 feet, increased more than 3 feet in less than 24 hours, then continued its climb to 11.7 feet by December 25, 1998. The stage crested on January 6 and 16, 1999 near 12.2 feet. Flood stage is 16 feet on the Missouri River at Bismarck; however, the critical ice-affected stage is 14 feet. Once the river conditions stabilized and river flows could pass safely under the established ice cover, Garrison releases were gradually increased in late January. The Bismarck stage remained ice affected, fluctuating between 10.0 and 12 feet, through early March. The stage dropped below 10 feet on March 6, 1999 and continued to decline slowly, ending the month just under 7.5 feet.

Spring and Summer 1999. Releases from Garrison during the spring and summer were above normal. Releases in April were 27,100 cfs, up 7,200 cfs from the mean of 19,900. In April, 22,000 acre-feet of water was transferred to Lake Audubon. An additional 2,000 acre-feet was transferred in July. Releases during May averaged 26,200 cfs, June averaged 29,700, and July averaged 28,600 cfs. Pool elevations for Lake Sakakawea were 1841.7 feet msl on April 1 and 1840.8 on May 1, 1842.0 on June 1, 1846.3 on July 1, and 1847.1 at the end of July. Lake Sakakawea peaked at an elevation of 1847.4 on July 25, 1999, up 3.9 feet from last year's peak. Pumping costs associated with the Buford-Trenton project for the period August 1, 1998 through July 31, 1999 were $19,816; the total pumping costs to date are $158,323.

4. <u>Oahe and Big Bend Operation - August 1998 to July 1999</u>. Oahe Reservoir, the second largest Corps of Engineers storage reservoir, serves all authorized purposes. The Oahe project's primary functions are: (1) to capture plains snow and localized rainfall runoffs from the large drainage area between Garrison and Oahe Dams. Captured floodwaters are metered out at controlled release rates to meet the main stem authorized purposes while reducing flood damages in the Oahe to Big Bend reach, especially in the urban Pierre and Fort Pierre areas; (2) to serve as a primary storage location for water accumulated in the System from reduced System releases due to major downstream flood control operations, thus helping to alleviate large pool increases in Big Bend, Fort Randall, and Gavins Point projects; and (3) to provide the extra water needed to meet all main stem authorized purposes which draft storage during low water years, particularly downstream water supply and navigation. In addition, hourly and daily releases from Big Bend and Oahe fluctuate widely to meet varying power loads. Over the long term, their release rates are geared to back up navigation releases from Fort Randall and Gavins Point in addition to providing storage space to permit a smooth transition in the scheduled annual fall drawdown of Lake Francis Case. Big Bend, with less than 2 MAF of storage, is primarily used for hydropower production, so releases from Oahe are generally passed directly through Big Bend.

Late Summer and Fall 1998. Monthly releases at Oahe and Big Bend were below normal between August and November. Releases ranged from 28 percent below normal in August to 5 percent below normal in November. The Big Bend pool fluctuated between elevations 1419.6 and 1421.4 feet. Lake Oahe began the period at elevation 1612.2 feet msl, 4.7 feet into the annual flood control pool and 6.1 feet lower than at the same time a year earlier. By the end of November it was at 1609.3, 3.1 feet lower than a year earlier.

Winter 1998-1999. Oahe Lake began the winter season at elevation 1609.3 feet msl and declined through the winter to 1606.1 feet msl by January 19, 1999, 1.4 feet lower than the previous winter's minimum pool level. The average release for the winter period was 26,800 cfs, 2,700 cfs lower than the previous winter and 4,000 cfs greater than the release rate from the downstream Fort Randall project. The additional volume released from the Oahe and Big Bend projects was stored in Lake Francis Case. Oahe's daily average releases varied from 13,600 to 37,100 cfs. The March 14, 1999 Oahe release of 21,800 cfs was a record high minimum daily average for the month of March.

Flooding in the Pierre-Fort Pierre area, especially at street intersections in the Stoeser Addition, has been a recurring problem since 1979. High Oahe releases, coupled with the formation of river ice in the LaFramboise Island area, cause water to back up into a storm sewer outlet flooding street intersections. The city of Pierre installed a valve on the Stoeser Addition storm sewer in the fall of 1998 to prevent winter flooding; however, Oahe releases will continue to be constrained as needed to prevent flooding at other locations. Release restrictions have been implemented in previous years but were not required during the 1998-1999 winter due to the mild weather.

Big Bend was operated to follow power peaking requirements with hourly releases varying widely. The daily average flow varied between 2,500 and 44,200 cfs. The level of Lake Sharpe varied in a narrow range from elevation 1419.7 to 1421.2 feet msl.

Spring and Summer 1999. Releases from Oahe were below normal from April through July with the exception of June. Although the March release was above normal, the daily average release for April was 19,500 cfs, down from the 22,600 cfs normal release. May's releases averaged 14,700 cfs, 9,300 cfs below normal; June was 2,600 cfs above average at 28,800 cfs and July was slightly below the 31,000 cfs average, at 30,100 cfs. Big Bend's releases generally mimic releases from Oahe. The below normal April and May releases from Oahe and Big Bend were due to reduced System releases from Gavins Point for downstream flood control.

Releases from Oahe usually are considerably lower during weekends than on weekdays. The normal plan is to maintain Oahe's releases above 3,000 cfs during weekend daylight hours beginning in early April. This minimum release criteria is scheduled to enhance downstream fishing and boating use during the recreation season. There have also been complaints relating to zero releases from Big Bend on the weekends. However, during the recreation season, Lake Francis Case extends into the Big Bend tailwater area and establishment of minimum release rates for Big Bend would be of little value to boating or fishing in the tailwaters.

Lake Oahe began the spring period on March 1, 1999, near elevation 1608 feet msl and crested at an elevation of 1617.4 feet msl on July 9, 1.3 feet below the 1618.71 feet msl maximum of record experienced on June 25, 1995. The normal 1-foot weekly fluctuation of Lake Sharpe was resumed in the summer of 1999 and the lake fluctuated between elevation 1419.5 and 1421.8 feet msl during the period.

5. Fort Randall Operation - August 1998 to July 1999. Fort Randall Dam, the fourth largest Corps of Engineers storage reservoir, serves all authorized purposes. Fort Randall's primary functions are: (1) to capture plains snow and localized rainfall runoffs in the drainage area from Big Bend Dam to Fort Randall Dam. Captured floodwaters are metered out at controlled release rates to meet the main stem authorized purposes while reducing flood damages in the Fort Randall reach where several areas have homes and cabins in close proximity to the river; (2) to serve as a primary storage location along with the Oahe project for water accumulated in the System from reduced System releases due to major downstream flood control operations, thus helping to alleviate large pool increases in the very small Gavins Point project; (3) to provide a location to store the water necessary to provide increased winter energy to the

basin by allowing an annual fall drawdown of the lake to occur with a winter refilling operation which is unique to this project; and (4) to provide the extra water needed to meet all main stem authorized purposes, particularly navigation and downstream water supply, which draft storage during low water years.

Late Summer and Fall 1998. Releases averaged 26,400, 30,900, 29,600, and 34,400 cfs during the August through November period; 9,200, 4,800, 5,500 below normal and 2,600 cfs greater than normal, respectively. Lake Francis Case was near elevation 1355.2 feet msl, 5.2 feet into the flood control and multipurpose pool zone at the beginning of August, down from the 1359.3 feet msl yearly maximum pool that occurred on June 26, 1998. The annual fall drawdown caused the lake to decline 22.6 feet to 1336.6 feet msl by December 1, 1998. This drawdown is accomplished each year near the end of the navigation season to provide space for storing winter power releases from the upstream projects.

Winter 1998-1999. Fort Randall releases were reduced from the autumn floodwater evacuation rate to the winter release rate during the month of December. Fort Randall releases ranged from 32,500 to 20,600 cfs in December. Ice conditions below Fort Randall remained stable through December 29, 1998. Between December 31, 1998 and January 6, 1999, releases from Fort Randall were held in the 22,000 to 23,000 cfs range as the Missouri River stages downstream rose just under 6 feet at the Greenwood, South Dakota gage. The ice jam caused minor flooding in the Old Niobrara townsite and prevented flows from reaching Lewis and Clark Lake. As a result Lewis and Clark Lake fell from 1206.7 to 1204.1 feet msl by January 6. This was the only ice-affected flooding event that was experienced downstream from the Fort Randall project during this winter season. The Gavins Point pool did not recover until January 30, 1999, when the midnight pool elevation reached 1207.0 feet msl. Through the remainder of the winter season, Fort Randall releases ranged between 17,900 and 25,300 cfs as needed to maintain the Lewis and Clark pool elevation near 1207 feet msl.

Fort Randall releases averaged 25,400, 21,100, and 21,900 cfs during December, January, and February, respectively, well above the normal winter release rate of 15,000 cfs, to continue the floodwater evacuation. The releases varied from 137 percent of normal in December to 134 percent in January and 156 percent of normal in February. The December, January, and February average monthly releases were the third highest since the main stem system first filled in 1967. Lake Francis Case rose from 1336.6 feet msl on the first of December to 1351.9 feet msl in late February.

Spring and Summer 1999. Releases from Fort Randall generally paralleled those from Gavins Point and averaged 26,200 cfs in March, 18,700 in April, 25,500 cfs in May, 29,300 in June, and 31,900 cfs in July. Daily average releases varied between 7,200 and 35,200 cfs during this period. Lake Francis Case was at an elevation of 1354.3 on April 1, 1999, 1357.8 on May 1, 1999, and peaked at elevation 1363.1 on May 13, 1999, up 3.8 feet from the previous year's peak. The lake level declined to 1358.4 by June 1, 1999, and was at elevation 1360.3 feet msl at the end of July. Lake Francis Case was held 3 to 6 feet higher than normal from April until mid-August to prevent Lake Oahe from rising substantially into its exclusive flood control pool.

6. Gavins Point Operation - August 1998 to July 1999. Gavins Point Dam, the most downstream of the main stem dams, is primarily used as a reregulating dam to level out the release fluctuations of the upper dams to serve downstream purposes. With a total storage of only 500,000 acre-feet, it provides very little flood control and is generally maintained in a narrow band between 1205 and 1207 feet msl. Due to the limited storage, releases from Gavins Point must be backed up with releases out of the upper reservoirs. Gavins Point is the key location in the initiation of release reductions for downstream flood control. Even though it has only a small amount of storage space for flood control, by coordinating Gavins release reductions with Fort Randall, this volume is usually adequate to perform significant downstream flood control. Releases greater than the powerplant capacity, near 35,000 cfs, are passed through the spillway.

Late Summer and Fall 1998. The primary operational objective of Gavins Point in the late summer and fall of 1998 was the evacuation of excess storage from the upper reservoirs. Although runoff during the first half of 1998 was near normal, in the late summer and fall it was much above normal. In response to the increased runoff, Gavins Point releases were stepped up from the 31,000 cfs summer release rate to 33,500 cfs in September, 35,000 in mid-October, 37,000 cfs in late October, and finally reached 40,000 cfs in early November. Average monthly releases were 30,700 cfs for August, 6,300 cfs lower than average; 33,500 cfs for September, 4,100 lower than average; 33,900 cfs for October, 3,400 cfs lower than average; and 39,500 cfs for November, 5,200 cfs greater than average. In early December releases were stepped down, reaching 31,000 cfs on December 7, 1998. Mild weather allowed the releases to be held at that level until December 19. With the threat of much colder weather and the anticipation of ice formation late in the month, releases were reduced further, reaching the 22,000 to 24,000 cfs range by December 22. The official closing of the 1998 navigation season at the mouth of the Missouri occurred on December 11, 1998.

Lewis and Clark Lake was operated to maintain a pool elevation near 1207 feet msl throughout the period, varying between 1205.8 and 1208.1 feet msl.

Winter 1998-1999. The plan for Gavins Point during the winter 1998-1999 was to evacuate the remaining 2.0 MAF of floodwater stored in the System by March 1. The winter release rate for Gavins Point Dam was set at 24,000 cfs, 4,000 cfs above the normal maximum winter release. The 24,000 cfs release was maintained from December 28, 1998 to January 20, 1999. On the following day releases were increased to 26,000 cfs and remained there until the end of January. February began with a 2,000 cfs increase in Gavins Point release to 28,000 cfs and releases remained at that level through March 1, 1999.

During this period, reductions in releases were not required to prevent flooding downstream from Gavins Point during ice building or bridging. Like the previous 2 years, ice bridging on the Missouri River downstream from Gavins Point was not a major problem; however, the above normal winter release required careful monitoring of downstream stages and weather conditions to prevent flooding and ice jams.

The Gavins Point average daily release was well above the normal winter release rates. Monthly averages were 29,500 cfs, for December, 24,600 cfs in January, and 28,000 cfs in

February, the same as February 1998. This was the third highest December, the fourth highest January, and the second highest February on record. The winter of 1998-1999 was also the fourth consecutive year that above normal winter releases were made.

One of the three Gavins Point generating units is usually out of service for maintenance during the winter months. A second unit failure or a transmission system failure during very cold conditions would necessitate opening the spillway gates to prevent releases from being reduced to that permitted by one generating unit. Municipal and powerplant intakes could experience inadequate river stages if ice jams occurred with only one unit generating. Operable spillway gates would also be needed to release floodwaters in excess of two-unit capacity if sudden changes in winter conditions produced high reservoir inflows.

Supplemental sidewall heaters were installed on the downstream walls of tainter gates 2, 4, and 6 during 1997 to prevent the ice bridging which normally occurs between the spillway gate and the sidewalls. Additionally, the existing side seal heaters on tainter gates 2, 4, and 6 were replaced. The heaters preformed satisfactorily during the winter of 1998-1999 when spillway releases varied from 700 to 8,000 cfs.

During the winter period, Lewis and Clark Lake was near 1207 feet msl, the same target as the previous seven winter seasons. The target elevation was lowered to 1206 feet msl at the end of February for flood control. The maximum pool level reached during the winter period was 1207.5 feet msl on December 28, 1998. The minimum pool level of the season occurred as a result of the ice bridge downstream from the old Niobrara townsite. The ice bridge blocked inflows to Gavins Point and the Lewis and Clark Lake dropped to 1204.1 feet msl on January 6, 1999. The Gavins pool recovered to the 1207 feet msl level by January 30 and remained at that level through early February.

Winter River and Ice Conditions Below Gavins Point Dam. The Gavins Point winter release rate of 24,000 cfs was reached on December 28, 1998. This was an unusual winter season on the Missouri River below Gavins Point; no ice cover developed and no ice-jam flooding was reported. The moderate winter temperatures and diligent regulation of releases from the Gavins Point Dam during the periods of ice formation allowed an increase to 26,000 cfs on January 22, 1999 and to 28,000 cfs on February 1, 1999. The first reports of floating ice on the Missouri River were received on December 21, 1999 with minimal amounts, 10 to 15 percent, and 4- to 10-foot size pads. In early January, during a brief cold period, the largest amount of floating ice for the winter season was reported between Sioux City, Iowa and Jefferson City, Missouri with 65 to 85 percent floating ice and 5- to 20-foot size pads. The last report of floating ice was made on January 29, 1999 with only 15 percent floating ice in the Sioux City, Iowa area and only 1- to 4-foot size pads. This winter season had remarkably low floating ice formation.

Spring and Summer 1999. Following the much above normal winter inflows into the System, Gavins Point releases were increased to 30,000 cfs on March 2, 1999 and to 32,000 cfs on March 8. The March average release rate was 31,200 cfs, more than 10,000 cfs above normal. The high winter releases made navigation on the lower river possible throughout most of the winter and flows at all downstream target locations were exceeding navigation requirements by

April 1, the first day of flow support for the 1999 navigation season. The first tow of 1999, the "Omaha," entered the river on February 13, 1999. Only four tows were operating on the Missouri River on April 1, but as many as six tows were on the river by late April.

With slightly above normal mountain snowpack and a light plains snowpack, Gavins Point releases were set to slightly exceed full service navigation targets from late March through the first half of May. However, reductions during April and May for downstream flood control kept monthly averages near normal; April's average of 25,700 cfs was 1,500 cfs below normal and May's average of 30,800 cfs was 300 cfs above normal.

There were several reductions in system releases to provide downstream flood control during the spring and summer of 1999. In mid-April, heavy rains produced a high volume of runoff in much of the lower basin. The most significant flow increases occurred on the Kansas, Platte, and Nemaha Rivers. The Kansas River, which had been running near 15,000 cfs prior to the storm, increased to 75,000 cfs. Likewise, the Platte River, which had been running a healthy 15,000 cfs, increased to 30,000 cfs. The Big Nemaha River at Falls City had been running only a few hundred cfs but increased to 30,000 cfs. As a result, Gavins Point releases were reduced to 17,000 cfs but were gradually increased to 28,000 by May 1.

In May, as high stages were reached on the Platte River in central Nebraska, Gavins Point releases were reduced to as low as 24,000 cfs on May 10 and 11, thus providing only minimum service navigation flows at Sioux City. As floodwaters receded, releases were increased to the 38,000 cfs summer release rate for the endangered species nesting season. In June, releases were cut back several times for downstream flood control, reaching as low as 30,000 cfs.

Average daily outflows were 35,100 cfs in June and 38,000 cfs in July, 3,400 cfs and 3,600 cfs above average, respectively.

Additionally, there was one special operation at Gavins Point. On March 19, the releases were reduced from 32,000 cfs to 10,000 cfs for 6 hours for a spillway slab inspection. Releases were then set at full powerplant for a few hours before returning to the 32,000 cfs rate.

Lewis and Clark Lake was targeted for elevation 1206 feet msl throughout the spring and summer of 1999. The lake elevation ranged from 1205.2 feet msl to 1208.2 feet msl.

E. <u>Non-Routine Operations and Other Items Pertaining to Main Stem Regulation</u>. Numerous operations are performed each year that, although at one time may have been considered special, are now considered almost routine. These include the release restrictions from a particular project for a period of time to permit soundings or to facilitate limited construction within or adjacent to the downstream channel, and to pattern releases to facilitate measurements of downstream discharges and water surface profiles. Events that occurred in connection with operations during the past year that may be considered unusual, or recently have come to the attention of the Reservoir Control Center, are discussed in the following paragraphs.

1. Fort Peck. Requests were received for a month-long warm water spill from Fort Peck in the spring of 1999 in combination with powerplant releases. This operation was not scheduled in 1999 because of potential impacts to flood control, hydropower, and downstream erosion. The lost power revenue estimates for these requests vary from $1.5 to $4.3 million.

2. Garrison. There were numerous complaints of streambank erosion with the high summer and fall Garrison releases during 1995, 1996, and 1997. Bank erosion from the high river flows is a primary concern of many citizens in the Garrison reach. Local initiatives are being pursued to resolve the erosion problem at the most significant areas. There are also several local initiatives regarding zoning and future construction along the Missouri River that received a great deal of publicity this past year.

3. Oahe. The channel capacity of the Missouri River in the reach between Oahe Dam and Lake Sharpe has been declining since the construction of the System due to sediment accumulation, mainly from the Bad River. Although major flooding in the Pierre-Fort Pierre area has been avoided since the construction of Oahe Dam, the threat of shallow flooding, especially during river ice-in periods, has increased. This has prompted operational constraints on Oahe hydropower production during the most critical river ice-in conditions. The loss in generation due to these operational constraints has been offset by additional power purchases on the open market by Western Area Power Administration (Western). Western replaces the lost generation to meet contractual obligations to electrical distributors.

Two investigations to address these concerns are currently underway. The first is in response to Section 441 of the Water Resources Development Act of 1996 which directed the Secretary of the Army to investigate potential solutions to the recurring flooding and related problems in the area of Pierre and Fort Pierre, South Dakota. The second is in response to Section 136 of the Omnibus Consolidated and Emergency Supplemental Appropriation Act of 1999, authorizing the Secretary of the Army to investigate relocation and/or floodproofing of structures in the Pierre-Fort Pierre area that are at risk of periodic flooding up to the full powerplant capacity of Oahe Dam. The Section 441 studies are ongoing. A report in response to Section 136 outlining the feasibility and cost of potential relocations and/or floodproofing has been approved. Relocations and floodproofing under the Section 136 authority will begin next year.

4. Downstream Reach. A general lowering trend of the river level and the accumulation of sediment in downstream marinas continue to be a concern for marina operators, water intakes, and recreational boaters. Dredging was necessary in 1990, 1991, and in 1992 because of sediment deposits resulting from high short duration flows. The Great Flood of 1993 deposited large amounts of sediment in many marinas making that the fourth consecutive year that sediment removal was necessary by the marina operators. From 1995 through 1997 most marina owners between Sioux City and Omaha did not have to deepen their entrances and dredge basins to provide access because of higher main stem flows. In 1998 significant problems surfaced due to the degradation and sedimentation. During 1999 releases were much above normal throughout the majority of the season, thus problems have occurred only during periods of release reductions

for downstream flood control. Generally, these problems are expected to reoccur in the future once flow levels near full service are again initiated.

F. Reservoir Releases and Storage Pool elevations and storage contents of the main stem reservoirs at the end of July 1999 are presented in ***Table IV***.

TABLE IV
PROJECT POOL LEVELS AND STORAGES

	Pool Elevation feet msl		Water in Storage - 1,000 AF July 31, 1999		
	July 31, 1999	12-Month Change	Total	Above Min. Pool*	12-Month Change
Fort Peck	2237.6	- 2.5	15,780	11,569	- 573
Garrison	1847.1	+ 4.1	21,294	16,314	+ 1,373
Oahe	1616.9	+ 4.7	22,042	16,669	+ 1,599
Big Bend	1420.6	+ 0.7	1,720	38	+ 37
Fort Randall	1360.3	+ 5.1	3,992	2,475	+ 448
Gavins Point	1205.3	- 1.0	339	18	- 25
			65,167	47,083	+ 2,859

*Net usable storage above minimum pool levels established for power, recreation, irrigation diversions, and other purposes.

G. Summary of Results.

1. Flood Control. System storage in the main stem reservoirs on August 1, 1998, was 62.3 million acre-feet (MAF), only 0.4 MAF greater than the 32-year average of 61.9 MAF and 8.9 MAF lower than in the record runoff year of 1997. After peaking at 62.5 MAF on July 23, 1998 System storage was down only 0.3 MAF, so releases during the late summer, fall, and winter were directed at evacuating flood storage. High runoff in the upper basin during the fall of 1998 and the winter of 1998-1999 kept system releases above normal to reduce System storage to the base of the annual flood control zone, 57.1 MAF, by March 1, 1999.

Above normal mountain snowpack, pockets of heavy plains snowpack, and spring and summer rains kept runoff in 1999 above normal and System storage peaked at 65.4 MAF on July 23, 2.9 MAF higher than the previous year's peak. The estimated total flood damage prevented by the main stem reservoirs during Fiscal Year (FY) 1999 is $2.1 billion. The $2.1 billion total damages prevented in the Missouri River basin includes $2.0 billion in the Kansas City District and $112 million in the Omaha District. The damages prevented by the Missouri River main stem reservoirs along the Mississippi River are not yet available. The flood damage prevented by the System since construction now totals $18.0 billion, the bulk of which was prevented between 1993 and 1999 (see ***Figure 6A***). Although the reservoirs prevent enormous amounts of damage, they are not capable of totally eliminating flooding along the Missouri River. The estimated actual flood damages incurred in the Omaha District along the Missouri River from above Fort Peck Dam to Rulo, Nebraska, for 1999 were $13.1 million. The estimated flood damages incurred along the Missouri River in the Kansas City District have not yet been provided for FY 1999. ***Figure 6B*** indicates the $1.2 billion cost to construct the main stem dams. High stages on the Missouri River from spring and summer rains prevented planting, destroyed crops, or forced late planting thereby reducing yields of 69,500 acres of farmland in the reach between Sioux City, Iowa and St. Joseph, Missouri.

The Kansas City District tributary reservoirs also prevented a tremendous amount of flood damages because of large rainfall events captured by the Kansas projects during this past year. The total damages prevented in the Kansas City District, exclusive of the Missouri River main stem dams, was $2.5 billion.

Figure 7 shows the actual regulated flows that were experienced at Sioux City, Iowa, Nebraska City, Nebraska, and St. Joseph, Missouri, and the unregulated flows that would have been experienced if the main stem and tributary reservoirs had not been in operation.

2. Irrigation. Federally developed irrigation projects are not being served directly from main stem reservoirs. However, releases from the reservoirs are being utilized by numerous private irrigators as well as Federally financed projects that take water from the river. Over 400 private irrigators have been granted permits to pump directly from the reservoirs. Releases from the reservoirs during 1998 and 1999 generally met the needs of irrigators.

Missouri River Main Stem

Cumulative Flood Damages Prevented

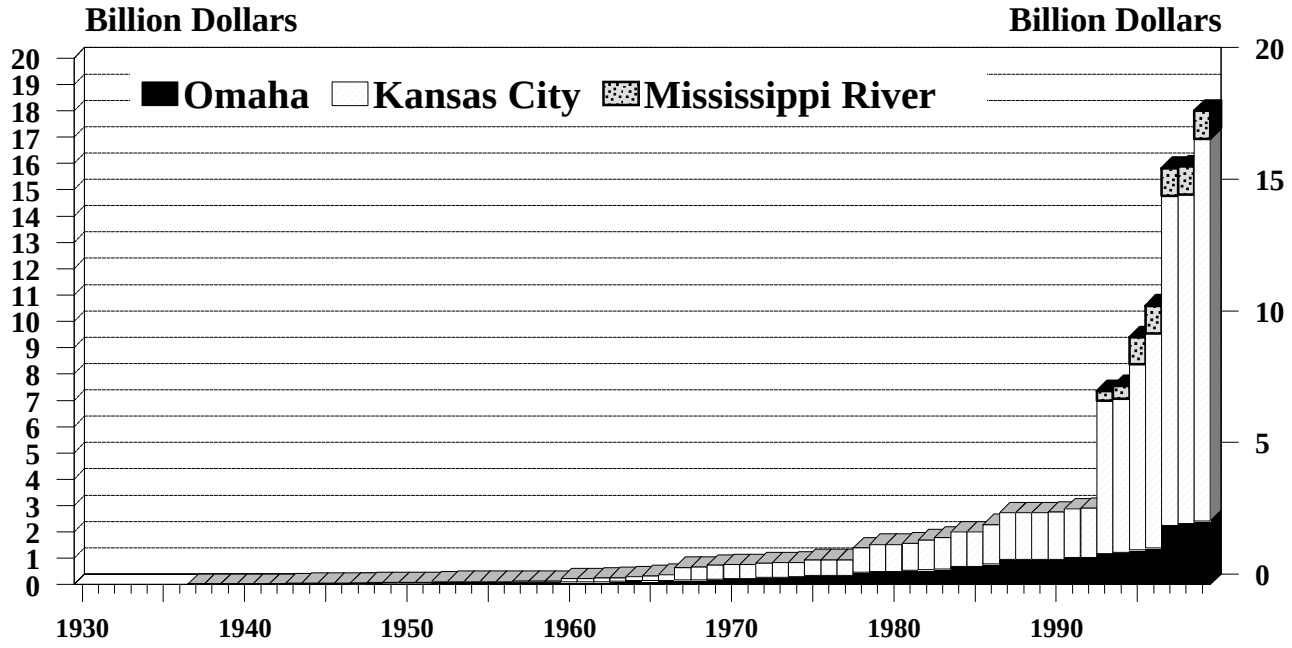


Figure 6A

Annual Flood Damages Prevented

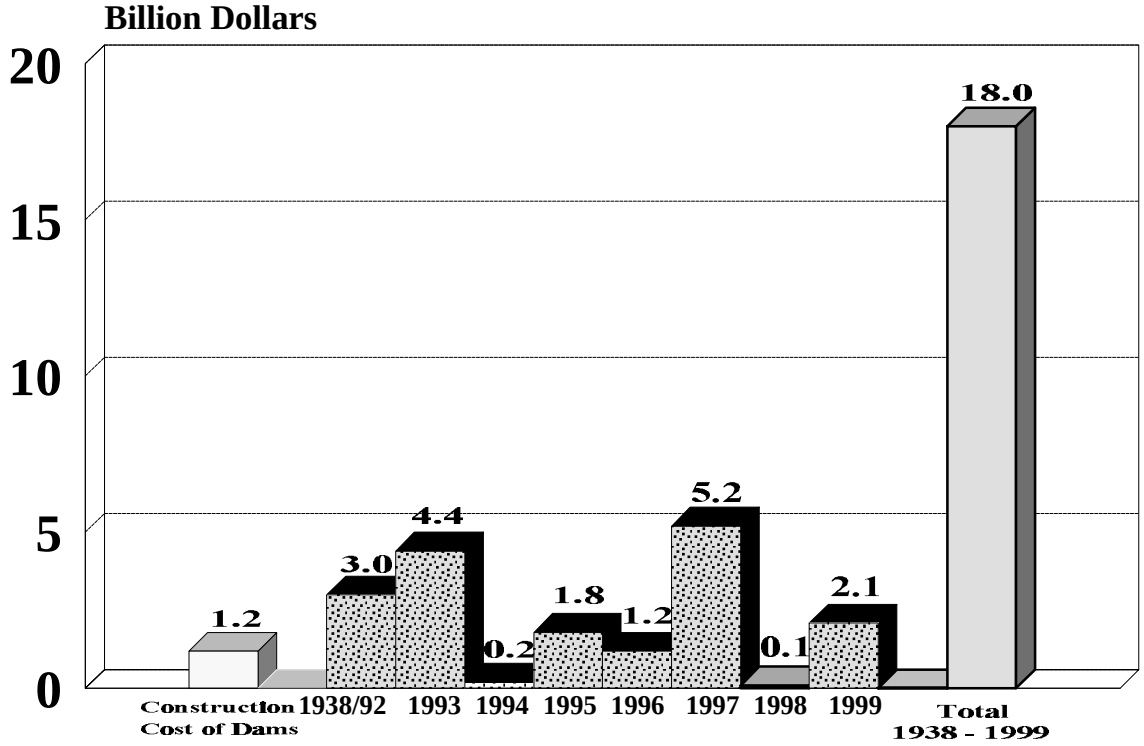
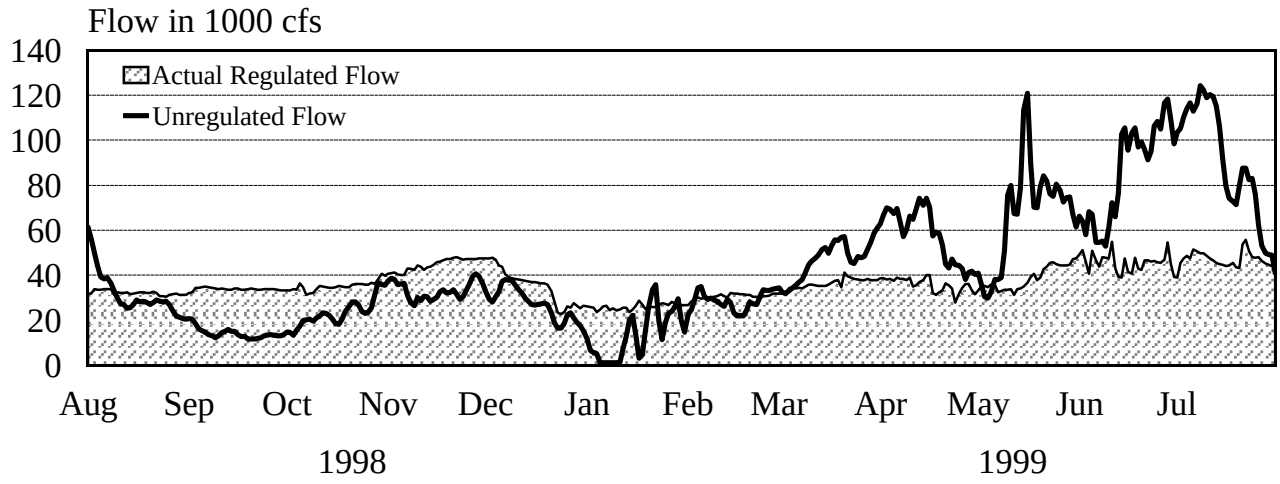
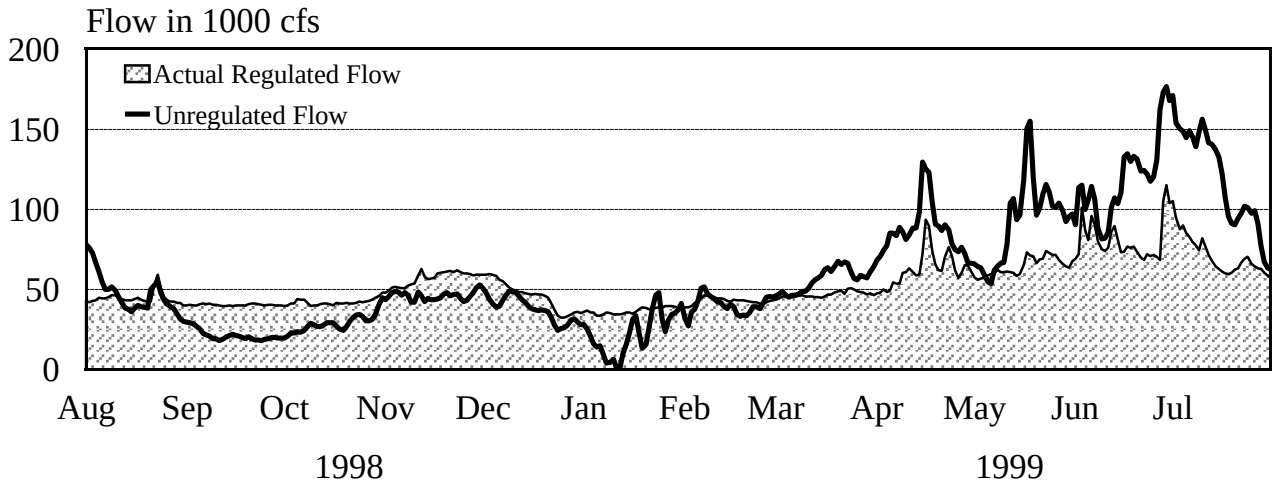


Figure 6B

Sioux City
Regulated and Unregulated Flows



Nebraska City
Regulated and Unregulated Flows



St. Joseph
Regulated and Unregulated Flows

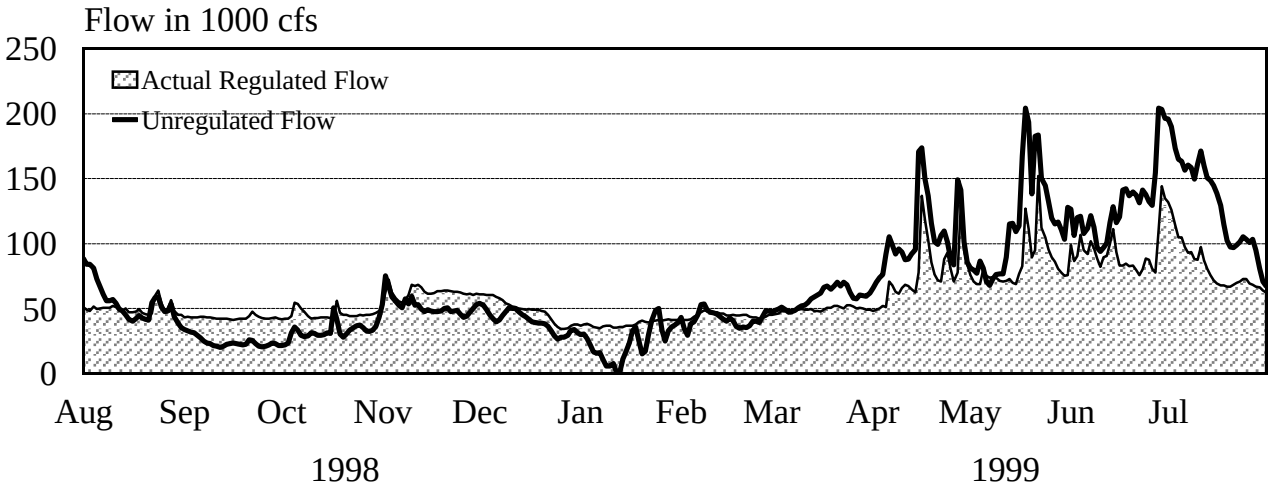


Figure 7

3. <u>Water Supply and Water Quality Control</u>. Daily flows exceeded minimum requirements for water supply and water quality control purposes throughout the system for the entire 1998-1999 period. With higher than average winter release rates, there were very few water supply problems. Intake owners today are also better prepared to handle periods of low water due to adjustments made to intakes or operating procedures as a result of the drought. Some of these adjustments involved using warm water to keep ice formation from building up on intake screens, installing new pumps, lowering intakes and installing sediment redirection vanes, installing ice deflectors, obtaining or arranging to obtain alternate sources of water, and cleaning screens more thoroughly and frequently. These remedial actions were expensive but have significantly improved the ability of the intakes to tolerate low river stages.

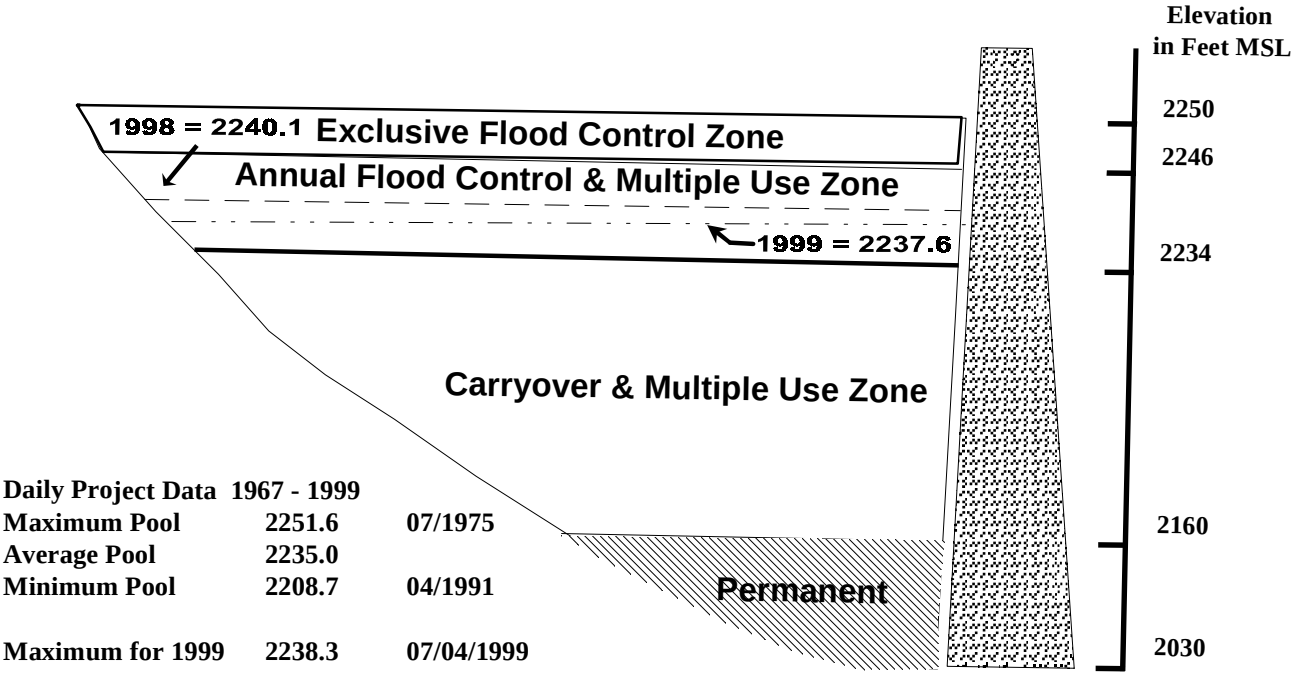
Figure 8 shows the end-of-July pool elevation for Fort Peck, Garrison, and Oahe plus total main stem System end-of-July storage for 1998 and 1999. An individual table with the maximum, average, and minimum end-of-July pool elevations for each major reservoir is also shown on this figure. The end-of-July 1999 pool elevation was lower than last year at Fort Peck but higher than last year at Garrison and Oahe. Fort Peck (2237.6 feet msl) was 3.6 feet into the annual flood control zone and 2.5 feet lower than the 1998 end-of-July level. Garrison (1847.1 feet msl) was 9.6 feet into the annual flood control zone, 4.1 feet higher than 1998. Oahe (1616.9 feet msl) was 9.4 feet into the annual flood control zone, only 0.1 foot below the base of the exclusive zone, and 4.7 feet higher than in 1998. Also shown are the minimum, maximum, and average pool elevations for the periods since the System closed in 1967.

Specific water quality problems detected in the Missouri River main stem projects in 1998 were the exceedence of state standards for several parameters. ***Table V*** lists the issues and problems identified at each of the main stem projects during 1998.

Parameters exceeding state standards at one or more main stem reservoir projects are arsenic, iron, phosphorus, sulfate, dissolved oxygen, manganese, pH, and lead. The majority of these parameter exceedences arise from sources outside project boundaries. This is particularly true for metals and organics. Agricultural practices, both past and present, included the application of pesticides throughout much of the Missouri River basin. While state ambient water quality standards do not exist for most pesticides, the following pesticides and herbicides have been detected in minute concentrations in the main stem reservoirs during the past 5 years: Atrazine, alachlor, chlordane, diacamba, diazinon, dacthal, benzene hexachloride, dieldrin, DDT, metolachlor, simazine, metribuzin, trifluralin, and propachlor. Pesticide levels will continue to be closely monitored.

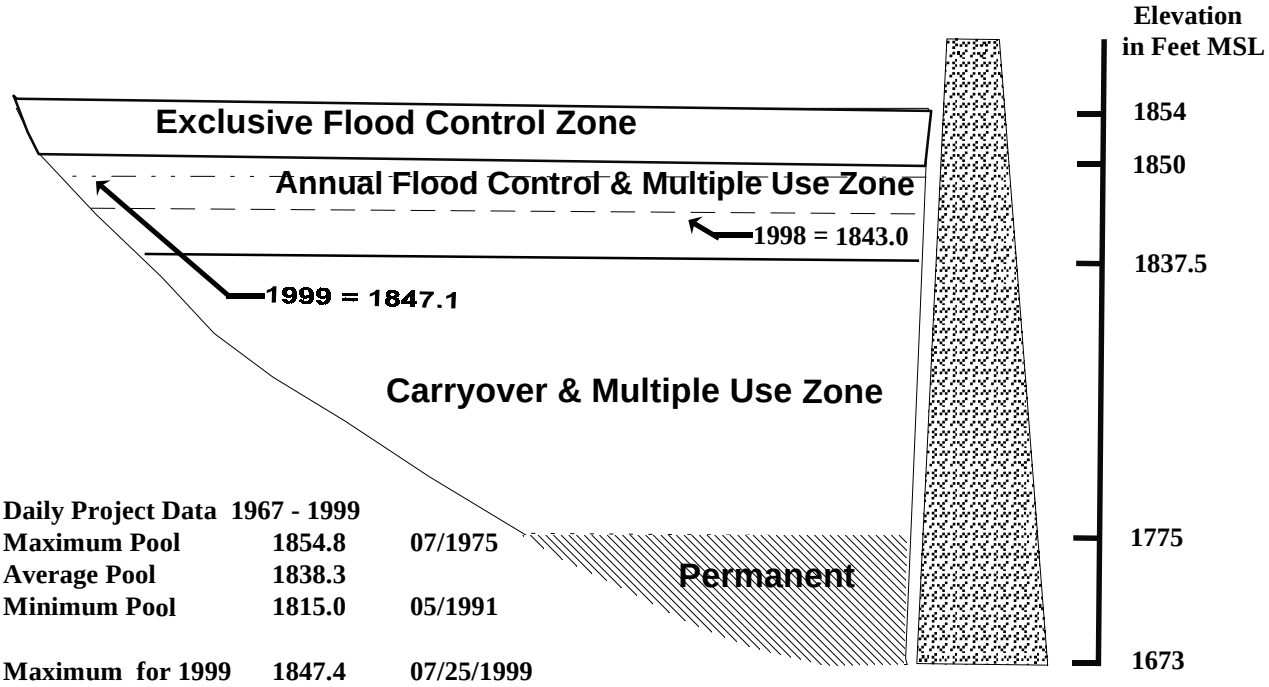
Low dissolved oxygen concentrations may result from the impoundment of water in lakes and reservoirs. Low dissolved oxygen concentrations may result in an influx of metals such as iron and manganese from the sediments into the water in concentrations that may exceed state standards.

Missouri River Main
End-of-July Lake Elevations and



Daily Project Data 1967 - 1999		
Maximum Pool	2251.6	07/1975
Average Pool	2235.0	
Minimum Pool	2208.7	04/1991
Maximum for 1999	2238.3	07/04/1999

Fort Peck Lake

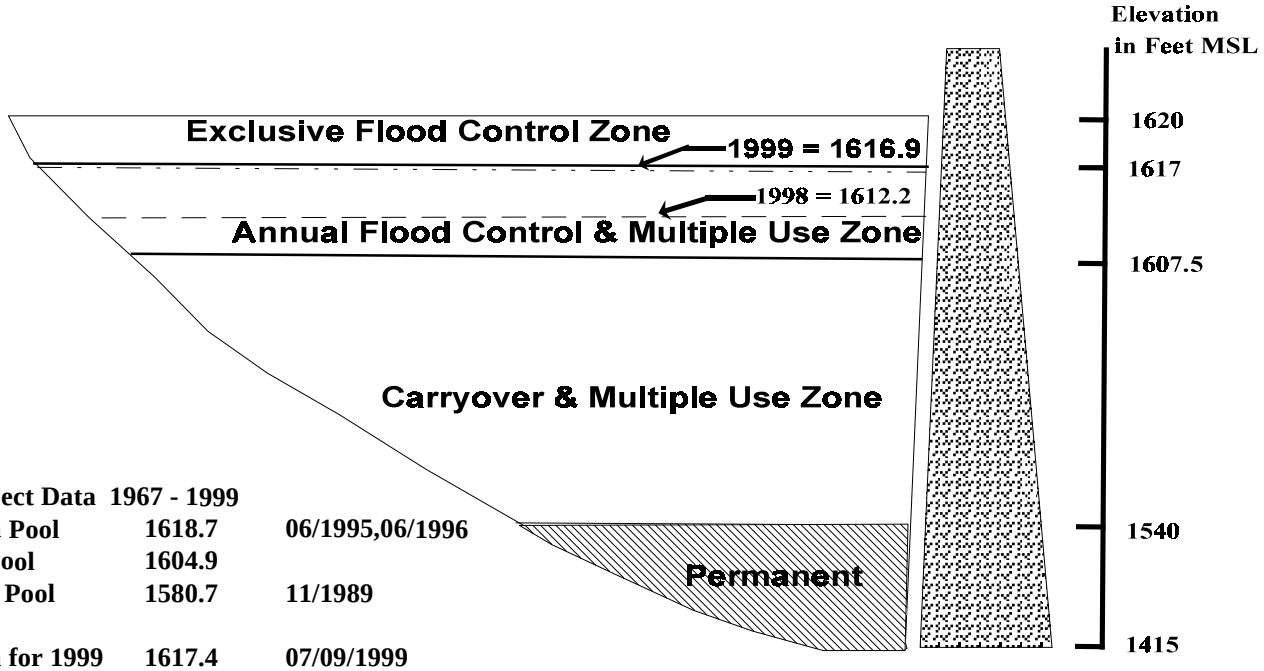


Daily Project Data 1967 - 1999		
Maximum Pool	1854.8	07/1975
Average Pool	1838.3	
Minimum Pool	1815.0	05/1991
Maximum for 1999	1847.4	07/25/1999

Garrison Dam - Lake Sakakawea

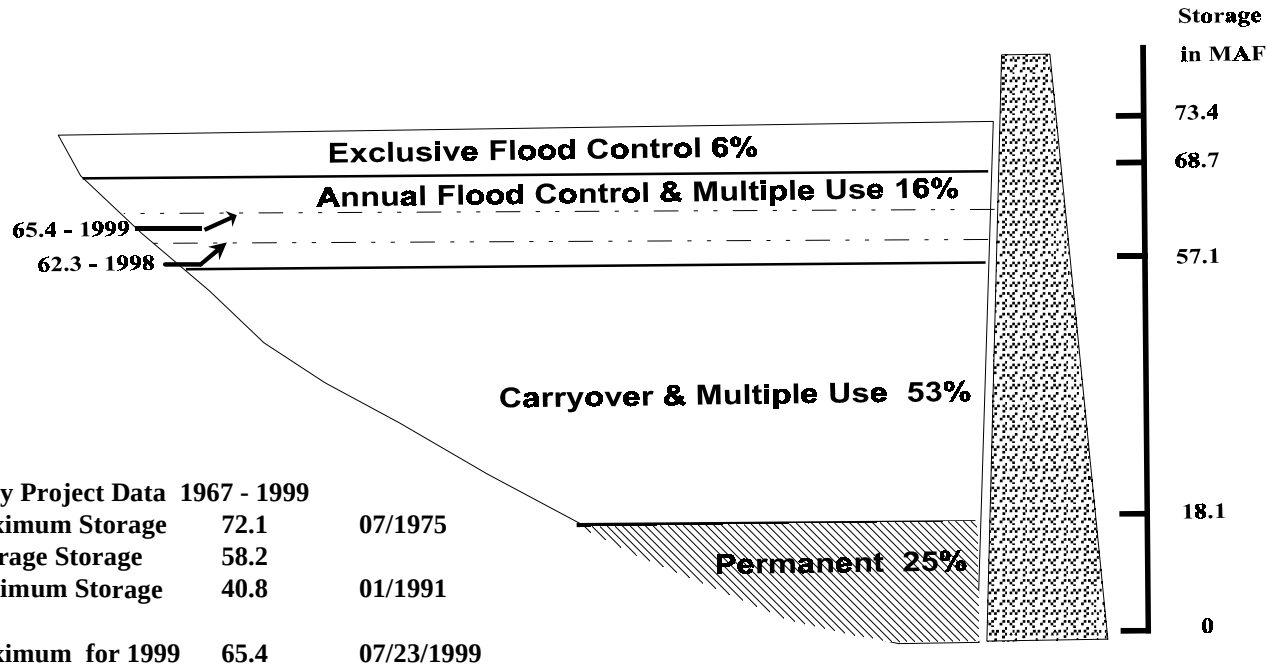
Figure 8 A

Stem Reservoirs
Total System Storage



Daily Project Data 1967 - 1999		
Maximum Pool	1618.7	06/1995,06/1996
Average Pool	1604.9	
Minimum Pool	1580.7	11/1989
Maximum for 1999	1617.4	07/09/1999

Oahe Dam - Lake Oahe



Daily Project Data 1967 - 1999		
Maximum Storage	72.1	07/1975
Average Storage	58.2	
Minimum Storage	40.8	01/1991
Maximum for 1999	65.4	07/23/1999

Total System Storage

Figure 8 B

TABLE V
WATER QUALITY ISSUES AND PROBLEMS
IN MAIN STEM LAKES - 1998

Project	Algal Blooms	Fish Kills	Potential Problem Areas	State Standard or EPA Ambient Water Quality Criteria; Exceedences
Fort Peck	No	No	Coal & oil development, algal blooms	*Inflow:* none identified *Reservoir*: dissolved oxygen, chlordane, iron, arsenic *Releases*: arsenic
Lake Sakakawea	Yes	No	Oil drilling, strip mining, algal blooms, low dissolved oxygen, Atrazine, metribuzin	*Inflow*: arsenic *Reservoir:* dissolved oxygen, phosphorus, lead, arsenic and iron *Releases:* none identified
Lake Oahe	No	No	Agricultural runoff, bioaccumulation of mercury, metribuzin	*Inflow*: none identified *Reservoir*: dissolved oxygen, pH, arsenic, iron, and manganese *Releases:* arsenic
Lake Sharpe	No	No	Agricultural runoff	*Inflow*: none identified *Reservoir:* dissolved oxygen, pH, arsenic *Releases*: arsenic, pH, and Atrazine
Lake Francis Case	No	No	Intrusion of the White River delta	*Inflow*: Atrazine *Reservoir*: dissolved oxygen, pH, sulfate *Releases*: sulfate and pH
Lewis and Clark Lake	No	No	Emergent aquatic vegetation, and metribuzin	*Inflow*: sulfate *Reservoir*: dissolved oxygen, pH, arsenic, iron, sulfate, manganese, and Atrazine *Releases:* arsenic, dissolved oxygen, pH, sulfate, iron, and Atrazine

In certain years, a potential exists for low dissolved oxygen levels in Garrison Reservoir. Garrison has had problems in the past with low dissolved oxygen during low water supply years when hypolimnetic volume is small. The oxygen demand exerted by the bottom sediments and within-lake organic matter reduces the hypolimnetic oxygen levels. The hypolimnetic dissolved oxygen levels may remain below state standards until the fall turnover. The dissolved oxygen levels in the releases from Garrison Reservoir have never been below state standards. Low dissolved oxygen levels were detected in the hypolimnion by the U.S. Geological Survey (USGS) in their 1993 studies; however, levels returned to above state standards at the next sampling period. The project will continue to be sampled for this problem. If a problem is detected, increased sampling will be initiated to determine the severity and extent of the low dissolved oxygen. The higher pool and increased volume since 1993 have diminished considerably the chance of a problem occurring. Lake Oahe has experienced problems similar to those at Garrison during low volume years, but the higher lake levels have alleviated the problem since 1993.

The North Dakota Department of Health and Consolidated Laboratories (NDDHCL) in Bismarck has annually issued since 1993 an advisory on consumption of fish caught in some streams and lakes in North Dakota. Lake Sakakawea was included in this advisory. The advisory was not intended to discourage anglers from eating fish but offers advice on how fish caught in these impoundments could be eaten safely. The NDDHCL analyzed fish fillets in 1996 and collected tissue samples again in 1997. The fish eating advisory remains in effect.

4. <u>Navigation</u>. A discussion of the first half of the 1998 navigation season is included in last year's AOP. The latter half of the 1998 navigation season began with flows near the full service level, but releases were increased as the season progressed and wet conditions spread throughout the basin. A 10-day extension to the navigation season was provided for the fourth consecutive year. Flow support was not needed in 1998 from the Corps' Kansas River tributary reservoirs to help meet Missouri River navigation flows at or below Kansas City.

Gavins Point releases were increased from 31,000 cfs in August to 33,500 cfs in September where they remained until late October. In late October and early November a series of increases were made stepping releases up to 40,000 cfs by November 6. The releases remained at that level until December 3 when they were stepped down at the end of the 1998 navigation season. A release rate of 31,000 cfs was reached on December 7. Beginning December 20 additional cuts were made to reduce releases to the 22,000 - 24,000 cfs winter release rate. Support flows for the 1998 extended navigation season ended on December 11 at the mouth of the Missouri. The last tow to leave the river, not involved with sand and gravel operations or the movement of cement, was the "Mark Shurden," Ergon Corp. (Magnolia Marine), on December 7, 1998. The "Jamie Leigh" of Jefferson City River Terminal ceased cement movement operations on December 14, 1998.

Reduced tributary flows on the lower river in late summer caused shoaling to occur between River Mile (RM) 61.2 and 51.7. In response, the Coast Guard restricted barge drafts to 8 feet through the reach from September 11–14, 1998.

The Missouri River stages were a roller coaster ride for the navigation industry because of fall rainstorms affecting the lower river during October and November of 1998. The Coast Guard issued no-wake advisories October 6-12, 1998 from RM 262 to the mouth. As the high stages passed, the Coast Guard lifted restrictions for specific reaches. Within this period, from October 9–11, the Coast Guard closed the river from RM 67.6 to the mouth. Soon after, from November 3-7, 1998, the Coast Guard issued no-wake advisories from RM 293 to the mouth, lifting restrictions as the high stages passed various reaches.

Navigation commodity tonnage for 1998 has been provided by the Waterborne Commerce Statistics Center (WCSC). The WCSC final data for the Missouri River are not normally available until nearly a year after the end of the season. The WCSC estimate of commercial navigation tonnage on the Missouri River for 1998 is 1.7 million tons. This number does not include sand, gravel, and waterway materials. The WCSC estimate of total tonnage indicates approximately 8.3 million tons were transported, slightly more than in 1996 and 1997. A record 8.5 million tons were transported in 1994, including 6.1 million tons of sand and gravel. The largest commercial tonnage season, excluding sand, gravel, and waterway material used to maintain the navigation and bank stabilization structures, occurred in 1977 when 3.3 million tons were moved on the Missouri River. Principal commodities transported downstream were corn, wheat, sorghum, soybeans, oilseeds, and animal feeds. Major commodities moved upstream were fertilizer, cement, salt, molasses, petroleum products, iron, and steel. The amounts of each commodity shipped during 1997 and 1998 are shown in ***Table VI***. Several companies mine sand and gravel from the Missouri River. Movement of the sand and gravel is usually within a few miles of the mining to the nearest loading facility.

TABLE VI
TONNAGE BY COMMODITIES
MISSOURI RIVER

COMMODITY CLASSIFICATION GROUP	**TOTAL (Thousand Tons)**	
	1997	**1998**
Grain (Wheat, Corn, Sorghum)	311	362
Other Food and Farm Products (incl soybeans)	277	342
Fertilizers and Other Chemicals	549	472
Petroleum Products	289	239
Primary Manufactured Goods	185	271
Other	39	48
Subtotals	1,651	1,733
Sand and Gravel	6,303	6,478
Waterway Material	218	167
Totals	**8,172**	**8,378**

A summary of tonnage by major commodities for 1960 through 1998 is displayed on the bar graphs shown on ***Figure 9***. The bottom graph shows the commercial commodity tonnage, excluding sand and gravel and waterway materials, while the top graph shows the total Missouri River tonnage. This includes sand and gravel moved on the river plus waterway materials for navigation project construction and maintenance. As the navigation project has been completed, waterway materials moved have diminished but the sand and gravel moved has increased greatly over the past years.

The official 1999 flow support for navigation began on the normal scheduled opening dates of March 23 at Sioux City, March 25 at Omaha, March 28 at Kansas City, and April 1 at the mouth near St. Louis. However, high releases scheduled during the winter to evacuate flood storage were sufficient to allow boats to operate on the lower river well before the official start of the navigation season.

The first towboat on the Missouri River in 1999 was the "Omaha," Blaske Marine Services, which entered on February 13, 1999. On April 1, the first official day of flow support for the 1999 navigation season at St. Louis, there were four tows operating on the river, the same number as the previous 2 years. The first tow arrived at Sioux City on March 30, 1999.

The stage on the lower reaches of the Missouri River varied widely as a result of heavy rains during spring and early summer of 1999. The Coast Guard closed the river from April 16 through April 21 from RM 366 to RM 130. Soon after, from April 28 through May 3, the river was closed from RM 448 to the mouth. Various reaches were progressively opened to navigation as the stages dropped. From May 6 through May 9 the river was closed from RM 144 to the mouth. Two months later, from July 2 through July 3, 1999, the Coast Guard closed the river to navigation between RM 293 and RM 143.

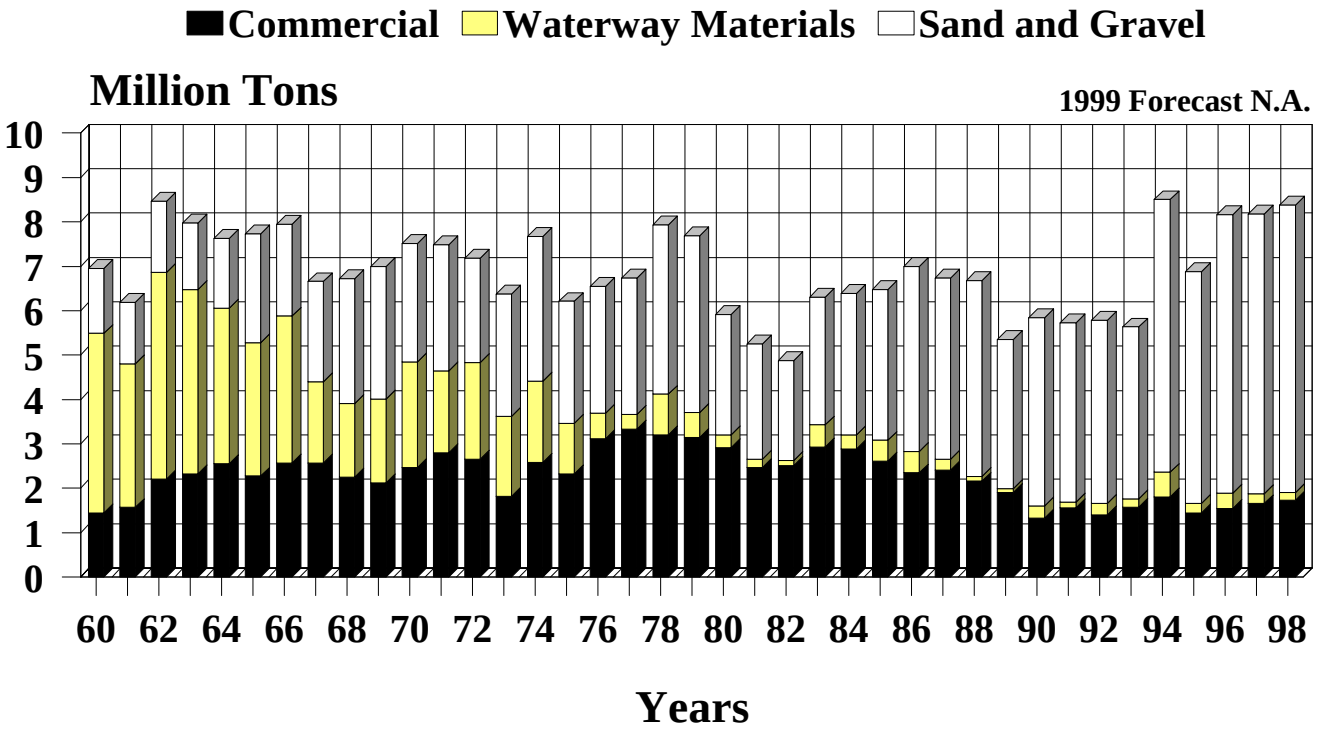
Navigation season target flows for past years are given in ***Table VII***. System storage peaked at 65.4 MAF on July 23, 1999, 2.9 MAF higher than the 1998 peak. Full service flows or above were provided at all target locations during the 1999 navigation season except for a brief period in late April when releases were reduced for downstream flooding. Minimum service flows were provided at Sioux City during the cutback.

Table VIII shows the scheduled lengths of past navigation seasons with total tonnage and ton-miles for the past year. The 1999 season is the fifth in a row that the navigation season will be extended by 10 days due to the ample water supply. The commercial tonnage figure for 1999 is a preliminary estimate and will change once WCSC tabulations are available. Missouri River commercial tonnage in 1999 may total about 1.5 million tons based on estimates from daily reports of towboat activity.

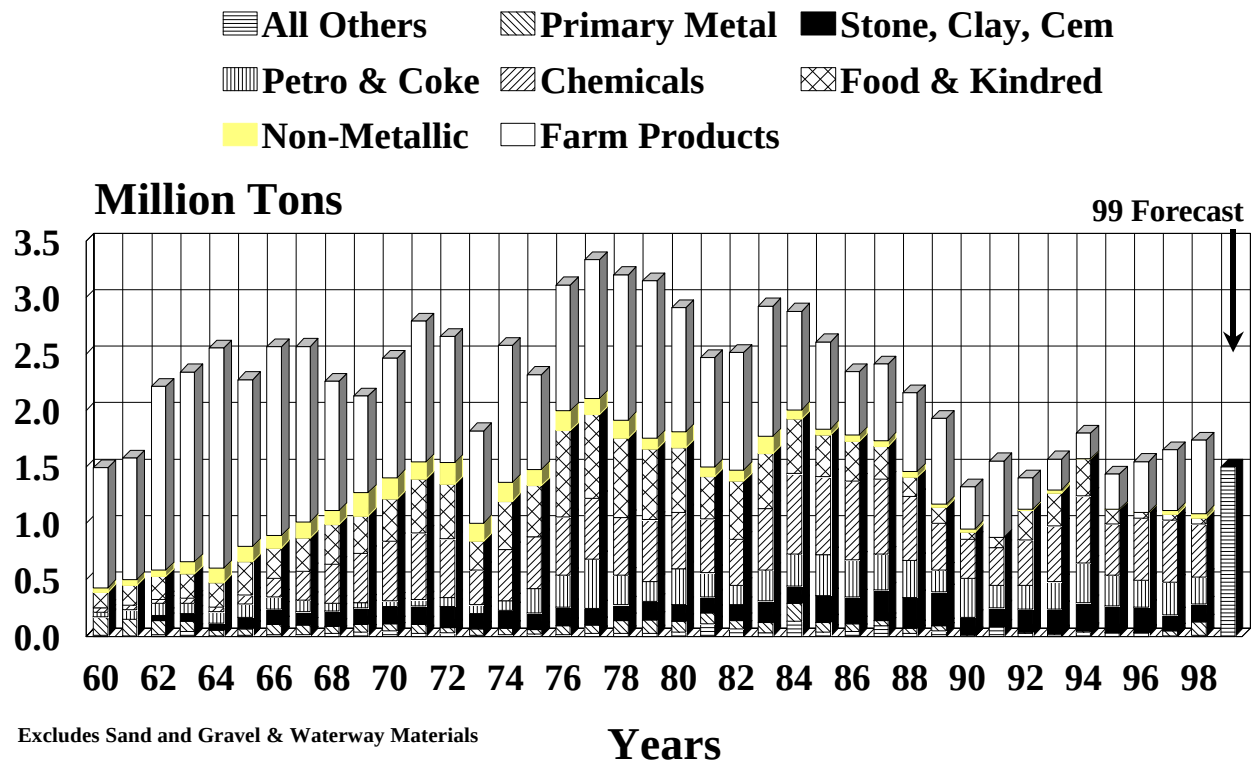
Figure 10 presents discharge data at Sioux City, Nebraska City, and Kansas City for the August 1998 through July 1999 period. The three graphs demonstrate that actual flows at these locations are influenced considerably by main stem releases. In 1998, flows were near full service

Missouri River

Total Navigation Tonnage



Commercial Navigation Tonnage



Excludes Sand and Gravel & Waterway Materials

Figure 9

TABLE VII
NAVIGATION SEASON TARGET FLOWS
Target Flows, 1,000 cfs

Year	Months	Sioux City	Omaha	Nebraska City	Kansas City
1967	Apr-Jun	28.0	28.0	34.0	38.0
	Jul-Nov	31.0	31.0	37.0	41.0
1968	Apr-Nov	31.0	31.0	37.0	41.0
1969	Apr-Jun (1)	35.0-40.0	35.0-40.0	41.0-46.0	45.0-50.0
	Jul (1)	36.0	36.0	42.0	46.0
	Aug-Sep (1)	50.0-55.0	50.0-55.0	55.0-60.0	55.0-60.0
	Oct-Nov (1)	40.0-45.0	40.0-45.0	45.0-50.0	50.0-55.0
1970	Apr-May	31.0	31.0	37.0	41.0
	May-Sep (1)	36.0	36.0	42.0	46.0
	Oct-Nov (1)	40.0	40.0	46.0	50.0
1971	Apr-May (1)	36.0	36.0	42.0	46.0
	May-Nov (1)	45.0-50.0	45.0-50.0	50.0-55.0	55.0-60.0
1972	Apr-Nov (1)	40.0-50.0	40.0-50.0	45.0-55.0	50.0-60.0
1973-74	Apr-Nov	31.0	31.0	37.0	41.0
1975	Apr	31.0	31.0	37.0	41.0
	May-Nov (1)	35.0-60.0	35.0-60.0	41.0-66.0	45.0-70.0
1976	Apr-Jul (1)	34.0-38.0	34.0-38.0	40.0-44.0	44.0-48.0
	Aug-Dec (1)	31.0-34.0	31.0-34.0	37.0-40.0	41.0-44.0
1977	Apr-Nov	31.0	31.0	37.0	41.0
1978	Apr	31.0	31.0	37.0	41.0
	May-Jul (1)	35.0-46.0	35.0-46.0	41.0-52.0	45.0-56.0
	Aug-Nov (1)	46.0-51.0	46.0-51.0	52.0-57.0	56.0-61.0
1979	Apr-Jul (1)	36.0-42.0	36.0-42.0	42.0-48.0	46.0-52.0
	Aug-Nov (1)	31.0-36.0	31.0-36.0	37.0-42.0	41.0-46.0
1980	Apr-Nov	31.0	31.0	37.0	41.0
1981	Apr-Nov (2)	31.0	31.0	37.0	41.0
1982	Apr-Sep	31.0	31.0	37.0	41.0
	Oct	31.0-36.0	31.0-36.0	37.0-42.0	41.0-46.0
	Nov-Dec (1)	36.0-46.0	36.0-46.0	42.0-52.0	46.0-56.0
1983	Apr-Jun	31.0	31.0	37.0	41.0
	Jul	31.0-36.0	31.0-36.0	37.0-42.0	41.0-46.0
	Aug-Nov (1)	36.0	36.0	42.0	46.0
1984	Apr-Jun	31.0	31.0	37.0	41.0
	Jul-Dec (1)	31.0-44.0	31.0-44.0	37.0-50.0	41.0-54.0
1985	Apr-Dec	31.0	31.0	37.0	41.0
1986	Apr (1)	36.0-41.0	36.0-41.0	42.0-47.0	46.0-51.0
	May-Dec (1)	41.0-46.0	41.0-46.0	47.0-52.0	51.0-56.0
1987	Apr-Nov	31.0	31.0	37.0	41.0
1988	Apr-Nov (2)	31.0	31.0	37.0	41.0
1989	Apr-Aug (3)	28.0	28.0	34.0	38.0
	Sep-Oct (3)	28.0	28.0	34.0	35.0
1990-93	Apr-Oct (4)	25.0	25.0	31.0	35.0
1994	Apr-Dec	31.0	31.0	37.0	41.0
1995	Apr-May	31.0	31.0	37.0	41.0
	Jun-Dec (1)	46.0-56.0	46.0-56.0	52.0-62.0	56.0-66.0
1996	Apr (1)	41.0	41.0	47.0	51.0
	May (1)	41.0-51.0	41.0-51.0	47.0-57.0	51.0-61.0
	Jun-Dec (1)	56.0	56.0	62.0	66.0
1997	Apr - Dec (5)	*	*	*	*
1998	Apr - Dec	31.0	31.0	37.0	41.0
1999	Apr-Jul (1)	31.0-43.0	31.0-43.0	37.0-49.0	41.0-53.0

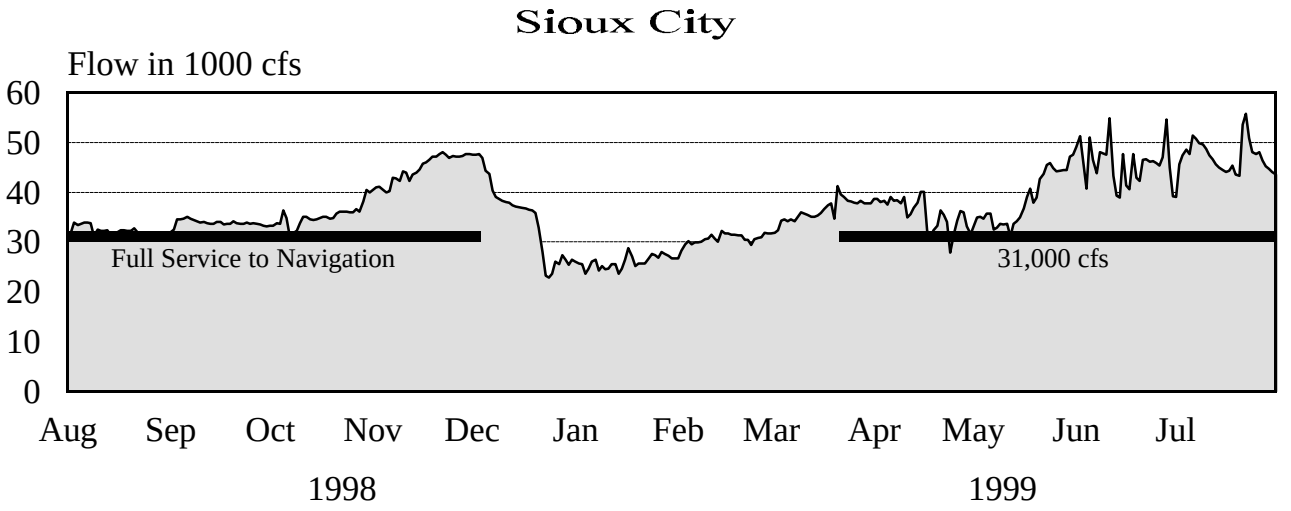
(1) Downstream flow targets above full-service navigation level as a flood control storage evacuation measure.
(2) Full service flows provided for shortened season.
(3) Navigation targets below full service as a water conservation measure.
(4) Navigation targets at minimum service as a water conservation measure.
(5) Releases determined by flood control storage evacuation criteria and not adjusted to meet specific navigation targets.

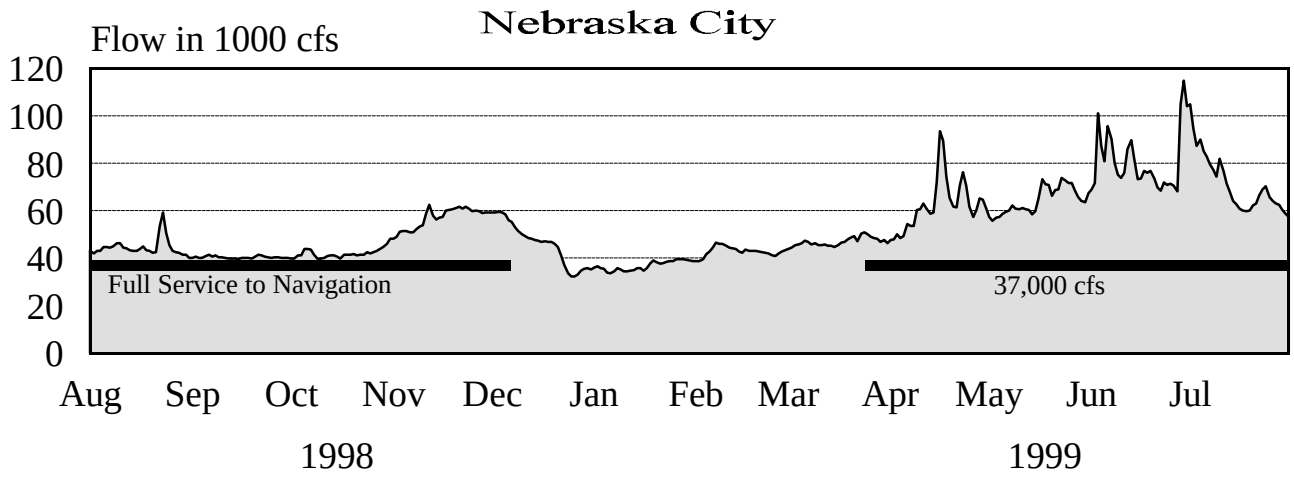
TABLE VIII
MISSOURI RIVER NAVIGATION
TONNAGE AND SEASON LENGTH

Year	Scheduled Length of Season (Months)	Commercial (Tons) (1)	Total Traffic (Tons) (2)	Total Traffic (1000 Ton-Miles) (1)
1967 (3)	8	2,562,657	6,659,219	1,179,235
1968	8 (4)	2,254,489	6,724,562	1,047,935
1969	8 (4)	2,123,152	7,001,107	1,053,856
1970	8 (5)	2,462,935	7,519,251	1,190,232
1971	8 (4)	2,791,929	7,483,708	1,329,899
1972	8 (4)	2,665,579	7,182,841	1,280,385
1973	8	1,817,471	6,370,838	844,406
1974	8	2,576,018	7,673,084	1,227,525
1975	8 (4)	2,317,321	6,208,426	1,105,811
1976	8 (4)	3,111,376	6,552,949	1,535,912
1977	8	3,335,780	6,734,850	1,596,284
1978	8 (4)	3,202,822	7,929,184	1,528,614
1979	8 (4)	3,145,902	7,684,738	1,518,549
1980	8	2,909,279	5,914,775	1,335,309
1981	7-1/4 (6)	2,466,619	5,251,952	1,130,787
1982	8 (4)	2,513,166	4,880,527	1,131,249
1983	8 (4)	2,925,384	6,301,465	1,300,000
1984	8 (4)	2,878,720	6,386,205	1,338,939
1985	8 (4) (7)	2,606,461	6,471,418	1,201,854
1986	8 (4) (7)	2,343,899	6,990,778	1,044,299
1987	8	2,405,212	6,735,968	1,057,526
1988	7-1/2	2,156,387	6,680,878	949,356
1989	6-3/4	1,906,508	5,352,282	796,799
1990	6-3/4	1,329,000	5,841,000	552,509
1991	6-3/4	1,563,000	5,729,000	
1992	6-3/4	1,403,000	5,783,000	
1993	8 (8)	1,570,000	5,631,000	615,541
1994	8	1,800,000	8,501,000	774,491
1995	8 (4) (8)	1,439,000	6,884,000	604,171
1996	8 (4)	1,547,000	8,165,000	680,872
1997	8 (4)	1,651,000	8,172,000	725,268
1998	8 (4)	1,733,000	8,378,000	
1999	8 (4) (8)	1,500,000 (9)		

(1) Includes commercial tonnage except for sand and gravel or waterway materials. Tonnage compiled by Waterborne Commerce Statistics Center (WCSC)
(2) Includes commodities; sand, gravel and crushed rock; and waterway improvement materials. Tonnage by WCSC.
(3) Main stem reservoir system reached normal operating storage level in 1967.
(4) 10-day extension of season provided.
(5) 10-day extension and 10-day early opening provided.
(6) Full service flows for shortened season in preference to reduced service.
(7) 10-day extension provided for 1985 season in trade for 10-day delayed support of 1986 season.
(8) Lower Missouri River closed: 57 days in 1993, 20 days in 1995, and 18 days in 1999.
(9) Preliminary estimate.

Missouri River Flows at Sioux City, Nebraska City and Kansas City





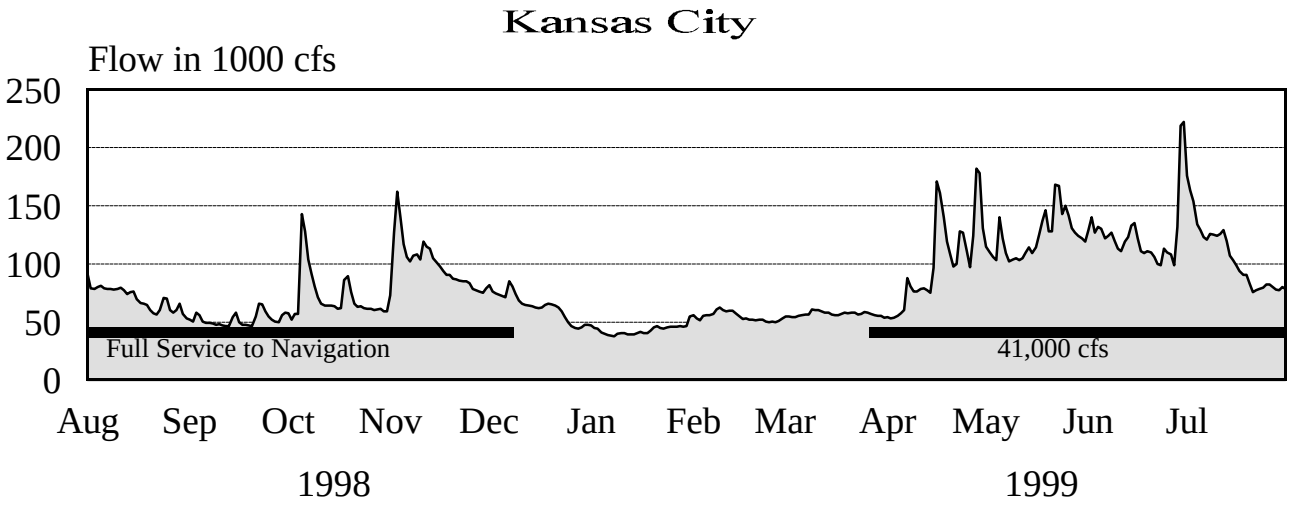


Figure 10

level from August and through early October at all three locations. Higher releases and heavy rain, particularly in the Kansas City area, resulted in flows much above the full service level later in the season. Flows during the first half of the 1999 navigation season were above the full service level at all locations due to above normal System releases, but were also heavily influenced by the abundant spring and summer rains in the lower basin.

5. <u>Power - Eastern Division, Pick-Sloan Missouri Basin Program (P-S MBP)</u>. The CY 1998 generated energy was transmitted over a Federal transmission system traversing 7,745 circuit miles. This past year, service was provided to 329 customers in a six-state area. Those receiving direct service include 187 municipalities, 4 Federal agencies, 36 state agencies, 29 U.S. Bureau of Reclamation projects, 3 irrigation districts, 26 rural electric cooperatives, 7 public utility districts, and 37 private utilities. Additional benefits were provided by the interconnections to the Southwestern and Bonneville Power Administrations and other areas of the Western Area Power Administration (Western). Statistics from the Omaha Public Power District (OPPD) show that the average customer uses approximately 11,000 kilowatt hours (kWh) of energy annually. Based upon these numbers, the energy generated in CY 1998 by the Federal power system could have supplied all of the yearly needs of one million residential OPPD customers for a retail value of over $830 million.

In addition to the clean, renewable power and energy transmitted to the Midwest area, the hydropower system provided an added measure of stability to the regional power system with the ability to meet full load in 5 seconds or less. These units can be reinforced by idle hydro units, typically in 30 seconds. Outside utilities can have access to the hydropower capability within several minutes of a known problem. The reliability of the hydropower system is indicated by having to maintain 10 percent reserve while thermal power must maintain 15 percent reserve. Although the Federal hydropower system accounts for only 9 percent of the region's power, it is large enough to fill gaps and provide a positive benefit to the integrated system.

CY 1998 generation was 99 percent of the average since the reservoir system first filled in 1967. Near normal average annual releases at all six powerplants resulted in the near normal generation. CY main stem generation with individual project distribution since 1954 is shown on ***Figure 11***.

Generation was 2.62 billion kWh for the December-through-February (1998-1999) winter energy period, 119 percent of the past 32-year average. Generation was above normal due to above normal releases at the lower four projects. Western purchased about 0.5 billion kWh between December 1, 1998 and February 28, 1999 at a cost of $7.4 million to supplement main stem hydropower production.

With the exception of May, energy production was above normal every month from November 1998 to July 1999 as excess flood control storage was evacuated from the system. Western sold 4.0 billion kWh over and above firm energy for the August 1998-July 1999 period valued at $92.6 million.

Main Stem Power Generation
1954 - 1999

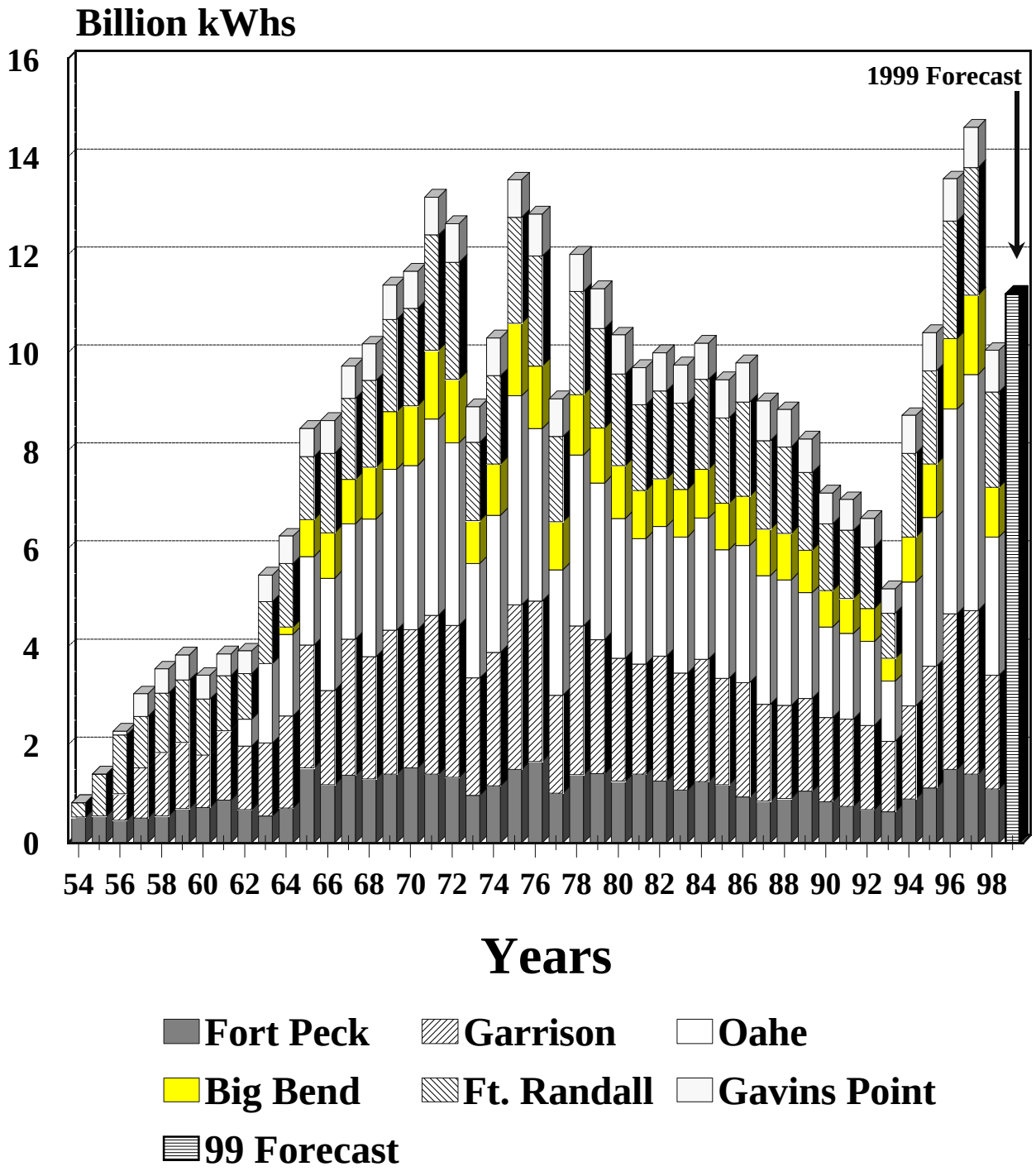


Figure 11

Total generation for the period August 1998 - July 1999 was 10.8 billion kWh, 106 percent of the 32-year average dating back to 1967. The gross generation from the Federal system (peak capacity and energy sales) for the August 1998 through July 1999 operating period is shown in ***Table IX***.

Western markets firm main stem hydropower to customers based on the capacity that would have been available in 1961 if the system had been operational at that time and based on long term average energy. The year 1961 was the last and most severe year of an 8-year drought.

TABLE IX
GROSS POWER SYSTEM GENERATION
(August 1998 through July 1999)

	Energy Generation 1,000 kWh	Peak Hour kW	Generation Date
Corps Powerplants - Main Stem			
Fort Peck	1,131,634	205,000	1/26/99
Garrison	2,574,225	489,000	4/3/99
Oahe	3,031,891	747,000	6/30/99
Big Bend	1,069,135	480,000	4/8/99
Fort Randall	2,094,237	351,000	8/24/98
Gavins Point	862,770	117,000	10/98, 6-7/99
Subtotal	10,763,892	2,220,000	8/24/98
USBR Powerplants			
Canyon Ferry	447,364	57,000	Numerous
Yellowtail*	673,757	136,000	6/99
USBR Subtotal	1,121,121		
FEDERAL SYSTEM TOTAL	11,885,013		

*Includes one half of total Yellowtail generation which is marketed by Eastern Division.

The tabulations in ***Tables X*** and ***XI*** summarize the total gross generation and power operations for the Eastern Division, P-S MBP, marketing area system for the past operating year. Actual settlement figures at the end of the billing periods differ somewhat from the calendar month figures shown.

TABLE X

HISTORICAL GENERATION AND LOAD DATA
EASTERN DIVISION, PICK-SLOAN MISSOURI BASIN PROGRAM*
Data at plant - 1,000 kW
August 1, 1998 through July 31, 1999

Period	Corps of Engineers Peak Hour Generation (Gross)	(plus)	USBR Hourly Generation (Gross)	(equals)	Federal Peak Hour Generation (Gross)	(plus)	Interchange and Purchases Received**	(equals)	Total System Load**
1998									
August	2,220		56		2,276		679		2,955
September	2,152		52		2,204		496		2,700
October	1,834		36		1,870		343		2,213
November	1,981		54		2,035		464		2,499
December	2,095		54		2,149		536		2,685
1999									
January	2,046		54		2,100		556		2,656
February	2,126		54		2,180		581		2,761
March	2,044		56		2,100		426		2,526
April	2,031		56		2,087		550		2,637
May	1,805		36		1,841		712		2,553
June	2,143		51		2,194		647		2,841
July	2,135		54		2,189		599		2,788

* This tabulation summarizes the total gross generation and power operations for the Eastern Division marketing area system shown on Table XV.
** During hour of Federal peak hour generation.

TABLE XI

HISTORICAL GENERATION AND LOAD DATA
EASTERN DIVISION, PICK-SLOAN MISSOURI BASIN PROGRAM*
Data at plant - 1,000 kWh
August 1, 1998 through July 31, 1999

Period	Corps of Engineers Generation (Gross)	(plus)	USBR Generation (Gross)	(equals)	Federal Generation (Gross)	(plus)	Scheduled Interchange and Purchases Received	(equals)	Total System Load
1998									
August	935,456		103,000		1,038,456		179,000		1,217,456
September	929,785		85,000		1,014,785		65,000		1,079,785
October	807,976		80,000		887,976		159,000		1,046,976
November	846,285		71,000		917,285		128,000		1,045,285
December	909,586		81,000		990,586		219,000		1,209,586
1999									
January	815,395		86,000		901,395		249,000		1,150,395
February	792,243		76,000		868,243		237,000		1,105,243
March	943,435		91,000		1,034,435		231,000		1,265,435
April	771,226		74,000		845,226		205,000		1,050,226
May	794,751		117,000		911,751		112,000		1,023,751
June	1,028,814		132,000		1,160,814		91,000		1,251,814
July	1,088,940		125,000		1,213,940		128,000		1,341,940

*Powerplants from Table XV

Annual energy production for 1999 will be about 111 percent of normal due to above normal releases at all projects except Fort Peck.

6. Fish Management. The Missouri River Natural Resources Committee (MRNRC), comprised of representatives from the Game and Fish agencies of the seven states bordering the Missouri River, was formed in the spring of 1987.

The MRNRC provided detailed recommendations in a September 4, 1998 letter to the Corps that focused on the 1999 AOP. The recommendations were discussed with the Corps at the fall MRNRC meeting in St. Joseph, Missouri on September 9, 1998. The years 1995 through 1997 were very large runoff years with high pool elevations and, in general, very good fish reproduction. For 1999, MRNRC recommended spring unbalance or offset storage in the upper three reservoirs, water conditions permitting, to enhance vegetation recruitment and fish spawning. The MRNRC recommended a warm water release from the Fort Peck spillway at least once every 4 years, to benefit native fish including the pallid sturgeon. Minimum instantaneous flow rates below the dams were also asked for. This request was partially honored. With few exceptions, the minimum release at Fort Randall was 14,000 cfs from April 20 through the end of June 1999. Fort Peck's minimum release was 4,500 cfs from early April through August. Every third-day spiking at Gavins Point was not considered ideal for fish or bird reproduction below that project and was not attempted. However, releases from Gavins Point fluctuated as much as 5,000 cfs during reductions for downstream flood control.

The Fort Peck Lake elevation remained near 2235 feet msl January through March 1999. The lake rose slowly April through June and peaked at elevation 2238.2 at the end of June. This peak was about 2.3 feet lower than the previous year's peak. Daily releases stayed in the 8,000 to 9,000 cfs range from early March through August, as runoff into this project remained lighter than expected through this period. Northern pike production reportedly dropped off materially this year because of the relatively low lake elevation. The walleye spawn was about average. An operation requested by the MRNRC, the U.S. Fish and Wildlife Service (FWS), and the American Fisheries Society involving mixing warmer spillway water with powerplant discharges to benefit native fish species for a month in the spring was not scheduled. The request was denied for several reasons, including potential effects on flood control, hydropower, and erosion and lack of coordination with potentially affected parties. In addition, this operation is an alternative under study in the upcoming Revised Draft Environmental Impact Statement (RDEIS) for the Master Manual.

The Garrison pool elevation fell from 1841.7 feet msl at the end of March to 1840.8 by the end of April. The elevation recovered to 1842.0 by the end of May, 1846.3 by the end of June, and peaked out at elevation 1847.4 on July 25. The peak was about 4 feet above the previous year's peak. Daily average releases were reduced the third week in April from 29,000 cfs to 25,000 cfs but were increased to 29,000 cfs on May 23 and to 30,000 cfs in June for endangered bird nesting. The Garrison release rate was reduced from 30,000 cfs to 28,000 cfs on July 12 where it remained through late August. Overall fish reproduction appeared average, although sauger, walleye, and smallmouth bass appeared to have had above average reproduction. Walleye stocking in the central portion of Sakakawea again produced good results. Northern pike fishing

in the spring of the year was outstanding on the lake. In addition, 1999 was likely the best year ever for consistent walleye fishing throughout most of the reservoir. Though there was not a creel (census), fishing effort also appeared high. Salmon fishing in August and September was also very good on Lake Sakakawea.

Lake Oahe elevation rose steadily through April from 1609.2 to 1611.1 feet msl by month's end. The lake gained an additional 4.5 feet in May and then increased steadily to 1617.0 by the end of June where it hovered until the end of August. This was nearly 5 feet above the previous year's peak. Oahe's average release rate for the June through July period was 29,500 cfs in 1999 compared to 1998's average release rate for the same time period of 20,300 cfs. Fish reproduction on upper Lake Oahe for walleye, white bass, and crappie was good due to high lake levels. There was some reproduction for walleye in Lake Sharpe. On upper Lake Oahe/Missouri River, small (<14 inches) walleye were abundant, but overall effort and catch dropped dramatically from previous years. The reduced forage base, consisting of rainbow smelt, again resulted in poor growth of predator species (e.g., walleye and pike) in the first half of the season. However, some improvement was noted in the condition of walleye in the fall months due to good reproduction (and subsequent consumption) primarily of crappie. The catch rate was good and was estimated at three-quarters of a million walleye caught April through August.

7. <u>Endangered and Threatened Species</u>. This is the 14th year of operation since the interior least terns and piping plovers were Federally listed as endangered and threatened species, respectively. Both the least tern and piping plover nest on sparsely vegetated sandbars, islands, and shoreline on the Missouri River. Stream gages have been installed on the Missouri River to monitor stream flows during the nesting season. These gages provide a check, as well as a stage history, throughout the season to help relate the effects of regulation and natural events at intervals along the river. The gaging data must be supplemented with observations of nesting activities and conditions to provide the information that is needed for regulation. A dynamic flow routing model has been developed to closely predict maximum river stages along the river for different combinations of daily discharge and hourly power peaking characteristics.

Beginning in 1999 the Omaha District created a computerized Threatened and Endangered Species Data Management System. Daily updated report data includes nest records, census and productivity data, site descriptions, field journals, and messages. This database provided vital information during the 1999 nesting season and proved to be a valuable tool in aiding release decisions benefiting endangered and threatened birds.

The river was flown during the 1999 nesting season and digital ortho photography was accomplished in the four river reaches for use in the Geographic Information System.

Although the Corps prevented inundation of nests where possible and accomplished habitat creation, fledging continued to be lower than predicted by the FWS 1990 Biological Opinion until 1998, when fledge ratios exceeded the goal for both species. Predation, habitat degradation, severe weather, nest inundation, recent record runoff, and other factors contributed to the previous disappointingly low fledging. The record fledging that occurred for both species in 1998 and the above average fledge ratios in 1999 can be attributed to the large amount of habitat

created by the high flows of 1997. The creation of additional habitat has also allowed greater flexibility in the release levels at the lower two main stem projects.

For 1999, the majority of piping plovers was found on the Missouri River reaches below Garrison Dam and Gavins Point Dam and on Lake Sakakawea. The majority of least terns were found on the Missouri River reaches below Garrison, Fort Randall and Gavins Point Dams.

Table XII shows the population distribution and productivity for terns and plovers for 1989 through 1999. Productivity estimates for these birds on the Missouri River in 1999 include only natural nesting. Adult birds in this table are considered breeders even though they may not have had nesting success. The term "fledglings/pair" means the number of young birds produced per breeding pair. This ratio is an estimate, as the fate of every single fledgling is impossible to obtain.

The following summarizes main stem regulation activities for the 1999 tern and plover season.

On April 1, 1999, System storage was above normal and the CY 1999 total runoff forecast was 115 percent of normal. By the third week in May, plovers were observed from Lake Sakakawea to below Gavins Point, and Gavins Point releases were increased from 30,000 cfs mid-May to a nesting season rate of 38,000 cfs by May 28. There were reductions in releases for flood control in different reaches as mentioned below. The final adult census on the Missouri River main stem was 572 adult terns and 534 adult plovers. This represents a 15 percent increase in plovers and a 10 percent decline in terns from 1998. The total number of adult birds was the highest since 1994. Due to favorable habitat conditions provided by the high flows of 1997, reproduction was the second highest level recorded for both species since System operations for the birds began in 1986. The fledge ratio for naturally raised terns was 1.42 fledglings per pair and for plovers 1.01. The fledge ratio for terns exceeded the goals suggested by the FWS in their 1990 Biological Opinion. A total of 35 tern eggs and 68 plover eggs were collected during the 1999 nesting season and reared at the Gavins Point hatching and rearing facility for study on plover survivability of captive-reared fledglings. Twenty-two terns and 49 plovers were released in July and August at selected locations along and near the Missouri River.

Activity by river reach is summarized below.

Reach below Gavins Point. The Gavins Point summer release was set late May at 38,000 cfs. By mid-June 1999, there were 31 plover and 56 active tern nests in this reach. On June 6 System storage had climbed to 63 MAF and the evacuation service level was determined to be 6,000 cfs above full service. The System release remained at 38,000 cfs per the June monthly forecast that indicated a 46,000 cfs evacuation rate was needed for the fall. Gavins Point releases were cut back for flood control several times in June to as low as 30,000 cfs. The peak number of nests was 90 just prior to June 27. However, 20 tern chicks and an adult perished in a June 27 storm that hit RM 790 and 789. Releases returned to a steady 38,000 cfs by July 5 as high downstream flows subsided. There were at this time 37 plover nests, 36 tern nests, and 52 chicks total. The adult census in this reach was 141 plovers and 161 terns. July 1 System storage was

Table XII
Missouri River Main Stem
Least Tern and Piping Plover Survey Data

	Interior Least Tern												Piping Plover											
	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Fort Peck Lake																								
Adults	3	4	6	10	0	7	9	2	0	0	4	0	20	12	22	25	26	30	4	5	0	0	4	2
Fledglings/Pair	0	3.00	0	0.40	0	0	0.44	0	0	0	0	0	1.70	1.50	3.18	1.20	1.00	0.60	1.50	1.20	0	0	0	2.00
Fort Peck to Lake Sakakawea																								
Adults	18	48	92	66	110	31	58	95	128	162	25	40	5	11	17	13	0	4	9	20	24	23	4	5
Fledglings/Pair	0.33	0	0.17	0.55	0.25	0.45	1.41	0.99	0.33	0.53	.1.52	1.70	0	0.18	0	0	0	0	0	3.50	1.00	0.87	1.00	0
Lake Sakakawea																								
Adults	7	15	6	8	29	17	35	7	27	2	23	9	143	57	132	150	108	8	45	24	70	3	119	83
Fledglings/Pair	0	0	0	0	0.83	0.12	0	0	0.15	0	1.04	0.67	0	0	0	0	1.50	8.50	1.24	0	0.57	0.67	1.24	1.25
Garrison to Lake Oahe																								
Adults	142	121	174	195	198	145	217	284	105	41	141	105	113	84	71	124	77	127	119	261	45	6	74	139
Fledglings/Pair	0.93	0.43	0.44	0.58	0.48	0.28	0.54	0.91	0.08	0.39	1.52	1.50	0.97	0.26	1.04	1.13	1.06	0.54	0.87	0.87	0.09	0	1.84	0.88
Lake Oahe																								
Adults	82	97	100	143	124	125	160	84	74	101	110	57	55	140	88	87	143	66	85	30	21	31	98	46
Fledglings/Pair	0	0	0	0	0.42	0	0.06	0	0.24	0.16	1.29	0.88	0	0	0	0	0.97	0.33	0.09	0.93	0.29	1.29	1.06	0.30
Ft. Randall to Niobrara																								
Adults	0	4	26	32	13	38	43	10	2	0	64	124	0	0	12	25	8	12	17	0	3	0	33	51
Fledglings/Pair	0	0	0.31	0.63	0.46	0	0	0	0	0	0.94	1.03	0	0	0.67	0.48	0.75	0	0	0	0	0	1.27	1.02
Lake Lewis and Clark																								
Adults	45	29	63	55	29	76	44	16	28	60	120	76	31	18	30	33	6	32	12	4	6	32	84	67
Fledglings/Pair	0.13	0.62	0.35	0	1.59	0.97	0	0	0	1.57	2.33	0.21	0.06	0.56	0.67	0	0	0.06	0.33	0	0	1.25	2.45	0.30
Gavins Point to Ponca																								
Adults	252	210	167	193	187	272	211	93	82	115	148	161	212	122	148	166	112	109	62	63	22	22	49	141
Fledglings/Pair	0.49	0.55	0.46	0.26	0.21	0.83	0.48	0.49	0.27	0.90	2.27	2.41	0.62	0.21	0.39	0.35	0.34	1.06	0.61	0.16	0	0	2.20	1.60
Total Adults	549	528	634	702	690	711	777	591	446	481	635	572	579	444	521	623	480	388	353	407	191	117	465	534
Fledglings/Pair	0.59	0.54	0.38	0.41	0.42	0.50	0.41	0.67	0.21	0.66	1.73	1.42	0.73	0.32	0.76	0.62	0.94	0.76	0.61	0.84	0.39	0.87	1.61	1.01
	Ten Year Interior Least Tern Fledge Ratio Goal = 0.70												**Fifteen Year Piping Plover Fledge Ratio Goal = 1.44**											
- Data not collected																								
* Partial Survey Results	1128	972	1155	1325	1170	1099	1130	998	637	598	1100	1106												
{} No Birds Found																								
+ Subsamplng of Selected Nesting Areas																								

The data does not include least terns and piping plovers raised in captivity. The data represents only wild fledged birds.

65 MAF, the annual runoff was predicted to be near an upper quartile, and the July forecast indicated a summer System release of 38,000 cfs and a fall release of 43,500 cfs. In the reach below Gavins Point, a total 113 plovers and 194 terns were fledged in the wild when the season ended by August 24.

Lewis and Clark Lake. By the end of May birds had begun to nest on this reach which extends from the mouth of the Niobrara River to the lake below Springfield, South Dakota. By May 26 daily, as well as hourly, powerplant releases from Fort Randall were scheduled to be no higher than 37,000 cfs as nesting began. By mid-June there were 7 plover nests and 20 tern nests on this reach. The total daily release from the Fort Randall project during June varied from 19,700 cfs to 34,800 cfs as the Gavins Point pool elevation and release, as well as the incremental flow between Gavins Point and Fort Randall, varied frequently due to rainfall runoff. Most of the nests were 18 inches above the water surface by the end of June. High inflows from tributaries below Fort Randall coupled with reduced releases from Gavins Point for downstream flood control caused upper Lewis and Clark Lake to rise 1.7 feet the first 5 days in July. Most of the nests and chicks were unaffected. On July 20 there were 22 active plover nests and 24 active tern nests, but a total of 43 of these nests were within 18 inches of the water surface. From July 20 through 21, high inflows from the Niobrara River, Bazile Creek, and other tributaries caused the upper lake to rise 1.7 feet. All nests and chicks were lost at RM 842.2, five nests were lost at RM 838 and the nesting area at RM 839 was inundated. Only four plover nests and one tern nest survived. Only one tern chick and one fledged tern juvenile were seen. By the end of July there was only one active nest left in this reach. All the chicks had fledged by the August 24 reporting period. The adult census for the Lewis and Clark Lake reach was 67 plovers and 76 terns. Only 10 plovers and 8 terns were fledged for this reach.

Fort Randall to Niobrara Reach. Birds began scraping nests shortly after mid-May. By mid-June there were 6 plover nests and 30 tern nests. To maintain the Lewis and Clark Lake elevation and support System releases, Fort Randall releases were increased from 31,000 cfs on May 25 to near 35,000 cfs the last 6 days of the month. The increase reduced the amount of suitable habitat, flooded a nest, and one nest had to be collected. By the end of June there were 10 plover nests, 40 tern nests, and several chicks. All nests were 18 inches above the water surface corresponding to a release rate of 36,000 cfs. Restricting hourly power peaking releases helped to prevent nest inundation in this reach. By the end of July there were only six active nests of both species, 44 young terns had fledged along with 4 young plovers. The adult census for this reach was 51 plovers and 124 terns, a record for both species. By the last week of August all the young birds had fledged and surveys were completed. A total of 26 plovers and 64 terns were fledged for this reach, also records.

Lake Oahe. Plovers began nesting in the lower lake reach in mid-May but not until later in the month in the Mobridge or Bismarck sections. By mid-June there were 22 plover nests and 24 tern nests on the lake. The lake rose from elevation 1615.6 feet msl at the end of May to 1617.0 by the end of June, and some nests were inundated. By mid-July the lake had peaked at elevation 1617.4 and there were 10 active tern nests and 12 plover nests. Some of the habitat was precarious as the lake rose about 1.5 feet during June. By mid-July, 10 plover chicks and 21 tern chicks were reported in this reach. The adult census for this reach was 46 plovers and only

57 terns. Several nests were lost to flooding. The last survey was the fourth week of August. Total fledged for this reach was only 7 plovers and 25 terns.

Below Garrison to Lake Oahe Reach. Garrison releases were increased to 29,000 cfs on May 23 as plovers began showing up in this reach. Garrison's maximum hourly power release was set at 35,000 cfs. There was already a plover nest with an egg in it the last week in May. By mid-June there were 29 plover nests and 26 tern nests. By mid-July there were 27 plover nests and 12 tern nests. Several nests in the Bismarck area were destroyed due to human disturbance. Releases were reduced to 28,000 cfs on July 13 for intra-system storage balance. This added freeboard protection to the nests located in this reach. The adult census was 139 plovers and 105 terns. The last of the fledged birds flew off near the end of August. Total fledged for this reach was 61 plovers and 79 terns. The fledge ratio of 1.50 for terns was near the 1998 record for this reach. Surveys concluded with the August 16 report.

Lake Sakakawea. Plovers began nesting in the reservoir area in late May in the Lake Audubon Refuge area. The lake rose from elevation 1842.1 to 1846.3 feet msl during June flooding several nests. However, eggs were recovered from several nests the first half of the month, some being transported to Yankton for rearing. By July 1 there were a total of 14 plover nests and 3 tern nests, 30 plover nests and 15 tern nests having been destroyed mostly by the rising lake elevation. The adult census was 83 plovers and 9 terns. Surveys were completed ending the second week in August. Total fledged for the reach were 52 plovers, but only 3 terns. The fledge ratio for plovers was 1.25.

Below Fort Peck. Fort Peck daily average releases were increased from 8,000 cfs to 9,000 cfs the first week in June and a tern nest was observed on the June 10 report. Hourly power peaking releases were restricted to 14,000 cfs. By July 4 there were no plover nests and seven tern nests on the river. The adult census was 5 plovers and 40 terns. Nesting remained light and surveys were completed for this reach the week ending August 20. Total fledged for the reach was 0 plovers and 34 terns.

Fort Peck Lake. Nesting began in early June. Precipitation was above normal through mid-June and several beaches had begun to vegetate over. By July 1 there were two plover nests and seven tern nests that had been destroyed. Fort Peck Lake elevation peaked out at elevation 2238.3 feet msl in early July, 2 feet below the previous year's peak. Two chicks that were sighted on July 9 eventually fledged in early August. The adult census was two plovers and no terns. Fledging was two plovers and zero terns.

8. Recreation and Resource Management. The Missouri River main stem reservoirs provide outstanding opportunities for boating, fishing, swimming, camping, and other outdoor recreation pursuits. Tourism related to the lakes is a major economic factor in all the states adjoining the main stem. During 1999, public use at these lakes was 61,788,200 visitor hours, a slight increase from 1998. Visitor attendance at the lake projects for 1997, 1998, and 1999 is shown in ***Table XIII.*** ***Figure 12*** displays recreation-related visitor hours at each of the six projects for the years 1954 through 1999. The reporting method was changed from recreation days to visitor hours in 1987, and the reporting period was changed from calendar year to fiscal

TABLE XIII
VISITATION IN VISITOR HOURS

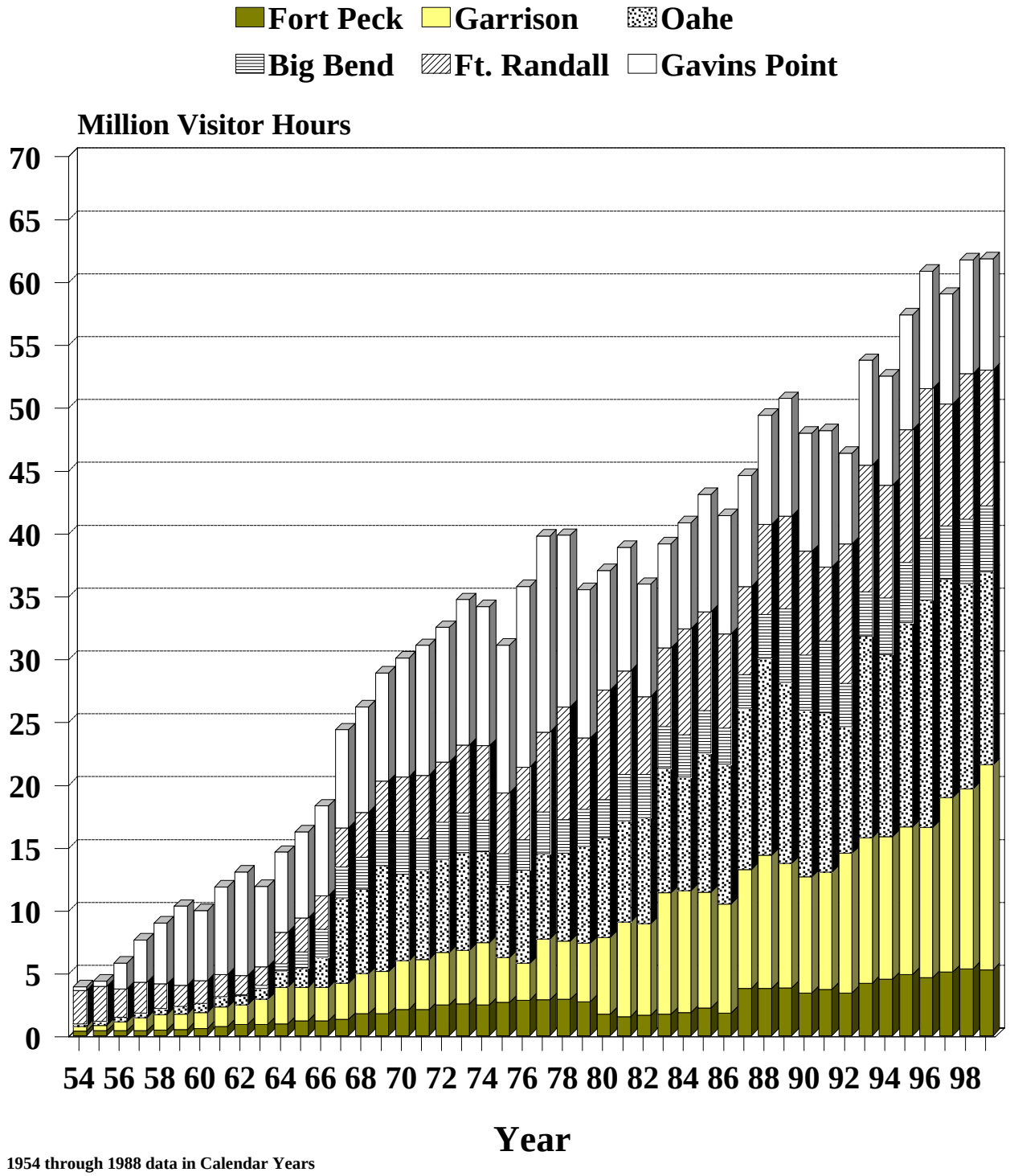
MAIN STEM PROJECT	YEAR			PERCENT INCREASE OR DECREASE
	1997	1998	1999	
Fort Peck	5,070,900	5,342,700	5,250,300	- 1.7
Garrison	13,887,700	14,314,300	16,312,100	+ 14.0
Oahe	17,381,600	16,324,300	15,372,500	- 5.8
Big Bend	4,196,400	5,107,500	5,215,300	+ 2.1
Fort Randall	9,734,600	11,593,600	10,811,200	- 6.7
Gavins Point	8,722,700	9,036,100	8,826,800	- 2.3
SYSTEM TOTAL	58,993,900	61,718,500	61,788,200	+ 0.1

Figures computed using the Visitation Estimating Reporting System

year in 1989 for all Corps of Engineers projects. All Corps projects, including the main stems, are now reporting visitation using the Visitation Estimation Reporting System (VERS).

Between 2003 and 2006, the nation will commemorate the 200th anniversary of the Lewis and Clark Expedition. A significant increase in visitation is expected at points of interest along the trail of Lewis and Clark's journey. Because the Corps manages more of the trail than any other entity (more than 90 percent), and because of its Army heritage of exploring and mapping the western United States, the Corps will play a key leadership role in the observance of the Lewis and Clark Expedition Bicentennial. The Corps is working with other Federal, tribal, State, and local governments on the National Bicentennial Council to ensure that adequate facilities and information are available to accommodate the increased visitation, to protect environmental and historical resources, and to plan and coordinate commemorative activities.

Missouri River Main Stem
Project Visitor Hours
1954 to 1999



1954 through 1988 data in Calendar Years
1989 to 1991 in Fiscal Years
1992 to present in VERS System.

Figure 12

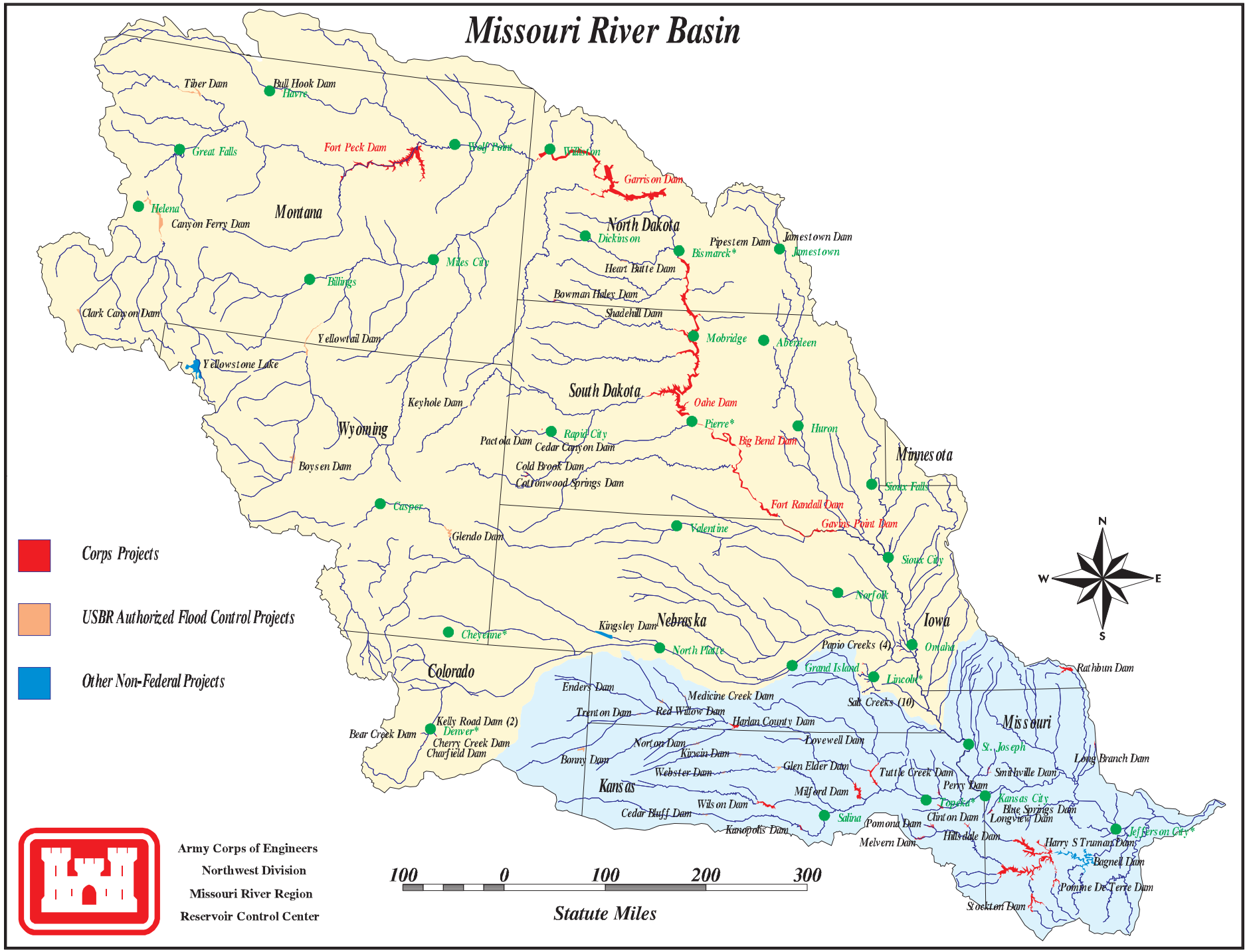

Missouri River Basin
Tiber Dam
Bull Hook Dam
Havre
Great Falls
Fort Peck Dam
Wolf Point
Williston
Garrison Dam
Helena
Canyon Ferry Dam
Montana
North Dakota
Dickinson
Pipestem Dam
Jamestown Dam
Bismarck*
Jamestown
Heart Butte Dam
Miles City
Billings
Bowman Haley Dam
Shadehill Dam
Clark Canyon Dam
Yellowtail Dam
Mobridge
Aberdeen
Yellowstone Lake
South Dakota
Keyhole Dam
Oahe Dam
Pierre*
Huron
Wyoming
Rapid City
Pactola Dam
Cedar Canyon Dam
Big Bend Dam
Minnesota
Boysen Dam
Cold Brook Dam
Cathedral Springs Dam
Sioux Falls
Fort Randall Dam
Casper
Gavins Point Dam
Valentine
Glendo Dam
Sioux City
Norfolk
Kingsley Dam
Nebraska
Iowa
Cheyenne*
North Platte
Papio Creeks (4)
Omaha
Grand Island
Rathbun Dam
Colorado
Lincoln*
Enders Dam
Medicine Creek Dam
Salt Creeks (10)
Trenton Dam
Red Willow Dam
Harlan County Dam
Missouri
Kelly Road Dam (2)
Bear Creek Dam
Denver*
Cherry Creek Dam
Chatfield Dam
Norton Dam
Lovewell Dam
St. Joseph
Long Branch Dam
Kirwin Dam
Bonny Dam
Webster Dam
Glen Elder Dam
Tuttle Creek Dam
Smithville Dam
Perry Dam
Kansas
Milford Dam
Topeka*
Kansas City
Blue Springs Dam
Wilson Dam
Longview Dam
Cedar Bluff Dam
Salina
Clinton Dam
Pomona Dam
Kanopolis Dam
Hillsdale Dam
Jefferson City*
Melvern Dam
Harry S Truman Dam
Bagnell Dam
Pomme De Terre Dam
Stockton Dam
Corps Projects
USBR Authorized Flood Control Projects
Other Non-Federal Projects
N
W
E
S
100 0 100 200 300
Statute Miles
Army Corps of Engineers
Northwest Division
Missouri River Region
Reservoir Control Center

Plate 1

Summary of Engineering Data -- Missouri River Main Stem Reservoirs

Item No.	Subject	Fort Peck Lake	Garrison Dam - Lake Sakakawea	Oahe Dam - Lake Oahe
1	Location of Dam	Near Glasgow, Montana	Near Garrison, ND	Near Pierre, SD
2	River Mile - 1960 Mileage	Mile 1771.5	Mile 1389.9	Mile 1072.3
3	Total & incremental drainage areas in square miles	57,500	181,400 (2) 123,900	243,490 (1) 62,090
4	Approximate length of full reservoir (in valley miles)	134, ending near Zortman, MT	178, ending near Trenton, ND	231, ending near Bismarck, ND
5	Shoreline in miles (3)	1520 (elevation 2234)	1340 (elevation 1837.5)	2250 (elevation 1607.5)
6	Average total & incremental inflow in cfs	10,200	25,600 15,400	28,900 3,300
7	Max. discharge of record near damsite in cfs	137,000 (June 1953)	348,000 (April 1952)	440,000 (April 1952)
8	Construction started - calendar yr.	1933	1946	1948
9	In operation (4) calendar yr.	1940	1955	1962
	Dam and Embankment			
10	Top of dam, elevation in feet msl	2280.5	1875	1660
11	Length of dam in feet	21,026 (excluding spillway)	11,300 (including spillway)	9,300 (excluding spillway)
12	Damming height in feet (5)	220	180	200
13	Maximum height in feet (5)	250.5	210	245
14	Max. base width, total & w/o berms in feet	3500, 2700	3400, 2050	3500, 1500
15	Abutment formations (under dam & embankment)	Bearpaw shale and glacial fill	Fort Union clay shale	Pierre shale
16	Type of fill	Hydraulic & rolled earth fill	Rolled earth filled	Rolled earth fill & shale berms
17	Fill quantity, cubic yards	125,628,000	66,500,000	55,000,000 & 37,000,000
18	Volume of concrete, cubic yards	1,200,000	1,500,000	1,045,000
19	Date of closure	24 June 1937	15 April 1953	3 August 1958
	Spillway Data			
20	Location	Right bank - remote	Left bank - adjacent	Right bank - remote
21	Crest elevation in feet msl	2225	1825	1596.5
22	Width (including piers) in feet	820 gated	1336 gated	456 gated
23	No., size and type of gates	16 - 40' x 25' vertical lift gates	28 - 40' x 29' Tainter	8 - 50' x 23.5' Tainter
24	Design discharge capacity, cfs	275,000 at elev 2253.3	827,000 at elev 1858.5	304,000 at elev 1644.4
25	Discharge capacity at maximum operating pool in cfs	230,000	660,000	80,000
	Reservoir Data (6)			
26	Max. operating pool elev. & area	2250 msl 246,000 acres	1854 msl 380,000 acres	1620 msl 374,000 acres
27	Max. normal op. pool elev. & area	2246 msl 240,000 acres	1850 msl 364,000 acres	1617 msl 360,000 acres
28	Base flood control elev & area	2234 msl 212,000 acres	1837.5 msl 307,000 acres	1607.5 msl 312,000 acres
29	Min. operating pool elev. & area	2160 msl 90,000 acres	1775 msl 128,000 acres	1540 msl 117,000 acres
	Storage allocation & capacity			
30	Exclusive flood control	2250-2246 975,000 a.f.	1854-1850 1,489,000 a.f.	1620-1617 1,102,000 a.f.
31	Flood control & multiple use	2246-2234 2,717,000 a.f.	1850-1837.5 4,222,000 a.f.	1617-1607.5 3,201,000 a.f.
32	Carryover multiple use	2234-2160 10,785,000 a.f.	1837.5-1775 13,130,000 a.f.	1607.5-1540 13,461,000 a.f.
33	Permanent	2160-2030 4,211,000 a.f.	1775-1673 4,980,000 a.f.	1540-1415 5,373,000 a.f.
34	Gross	2250-2030 18,688,000 a.f.	1854-1673 23,821,000 a.f.	1620-1415 23,137,000 a.f.
35	Reservoir filling initiated	November 1937	December 1953	August 1958
36	Initially reached min. operating pool	27 May 1942	7 August 1955	3 April 1962
37	Estimated annual sediment inflow	18,100 a.f. 1030 yrs.	25,900 a.f. 920 yrs.	19,800 a.f. 1170 yrs.
	Outlet Works Data			
38	Location	Right bank	Right Bank	Right Bank
39	Number and size of conduits	2 - 24' 8" diameter (nos. 3 & 4)	1 - 26' dia. and 2 - 22' dia.	6 - 19.75' dia. upstream, 18.25' dia. downstream
40	Length of conduits in feet (8)	No. 3 - 6,615, No. 4 - 7,240	1529	3496 to 3659
41	No., size, and type of service gates	1 - 28' dia. cylindrical gate 6 ports, 7.6' x 8.5' high (net opening) in each control shaft	1 - 18' x 24.5' Tainter gate per conduit for fine regulation	1 - 13' x 22' per conduit, vertical lift, 4 cable suspension and 2 hydraulic suspension (fine regulation)
42	Entrance invert elevation (msl)	2095	1672	1425
43	Avg. discharge capacity per conduit & total	Elev. 2250 22,500 cfs - 45,000 cfs	Elev. 1854 30,400 cfs - 98,000 cfs	Elev. 1620 18,500 cfs - 111,000 cfs
44	Present tailwater elevation (ft msl)	2032-2036 5,000 - 35,000 cfs	1670-1680 15,000- 60,000 cfs	1423-1428 20,000-55,000 cfs
	Power Facilities and Data			
45	Avg. gross head available in feet (14)	194	161	174
46	Number and size of conduits	No. 1-24'8" dia., No. 2-22'4" dia.	5 - 29' dia., 25' penstocks	7 - 24' dia., imbedded penstocks
47	Length of conduits in feet (8)	No. 1 - 5,653, No. 2 - 6,355	1829	From 3,280 to 4,005
48	Surge tanks	PH#1: 3-40' dia., PH#2: 2-65' dia.	65' dia. - 2 per penstock	70' dia., 2 per penstock
49	No., type and speed of turbines	5 Francis, PH#1-2: 128.5 rpm, 1-164 rpm , PH#2-2: 128.6 rpm	5 Francis, 90 rpm	7 Francis, 100 rpm
50	Discharge cap. at rated head in cfs	PH#1, units 1&3 170', 2-140' 8,800 cfs, PH#2-4&5 170'-7,200 cfs	150' 41,000 cfs	185' 54,000 cfs
51	Generator nameplate rating in kW	1&3: 43,500; 2: 18,250; 4&5: 40,000	3 - 109,250, 2 - 95,000	112,290
52	Plant capacity in kW	185,250	517,750	786,030
53	Dependable capacity in kW (9)	181,000	388,000	534,000
54	Avg. annual energy, million kWh (12)	1,167	2,467	2,896
55	Initial generation, first and last unit	July 1943 - June 1961	January 1956 - October 1960	April 1962 - June 1963
56	Estimated cost September 1996 completed project (13)	$158,428,000	$299,938,000	$346,521,000

Summary of Engineering Data -- Missouri River Main Stem Reservoirs

Big Bend Dam - Lake Sharpe	Fort Randall Dam - Lake Francis Case	Gavins Point Dam - Lewis & Clark Lake	Total	Item No.	Remarks
21 miles upstream Chamberlain, SD	Near Lake Andes, SD	Near Yankton, SD		1	(1) Includes 4,280 square miles of non-contributing areas.
Mile 987.4	Mile 880.0	Mile 811.1		2	
249,330 (1) 5,840	263,480 (1) 14,150	279,480 (1) 16,000		3	
80, ending near Pierre, SD	107, ending at Big Bend Dam	25, ending near Niobrara, NE	755 miles	4	(2) Includes 1,350 square miles of non-contributing areas.
200 (elevation 1420)	540 (elevation 1350)	90 (elevation 1204.5)	5,940 miles	5	(3) With pool at base of flood control.
28,900	30,000 1,100	32,000 2,000		6	
440,000 (April 1952)	447,000 (April 1952)	480,000 (April 1952)		7	(4) Storage first available for regulation of flows.
1959	1946	1952		8	(5) Damming height is height from low water to maximum operating pool. Maximum height is from average streambed to top of dam.
1964	1953	1955		9	
1440	1395	1234		10	
10,570 (including spillway)	10,700 (including spillway)	8,700 (including spillway)	71,596	11	(6) Based on latest available storage data.
78	140	45	863 feet	12	
95	165	74		13	(7) River regulation is attained by flows over low-crested spillway and through turbines.
1200, 700	4300, 1250	850, 450		14	
Pierre shale & Niobrara chalk	Niobrara chalk	Niobrara chalk & Carlile shale		15	(8) Length from upstream face of outlet or to spiral case.
Rolled earth, shale, chalk fill	Rolled earth fill & chalk berms	Rolled earth & chalk fill		16	
17,000,000	28,000,000 & 22,000,000	7,000,000	358,128,000 cu. yds	17	(9) Based on 8th year (1961) of drought drawdown (From study 8-83-1985).
540,000	961,000	308,000	5,554,000 cu. yds.	18	
24 July 1963	20 July 1952	31 July 1955		19	
Left bank - adjacent	Left bank - adjacent	Right bank - adjacent		20	(10) Affected by level of Lake Francis case. Applicable to pool at elevation 1350.
1385	1346	1180		21	
376 gated	1000 gated	664 gated		22	(11) Spillway crest.
8 - 40' x 38' Tainter	21 - 40' x 29' Tainter	14 - 40' x 30' Tainter		23	(12) 1967-1998 Average
390,000 at elev 1433.6	620,000 at elev 1379.3	584,000 at elev 1221.4		24	(13) Source: Annual Report on Civil Works Activities of the Corps of Engineers. Extract Report Fiscal Year 1996.
270,000	508,000	345,000		25	
1423 msl 61,000 acres	1375 msl 102,000 acres	1210 msl 31,000 acres	1,194,000 acres	26	(14) Based on Study 8-83-1985
1422 msl 60,000 acres	1365 msl 95,000 acres	1208 msl 28,000 acres	1,147,000 acres	27	
1420 msl 57,000 acres	1350 msl 77,000 acres	1204.5 msl 24,000 acres	989,000 acres	28	
1415 msl 51,000 acres	1320 msl 38,000 acres	1204.5 msl 24,000 acres	450,000 acres	29	
1423-1422 60,000 a.f.	1375-1365 985,000 a.f.	1210-1208 59,000 a.f.	4,670,000 a.f.	30	
1422-1420 117,000 a.f.	1365-1350 1,309,000 a.f.	1208-1204.5 90,000 a.f.	11,656,000 a.f.	31	
	1350-1320 1,607,000 a.f.		38,983,000 a.f.	32	
1420-1345 1,682,000 a.f.	1320-1240 1,517,000 a.f.	1204.5-1160 321,000 a.f.	18,084,000 a.f.	33	
1423-1345 1,859,000 a.f.	1375-1240 5,418,000 a.f.	1210-1160 470,000 a.f.	73,393,000 a.f.	34	
November 1963	January 1953	August 1955		35	
25 March 1964	24 November 1953	22 December 1955		36	
4,300 a.f. 430 yrs.	18,300 a.f. 250 yrs.	2,600 a.f. 180 yrs.	92,500 a.f.	37	
	Left Bank			38	
None (7)	4 - 22' diameter	None (7)		39	
	1013			40	
	2 - 11' x 23' per conduit, vertical lift, cable suspension			41	
1385 (11)	1229	1180 (11)		42	
	Elev 1375			43	
	32,000 cfs - 128,000 cfs				
1351-1355(10) 25,000-100,000 cfs	1228-1239 5,000-60,000 cfs	1155-1163 15,000-60,000 cfs		44	
70	117	48	764 feet	45	
None: direct intake	8 - 28' dia., 22' penstocks	None: direct intake		46	
	1,074		55,083	47	
None	59' dia, 2 per alternate penstock	None		48	
8 Fixed blade, 81.8 rpm	8 Francis, 85.7 rpm	3 Kaplan, 75 rpm	36 units	49	
67' 103,000 cfs	112' 44,500 cfs	48' 36,000 cfs		50	
3 - 67,276, 5 - 58,500	40,000	44,100		51	
494,320	320,000	132,300	2,435,650 kw	52	
497,000	293,000	74,000	1,967,000 kw	53	
1,051	1,849	752	10,182 million kWh	54	Corps of Engineers, U.S. Army
October 1964 - July 1966	March 1954 - January 1956	September 1956 - January 1957	July 1943 - July 1966	55	Compiled by
$107,498,000	$199,066,000	$49,617,000	$1,161,068,000	56	Missouri River Division May 1999