



KANSAS CITY DISTRICT

Lower Kansas River– Lake Operations

Brian McNulty

Operations Project Manager
Tuttle Creek Lake
Manhattan, Kansas



Kansas City District



- Total of 18 USACE lakes
 - ▶ All Multi-Purpose
 - ▶ 2 have Hydropower - (Stockton/Truman, MO)
 - ▶ 1 has Irrigation - (Harlan County, NE)
 - ▶ 105 Recreation Areas
- 498 Mile Navigation Channel
- Inspect and Repair Levees (PL 84-99)
 - ▶ 54 Federally Constructed Levees (408 miles)
 - ▶ 103 Non-Federal Levees (626 miles)



FACTS OF TUTTLE CREEK LAKE

Authorized in the Flood Control Acts of
1938 & 1944

Designed in late 1940's (as a dry dam)

Construction started in 1952

Permanent pool added after mid 1950's
drought in midwest

Project placed into operation in 1962

Project is in Pottawatomie, Riley, and
Marshall Counties

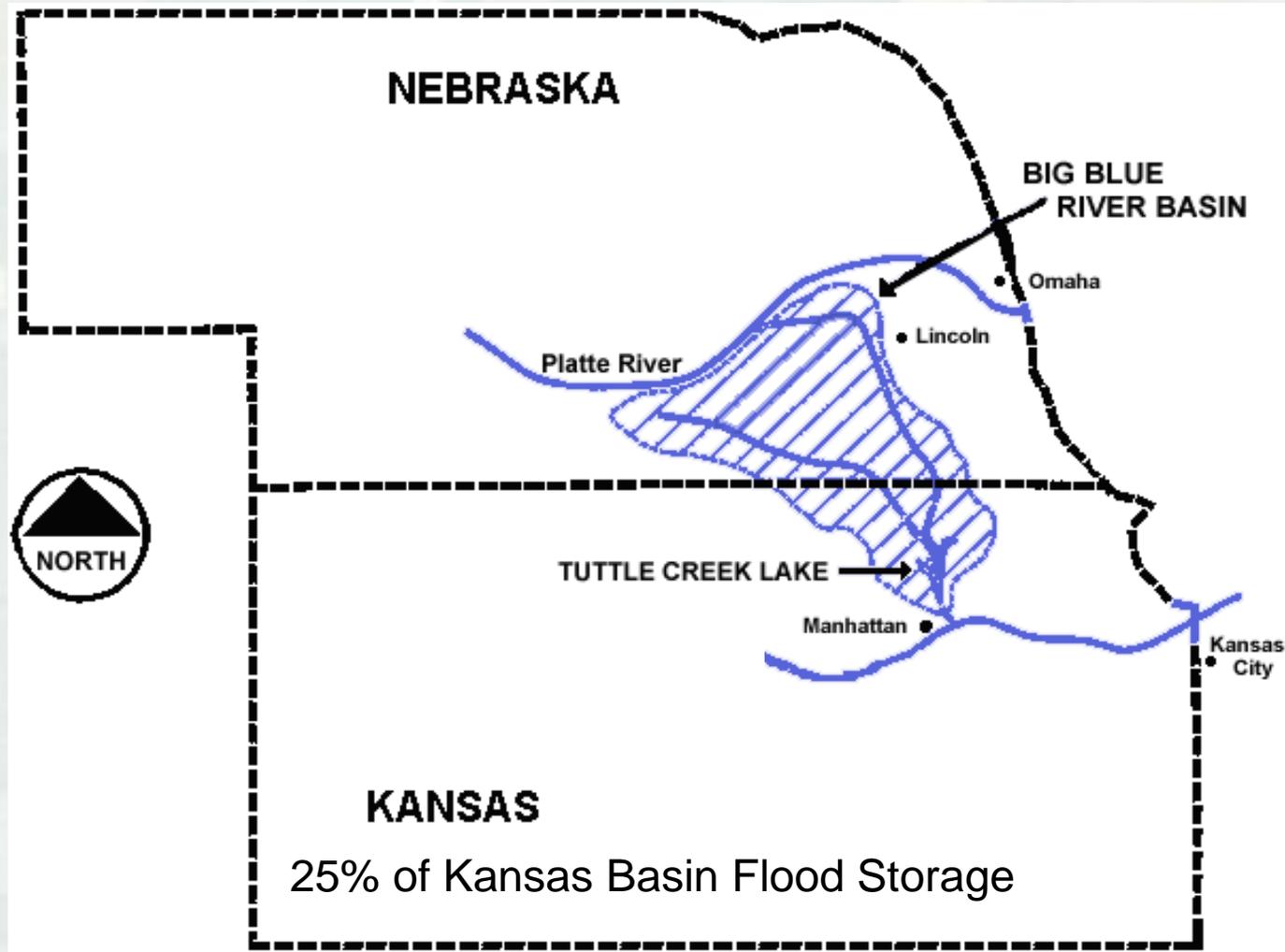
10,900 acre multipurpose pool (el 1075)

54,000+ acre flood control pool (el 1136)

Record Pool – el 1137.77 (July 1993)



Tuttle Creek Lake Drainage Basin



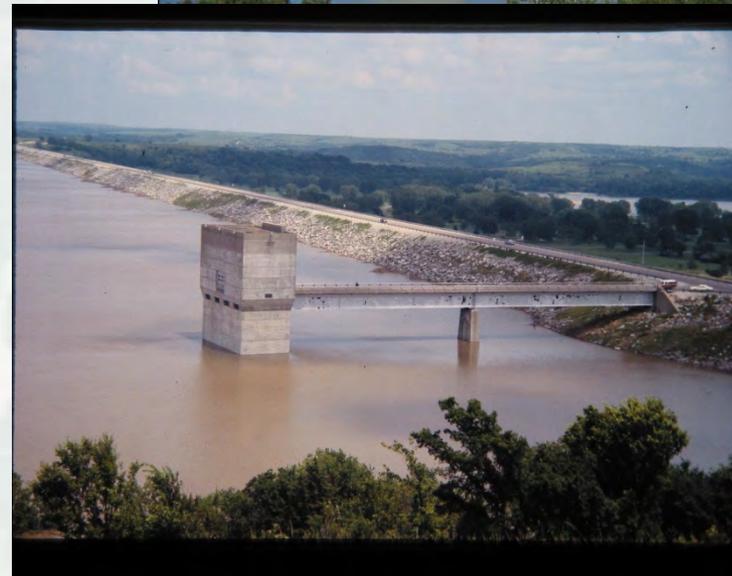
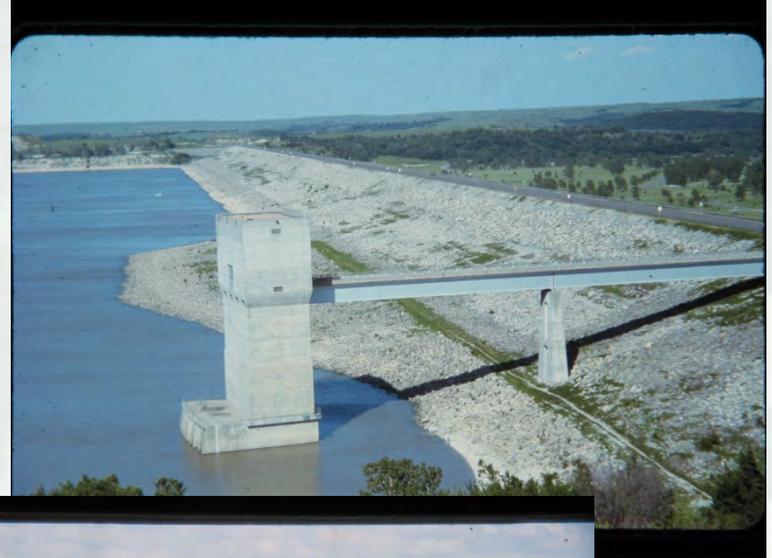
Tuttle Creek Flood Control Facilities

- Control Tower/Outlet Tubes
 - ▶ Four Service Gates, 10x20 feet
 - ▶ Max discharge at full pool - 48,800 cfs
- Controlled Emergency Spillway (perched)
 - ▶ 18 Tainter Gates, 40x21 feet
 - ▶ Design Discharge at full flood pool - 233,500 cfs
 - ▶ Design Discharge at full surcharge approaching 600,000 cfs
- Blue Rapids Levee
 - ▶ 2 Sluice Gates, 9x9 feet
 - ▶ Approximately 1 mile of levee
 - ▶ Pumping Plant w/two 16-inch, 125 hp pumps



Flood Control

- Tuttle Creek is the Flood Control Workhorse for the Kansas River
- Provides flood protection to Manhattan, Topeka, Lawrence, and Kansas City
 - ▶ Drainage basin of 9,600+ square miles
 - ▶ No upstream reservoirs
 - ▶ Great fluctuations in the pool are common
 - ▶ Drainage basin high in agricultural production, thus has a high sediment yield
 - ▶ A large percentage of the water in the Kansas River flows through the gates of Tuttle Creek Dam



How is Tuttle Creek Operated?

Part of the Missouri River flood control system

- Normal Operations (up to 1136.0 feet msl)
 - ▶ Basin flows administered by Missouri River Basin Water Management in Omaha, Nebraska
 - ▶ Tuttle Creek releases are determined by Water Management Section (Kansas City, Missouri)
 - Release based on flow targets on the Kansas and Missouri Rivers, current pool elevation, and amount of water entering reservoir
 - Water Control evaluates these factors, determines release rate, and issues a gate order to the project
 - Project operates gates to release water



Kansas River Water Management

- Kansas River Lakes are Operated as a System – lake levels at all lakes considered before releases are made
- Lakes in Phase III, then Phase II Flood Control Zones get Top Priority for flood releases
- Control Point for Kansas River Lakes is Waverly, Missouri - located 73 river miles downstream of Kansas City
- Flows at Waverly cannot exceed 90,000 cfs or flooding will occur
- Local Flood Conditions also considered before releases are made



Phased Operation

Seasonal Guidelines for releases

Phase I - Downstream flows at a level w/out causing any downstream damages

- Provides space in lake for containing inflow of rain events
- Releases conserve channel space for protection of downstream with further rain

Phase II – Downstream flows well below those that cause significant downstream damages

- Little to no damages to agricultural development
- Small margin for protection of downstream with further rain
- Intended to allow control of the one percent chance of inflow with phase I release
 - 1114.4 msl August – March
 - 1102.2 msl April – July

Phase III - Downstream flows at maximum w/out causing significant downstream damages

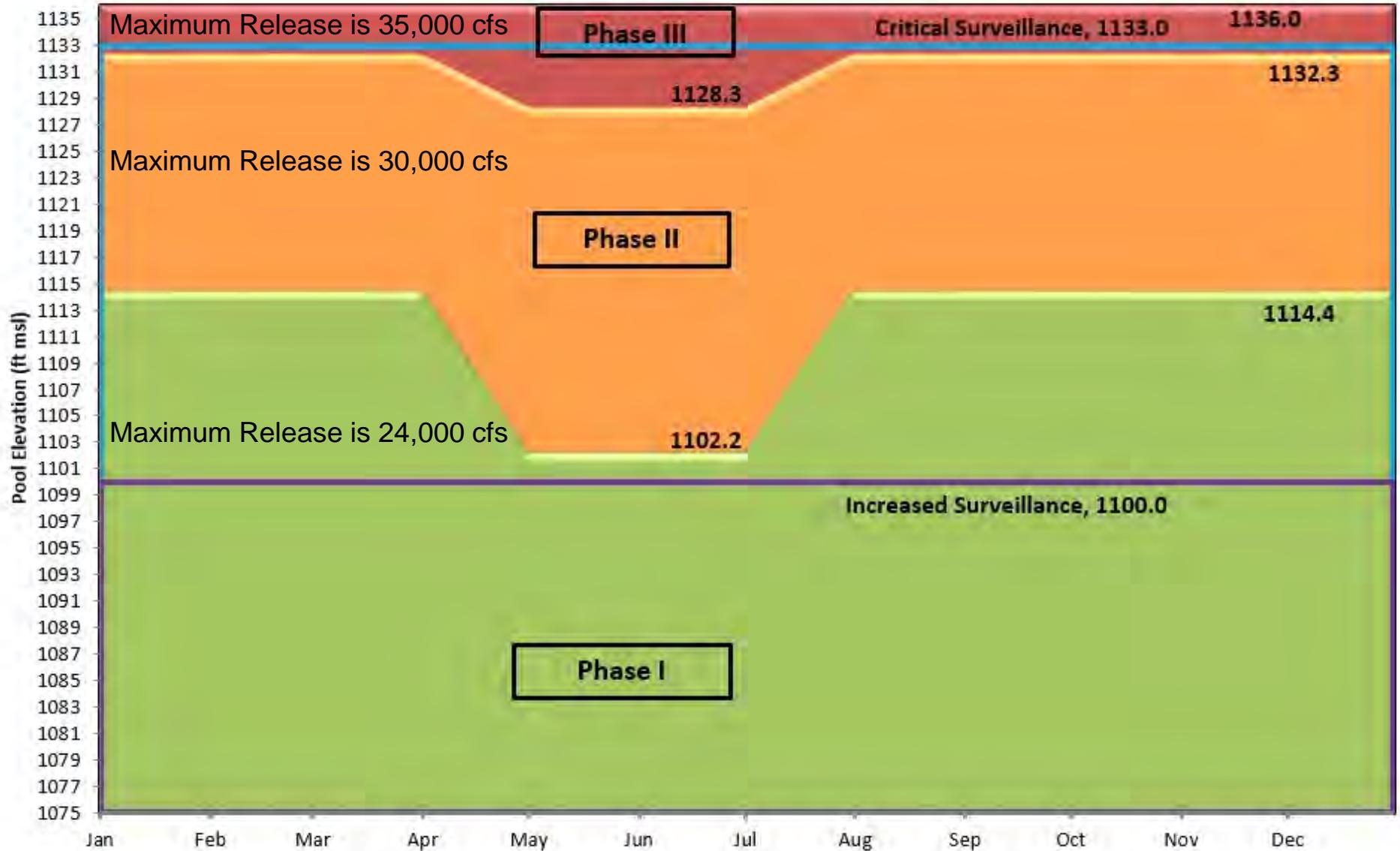
- Will inundate some agricultural development
- No margin for protection of downstream with further rain
- Is the very upper portion of the flood control pool
 - 1132.3 msl August – March
 - 1128.3 msl April - July

Parallel Balance – Two or more lakes which are located so that their releases pass thru a common downstream river reach

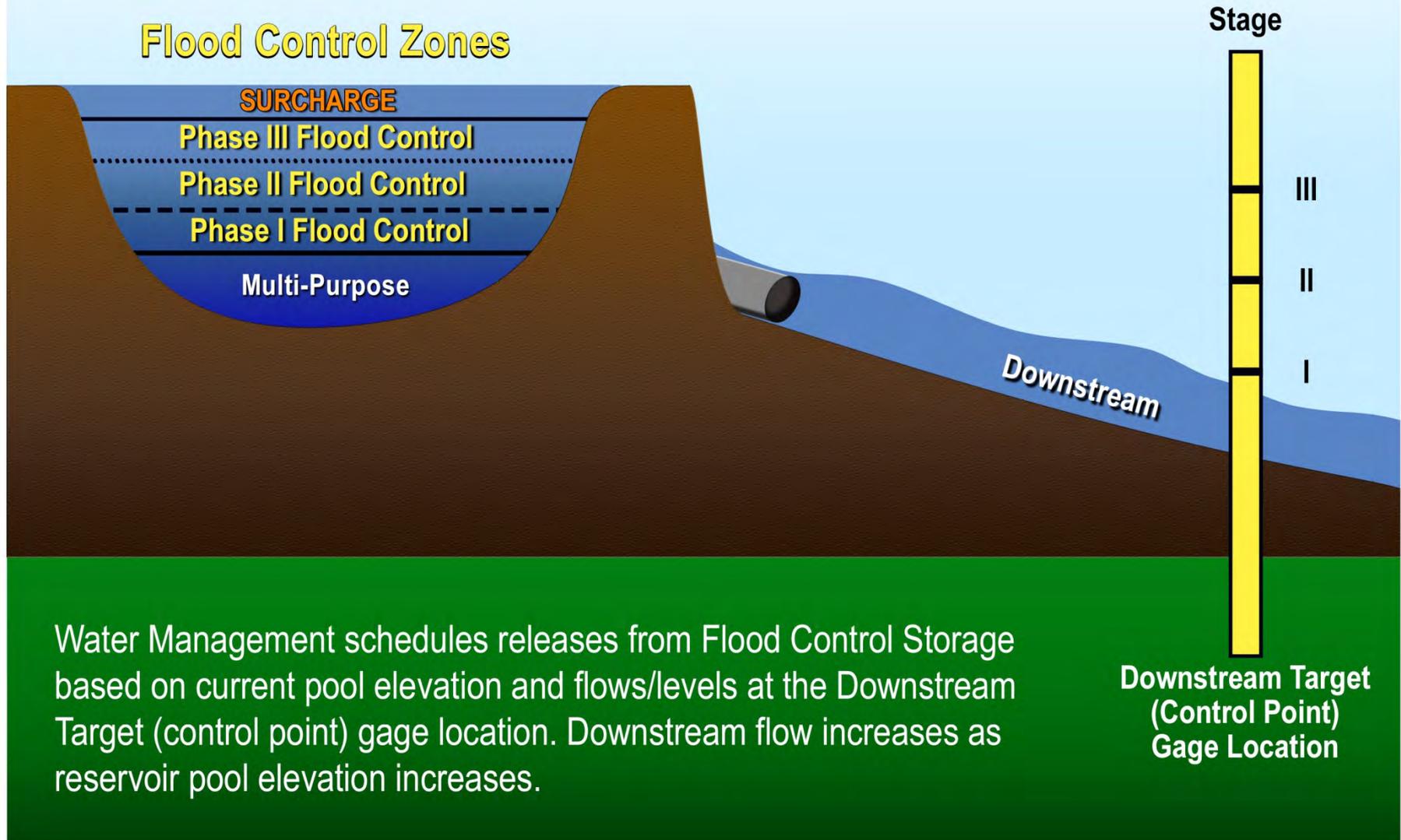
- Tuttle Creek, Milford, and Perry are primary parallel lakes for the Lower Kansas River Basin and below
- Kanopolis, Wilson, and Waconda (Glen Elder) are also parallel
- Normally a 10-14 day Phase I Evacuation of flood water when downstream conditions allow



Tuttle Creek Reservoir Water Control Plan Seasonal Release Rates

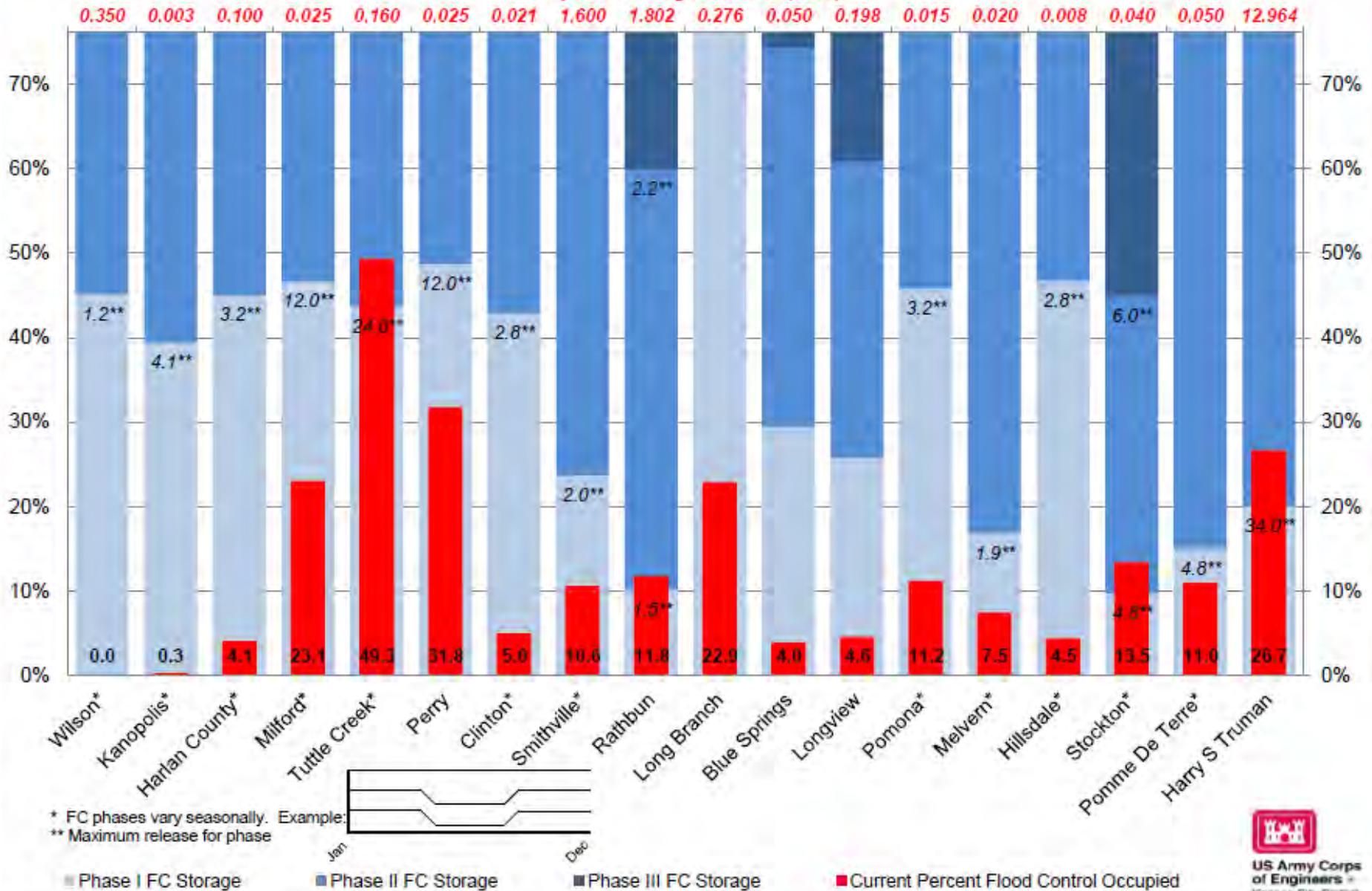


Relationship between Control Points and Flood Control Zones

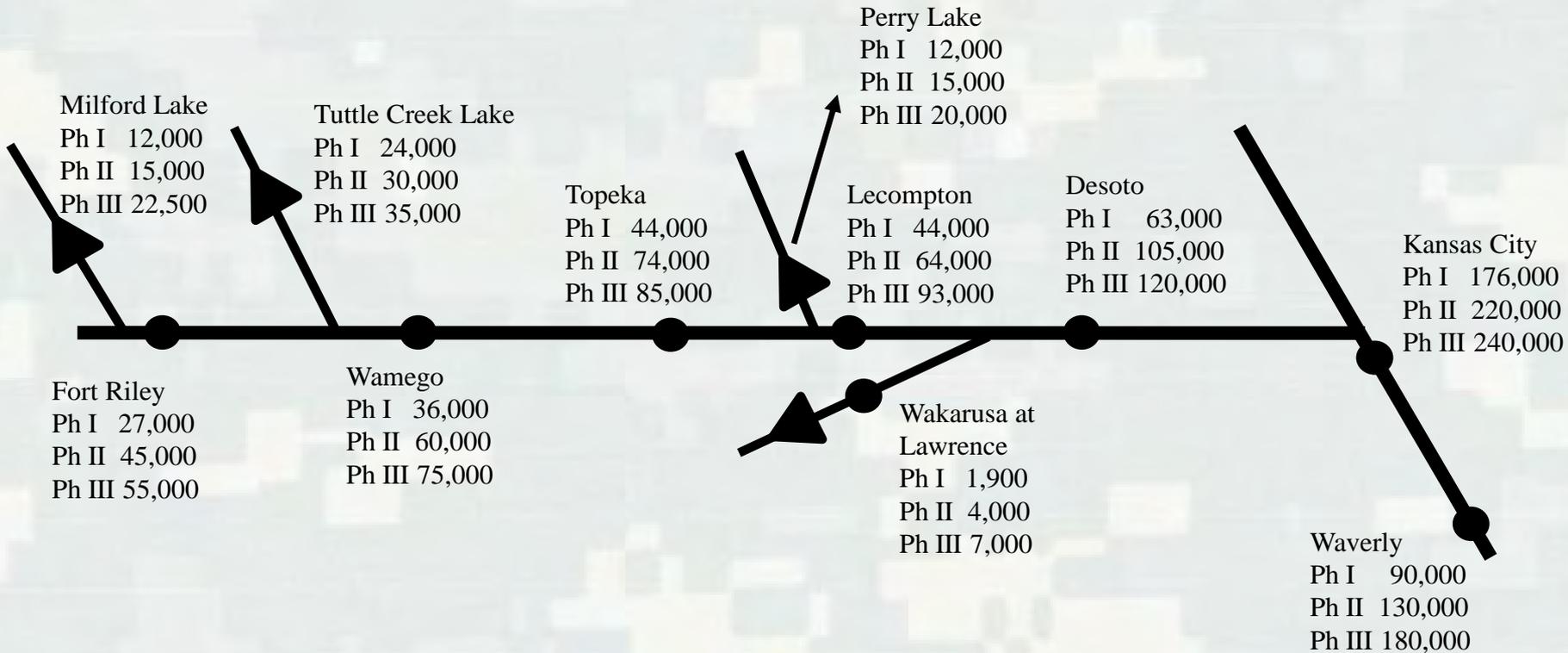


Percent of Flood Control Pool Occupied: 8 Apr 2019

8-Apr-19 Average Release (kcfs)



Kansas River Control Point Gages

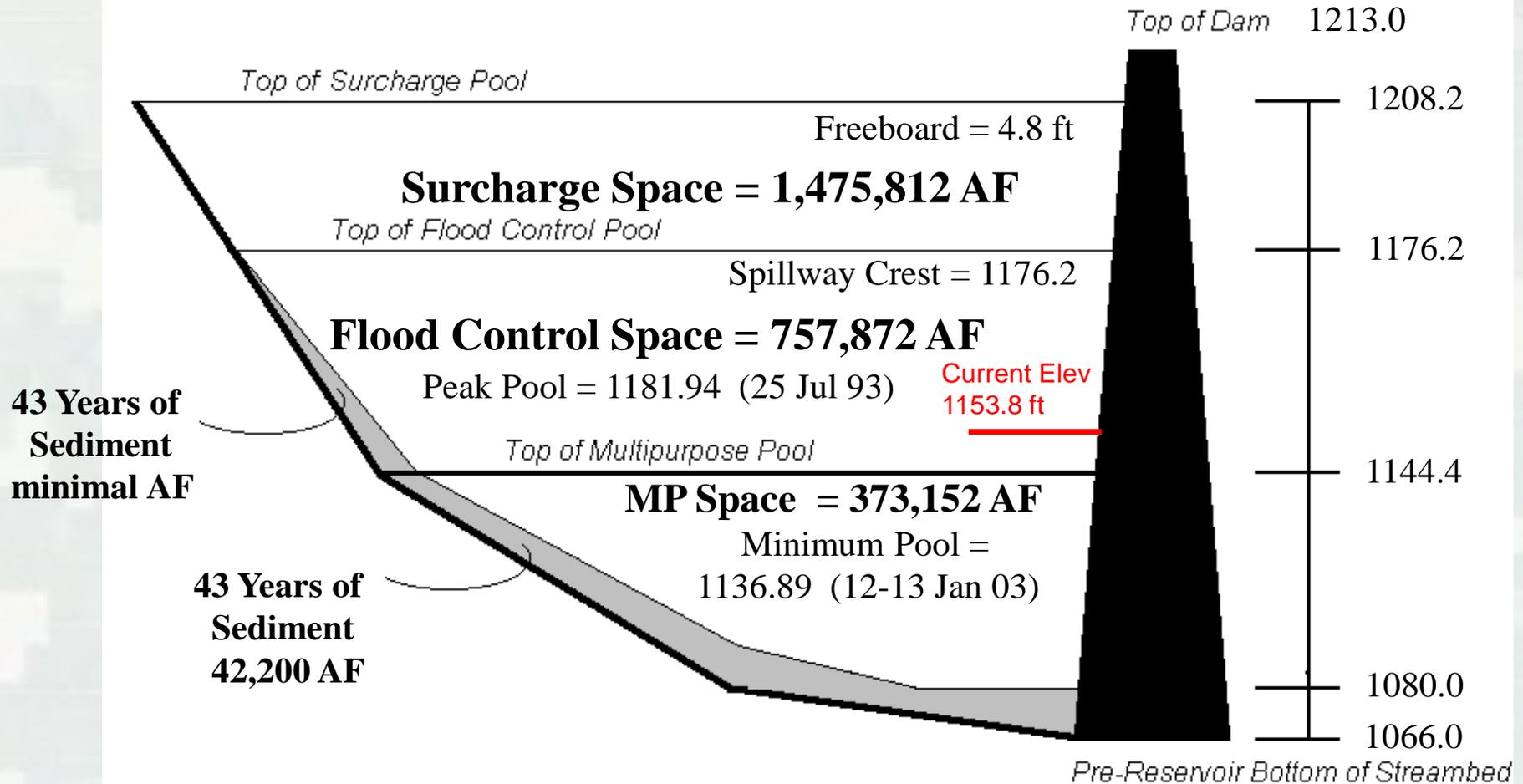


All flows are in cfs; schematic is not to scale.



Milford Lake Storage Allocations

As of Last Sediment Survey Completed in October 2009



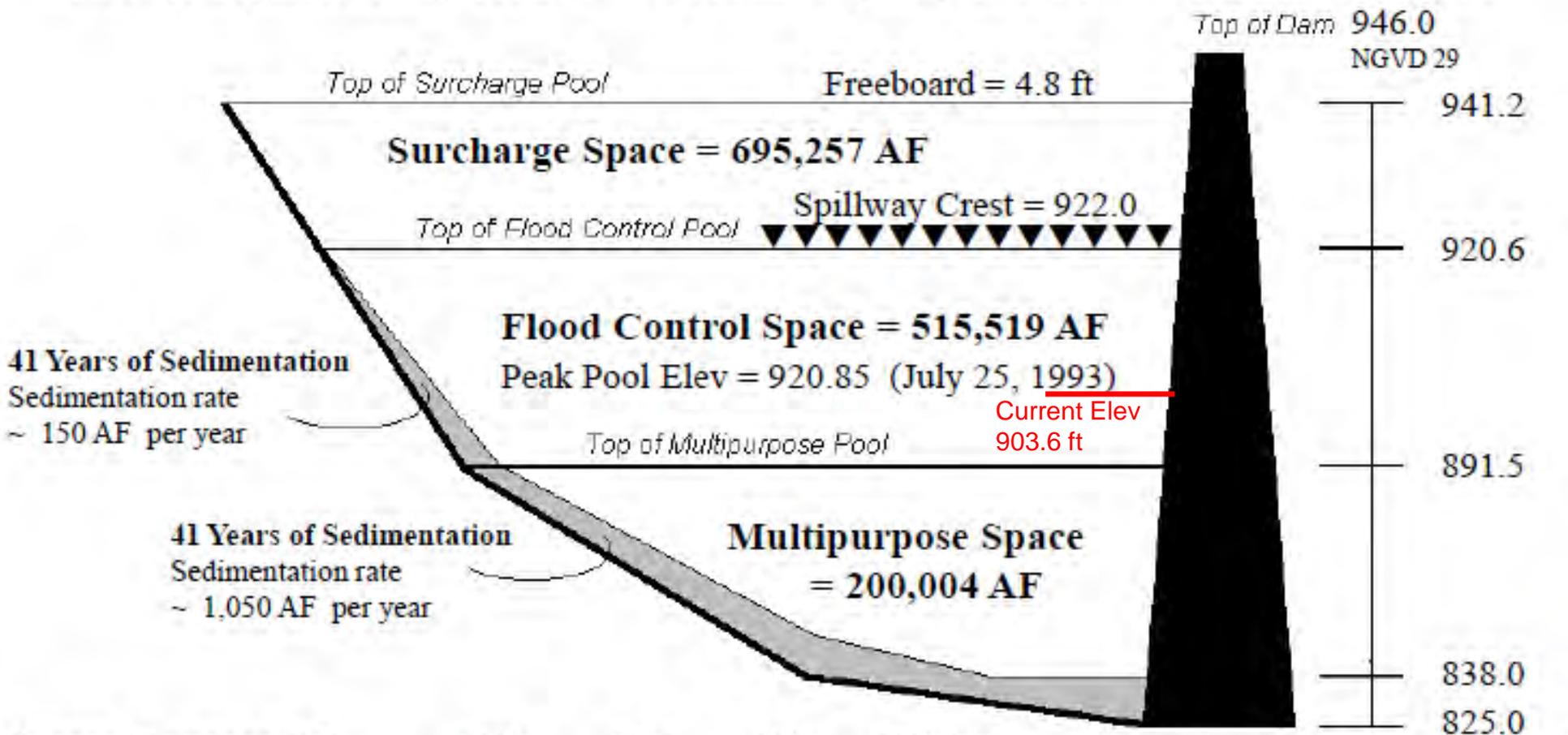
<u>Storage Allocations (AF)</u>	1967 (begin)	2009 survey	2067 (design)
Flood Control	757,746	757,872	700,000
Total Multipurpose Pool	415,352	373,152	300,000
Water Supply in service	0	101,650	101,650 (33.88%)
Water Supply reserved	300,000	198,350	198,350 (66.12%)
MP Sediment Reserve	115,352	73,152	0



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Perry Lake Storage Allocations

Storage Began January 15, 1969 Current Capacity Table Use Began March 1, 2012

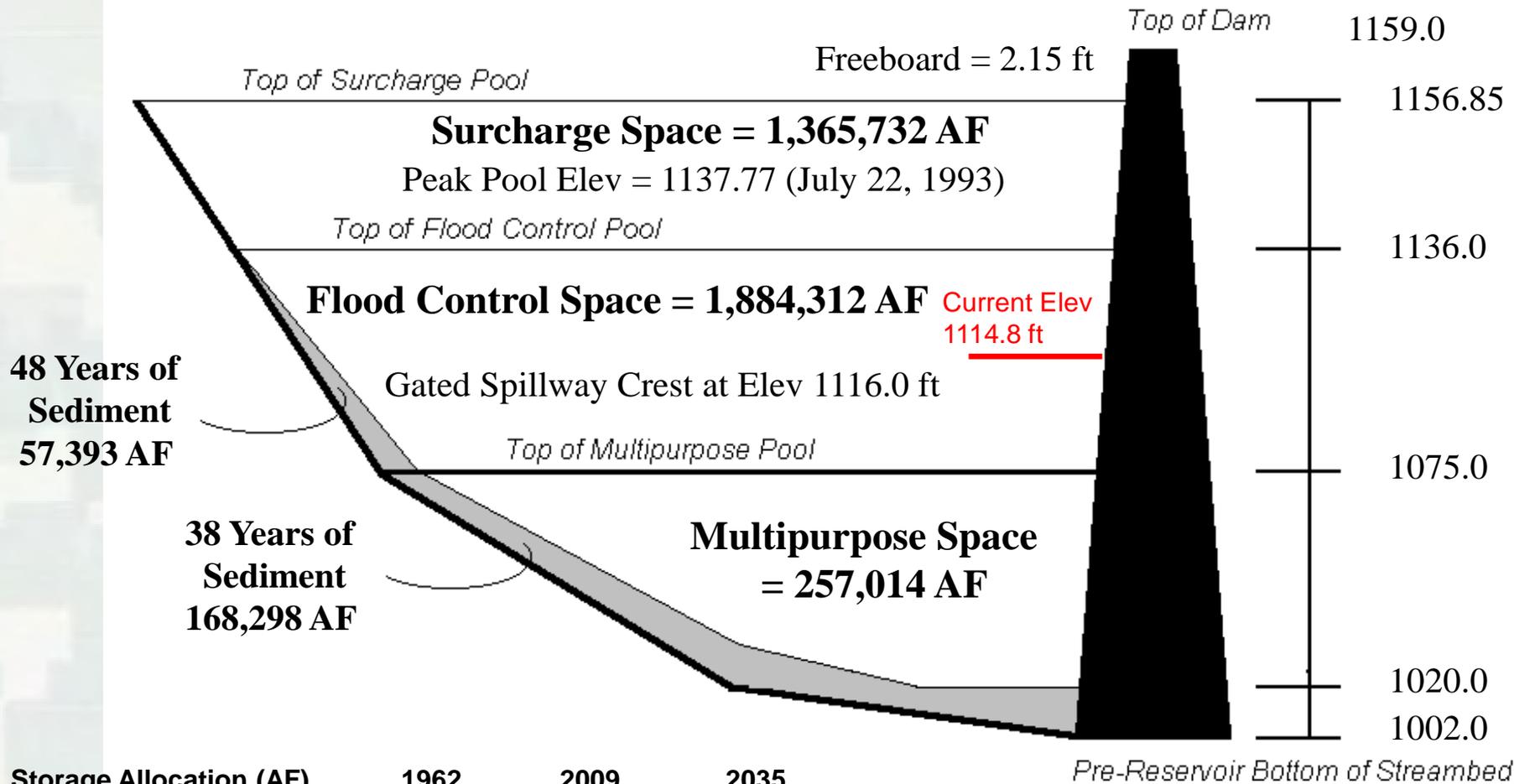


Storage Allocations (AF)	1969	2001	2009	2069 (est)
Total Flood Control Pool	521,880	515,397	515,519	480,000
Exclusive Flood Control	480,000	480,000	480,000	480,000
FP Sediment Reserve	41,880	35,397	35,519	0
Total Multipurpose Pool	243,220	206,682	200,004	150,000
In-Service Water Supply	0	25,000	25,000	150,000
Future Use Water Supply	150,000	125,000	125,000	0
MP Sediment Reserve	93,220	56,582	50,004	0

2009 tables now used for operations. The State of Kansas (KWO) contracted for the water supply allocation in 1977. The initial 25,000 AF increment is contracted to the Kansas River Water Assurance District. Valley Falls has a separate water withdrawal contract.

Tuttle Creek Lake Storage Allocations

Sediment Survey Last Conducted in June 2009



<u>Storage Allocation (AF)</u>	1962	2009	2035
Flood Control	1,941,705	1,884,312	1,879,000
Total Multipurpose	425,312	257,014	122,000
Water Supply	0	50,000	50,000
WQ, Nav, Other Purposes	185,000	72,000	72,000
MP Sediment Reserve	240,312	135,014	50,000



Current Conditions



**US Army Corps
of Engineers®**

Northwestern Division, Kansas City District
Lower Missouri River Basin Reservoir Bulletin

Project Data Date/Time: 04-08-2019 06:00

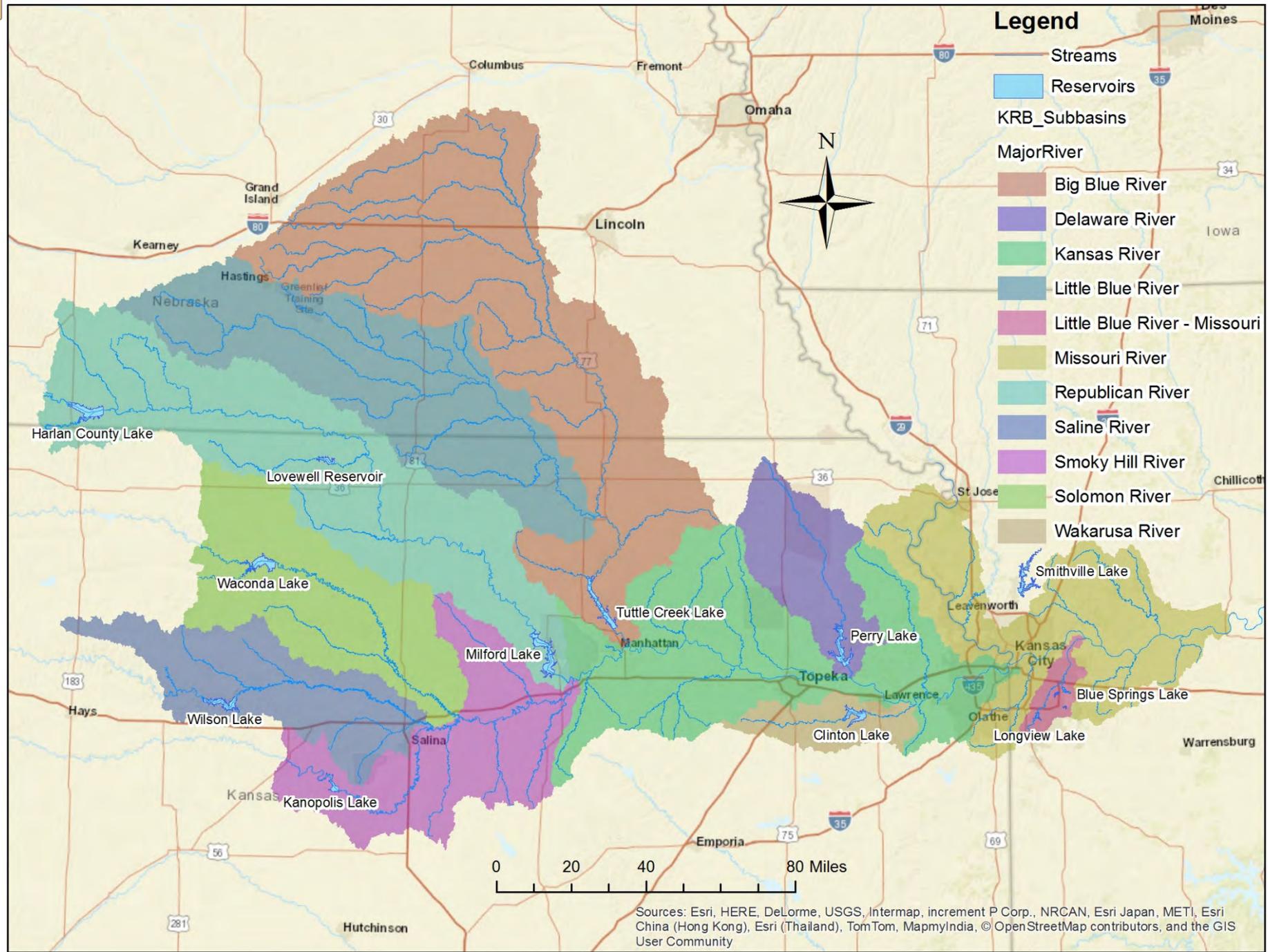
Last Updated Date/Time: 04-08-2019 13:06



Project	Project Information				Current Data						Occupied Storage		
	Elevations (ft)		Net Storage (ac-ft)		Elev (ft)	Daily Elev Change (ft)	Storage (ac-ft)	Inflow (cfs)	Release (cfs)	Precip (in)	MP (%)	FC (ac-ft)	FC (%)
	MP	FC	MP	FC									
Republican River Basin													
Bonny Dam	3672.00	3710.00	41,340	128,820	3638.00	0.00	0	15	14	0.00	-0.0	0	0.0
Trenton Dam (Swanson Lake)	2752.00	2773.00	112,285	134,006	2743.13	0.01	73,228	40	1	0.00	65.2	0	0.0
Enders Dam	3112.30	3127.00	42,929	30,029	3083.99	-0.02	9,993	10	3	0.00	23.3	0	0.0
Red Willow Dam (Hugh Butler L)	2581.80	2604.90	36,231	48,862	2571.49	-0.02	21,646	10	2	0.00	59.7	0	0.0
Medicine Cr Dam (Harry Strunk L)	2366.10	2386.20	34,654	52,724	2367.77	-0.04	37,842	80	90	0.00	100.0	3,188	6.0
Norton Dam (Keith Sebelius Lake)	2304.30	2331.40	34,509	99,231	2296.64	0.01	20,344	30	1	0.00	59.0	0	0.0
Harlan County Dam	1945.73	1973.50	314,111	500,000	1947.51	0.03	338,268	375	100	0.00	100.0	24,157	4.8
Lovewell Dam	1582.60	1595.30	35,714	50,458	1582.93	-0.03	36,670	65	100	0.32	100.0	956	1.9
Milford Dam	1144.40	1176.20	373,152	757,874	1153.80	0.18	547,929	1,900	25	0.00	100.0	174,777	23.1
Smoky Hill River Basin													
Cedar Bluff Dam	2144.00	2166.00	172,451	191,891	2125.43	0.01	75,897	40	0	0.00	44.0	0	0.0
Kanopolis Dam	1463.00	1508.00	48,378	365,143	1463.40	0.22	49,578	370	3	0.00	100.0	1,200	0.3
Wilson Dam	1516.00	1554.00	236,188	530,152	1515.90	-0.01	235,338	345	350	0.00	99.6	0	0.0
Webster Dam	1892.45	1923.70	76,202	183,401	M	M	79,428	100	100	0.00	100.0	3,226	1.8
Kirwin Dam	1729.25	1757.30	98,190	215,175	M	M	105,728	90	70	0.00	100.0	7,538	3.5
Glen Elder Dam (Waconda Lake)	1455.60	1488.30	219,420	722,986	M	M	228,229	500	1,501	0.15	100.0	8,809	1.2
Lower Kansas River Basin													
Tuttle Creek Dam	1075.00	1136.00	257,014	1,884,312	1114.80	0.26	1,186,300	5,000	160	0.65	100.0	929,286	49.3
Perry Dam	891.50	920.60	200,004	515,520	903.60	0.16	363,887	1,400	25	0.32	100.0	163,883	31.8
Clinton Dam	875.50	903.40	118,699	292,496	877.40	0.02	133,763	400	21	0.00	100.0	15,064	5.2
Platte River Basin													
Smithville Dam	864.20	876.20	141,772	101,798	865.69	-0.36	152,606	260	1,600	0.00	100.0	10,834	10.6
Little Blue River Basin													

Milford Maximim Pool Elevations by Year			Tuttle Creek Maximim Pool Elevations by Year			Perry Maximim Pool Elevations by Year		
Rank	Year	Pool Elevation (ft)	Rank	Year	Pool Elevation (ft)	Rank	Year	Pool Elevation (ft)
1	1993	1181.94	1	1993	1137.66	1	1993	920.88
2	1973	1169.92	2	1973	1127.88	2	1973	917.04
3	1987	1160.58	3	2019	1114.8	3	1995	913.19
4	2010	1159.85	4	1984	1112.3	4	1984	910.9
5	1995	1158.42	5	1987	1111.92	5	2015	909.68
6	2011	1158.28	6	2015	1110.91	6	2001	908.51
7	2016	1154.77	7	1979	1109.1	7	1999	908.02
8	1986	1154.25	8	2010	1106.54	8	1996	907.55
9	2018	1154.01	9	1995	1105.02	9	2010	907.42
10	2019	1153.8	10	2018	1104.1	10	1977	907.14
						11	2005	906.77
						12	1982	905.31
						13	2016	905.28
						14	1998	905.07
						15	2005	904.26
						16	1986	903.78
						17	2019	903.6

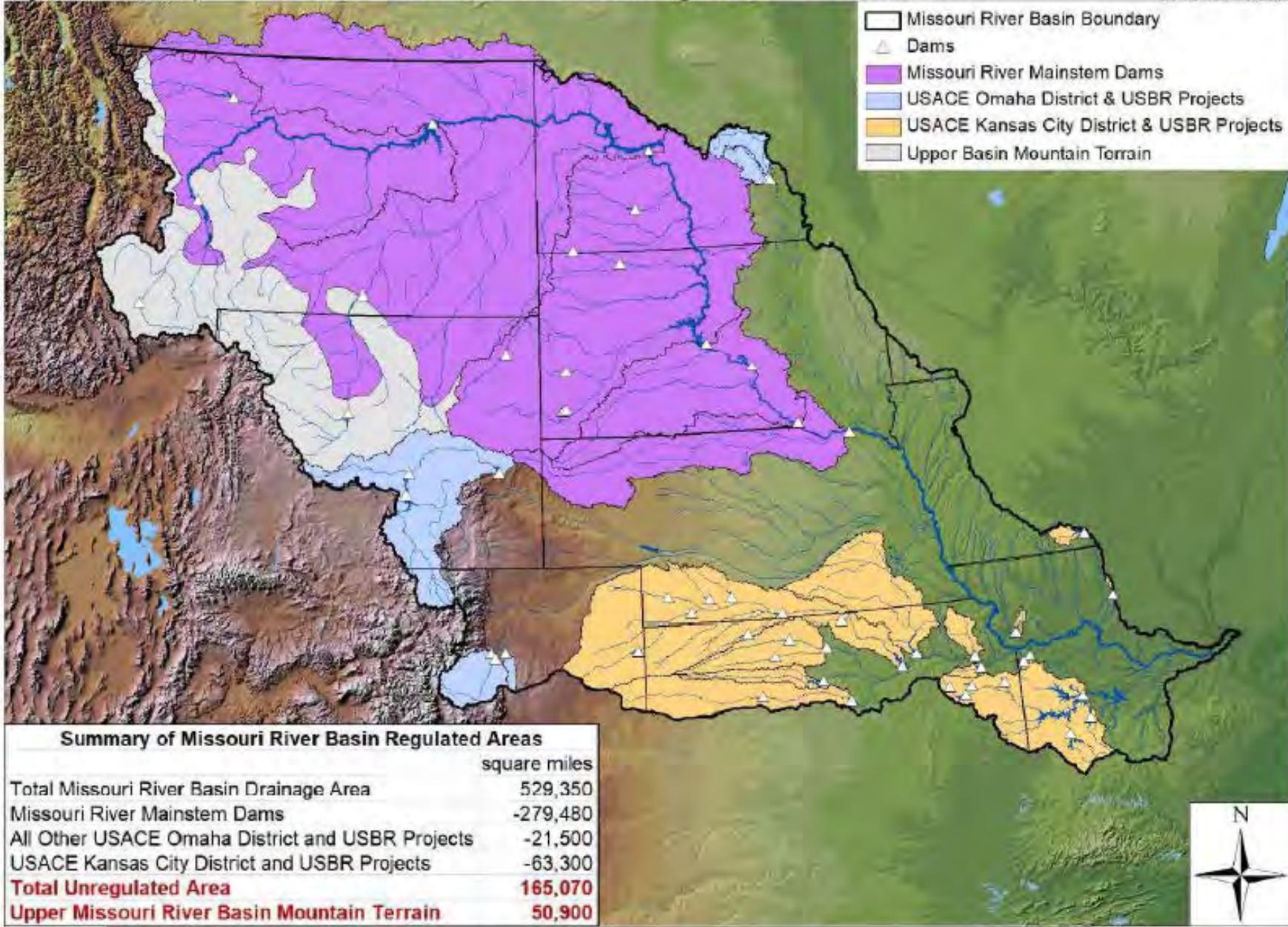




Missouri River Basin Regulated Watersheds

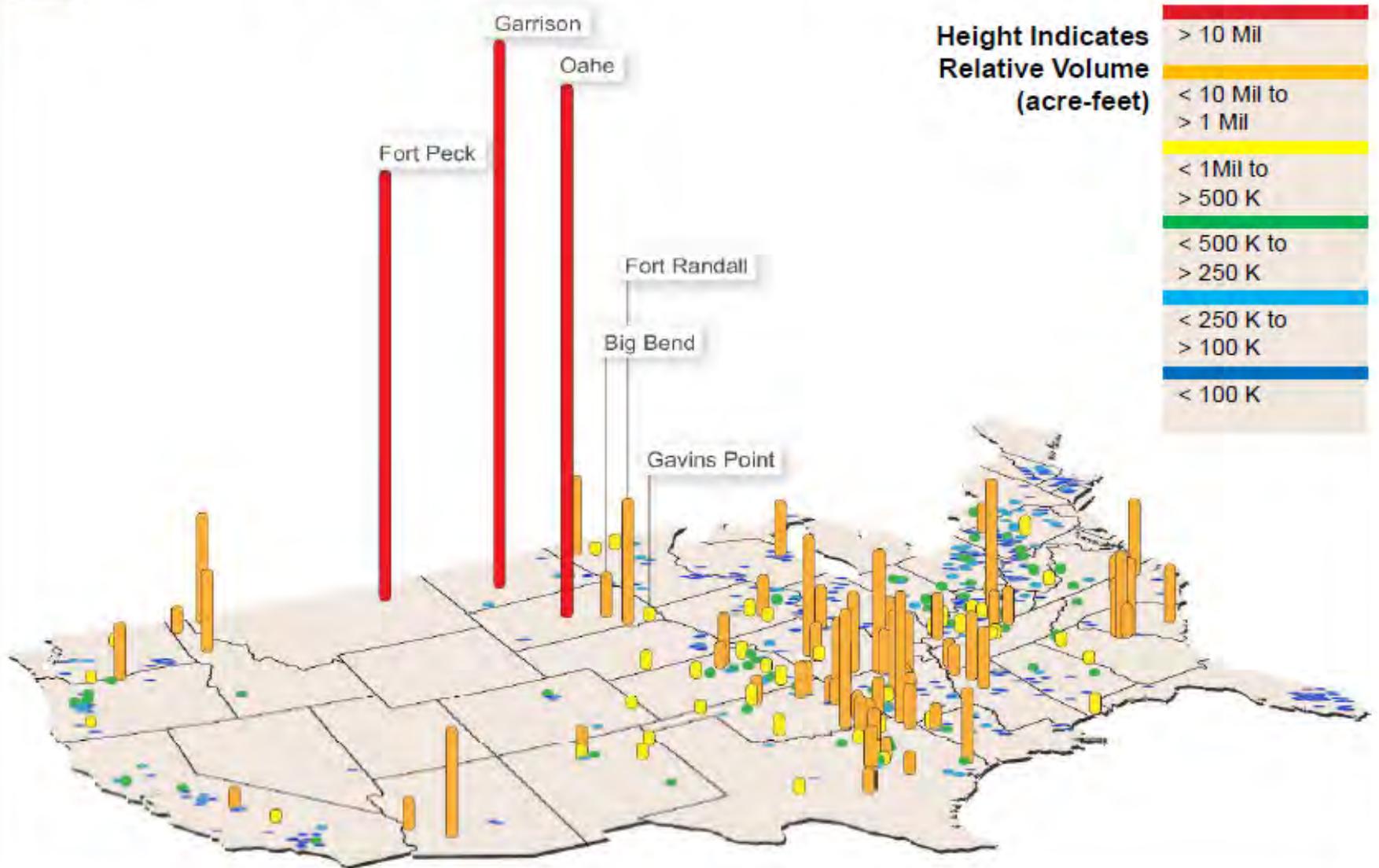
Background: North America Relief Map

USACE RWO March 2018





USACE RESERVOIR STORAGE CAPACITY

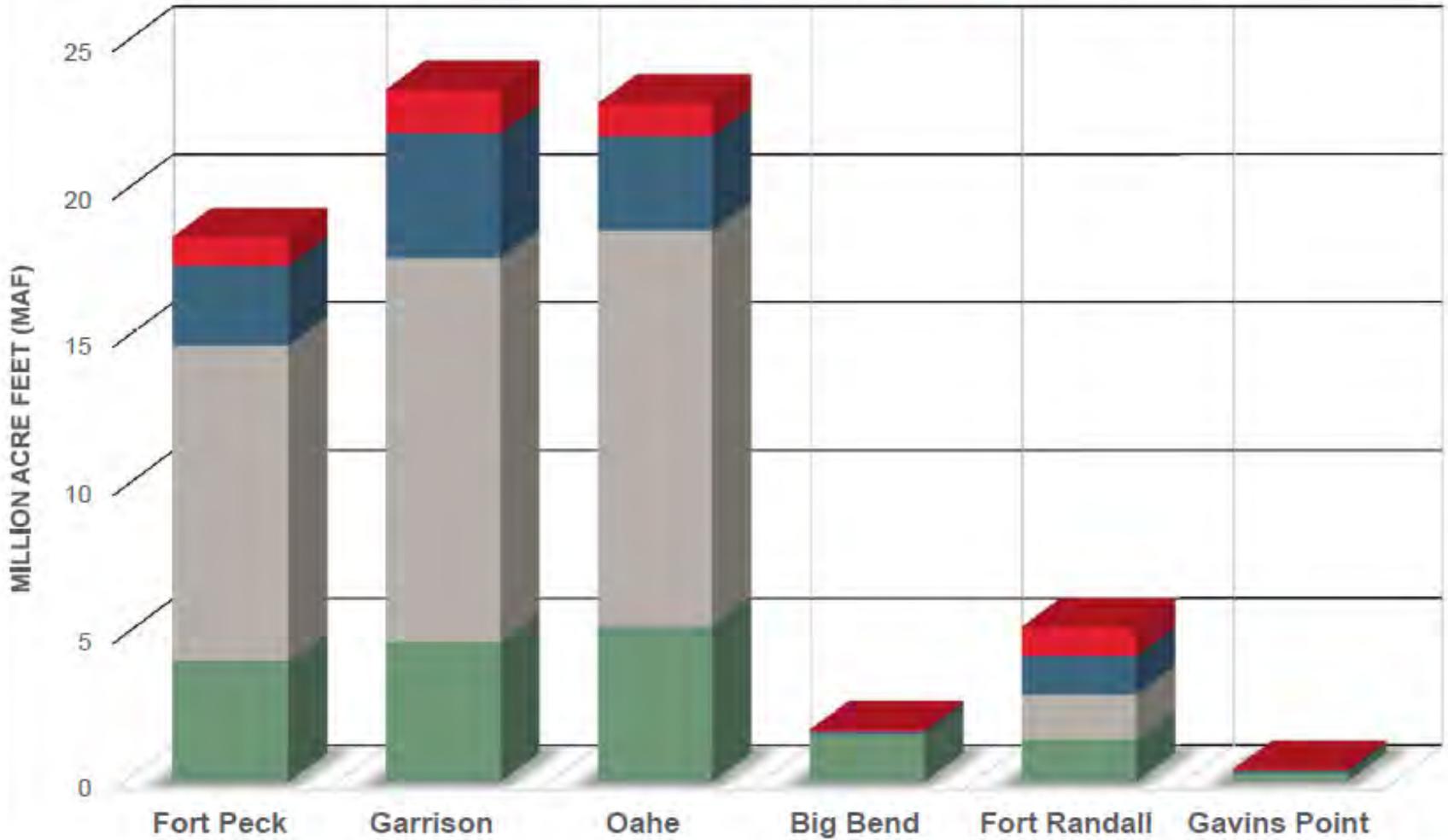




MAINSTEM RESERVOIR STORAGE CAPACITY



■ Permanent ■ Carryover ■ Annual Flood ■ Exclusive Flood



Mainstem Current Conditions



**US Army Corps
of Engineers®**

Northwestern Division, Missouri River Basin Water Management
Mainstem and Tributary Reservoir Bulletin
 Project Data Date/Time: 04-08-2019 00:00
 Last Updated Date/Time: 04-08-2019 16:05

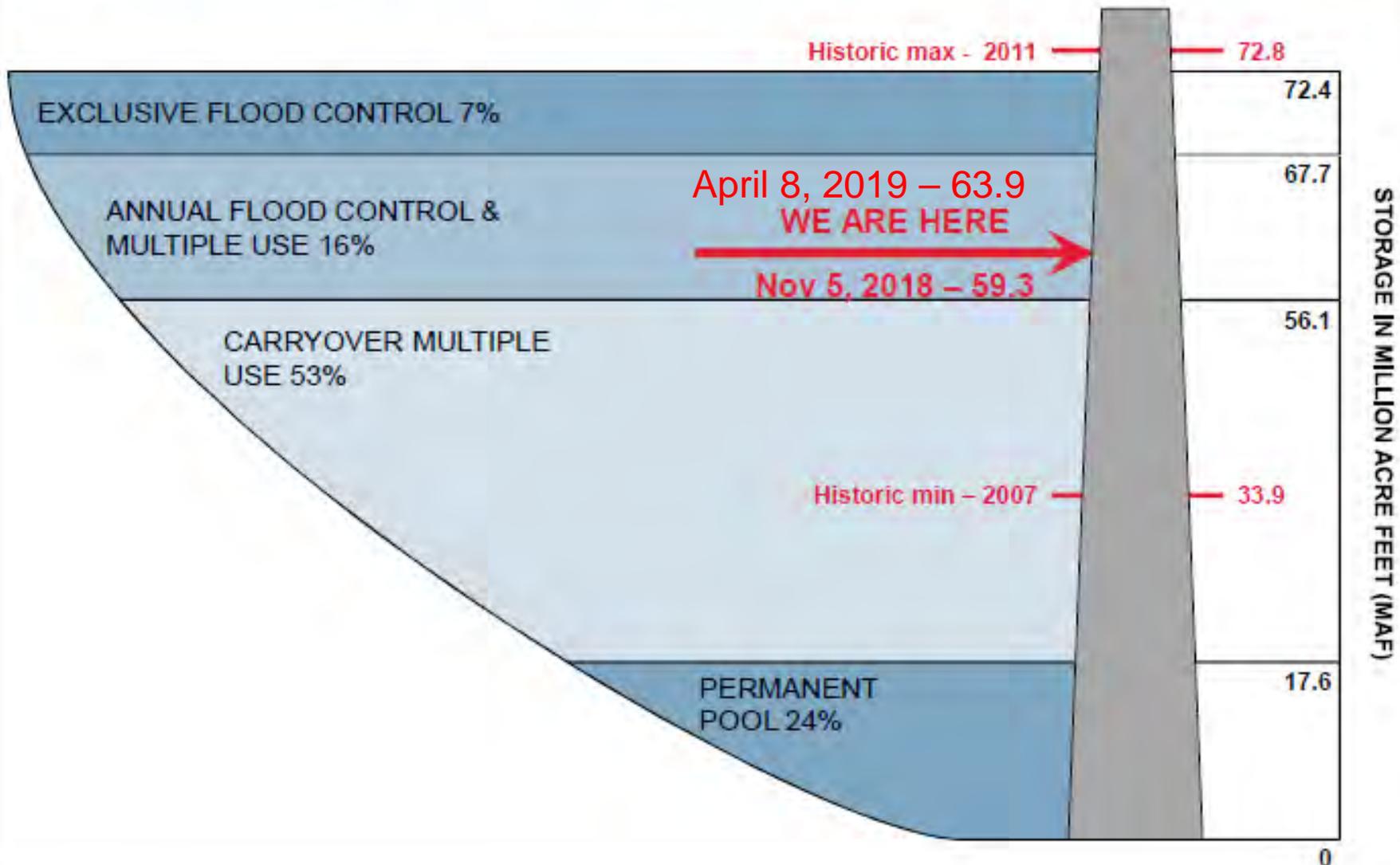


Project	Project Information				Current Data					Occupied Storage		
	Elevations (ft)		Cumulative Storage (ac-ft)		Elev (ft)	Daily Elev Change (ft)	Storage (ac-ft)	Inflow (cfs)	Release (cfs)	MP (%)	FC (ac-ft)	FC (%)
	MP	FC	MP	FC								
MRR - Missouri River Mainstem Projects												
Fort Peck Dam	2234.0	2250.0	14,788,340	18,462,840	2238.66	0.08	15,790,000	14,000	6,600	100.0	1,001,660	27.3
Garrison Dam	1837.5	1854.0	17,744,640	23,451,300	1844.56	0.12	20,062,000	43,000	13,000	100.0	2,317,360	40.6
Oahe Dam	1607.5	1620.0	18,667,635	22,982,900	1616.31	0.15	21,640,000	55,000	21,700	100.0	2,972,365	68.9
Big Bend Dam	1420.0	1423.0	1,631,474	1,810,414	1421.00	0.16	1,690,000	28,000	22,300	100.0	58,526	32.7
Fort Randall Dam	1350.0	1375.0	3,000,732	5,293,473	1365.68	-0.24	4,373,000	29,000	43,900	100.0	1,372,268	59.9
Gavins Point Dam	1204.5	1210.0	295,406	428,033	1206.34	0.14	335,000	53,000	50,900	100.0	39,594	29.9
System Totals	--	--	56,128,227	72,428,960	--	--	63,890,000	--	--	100.0	7,761,773	47.6





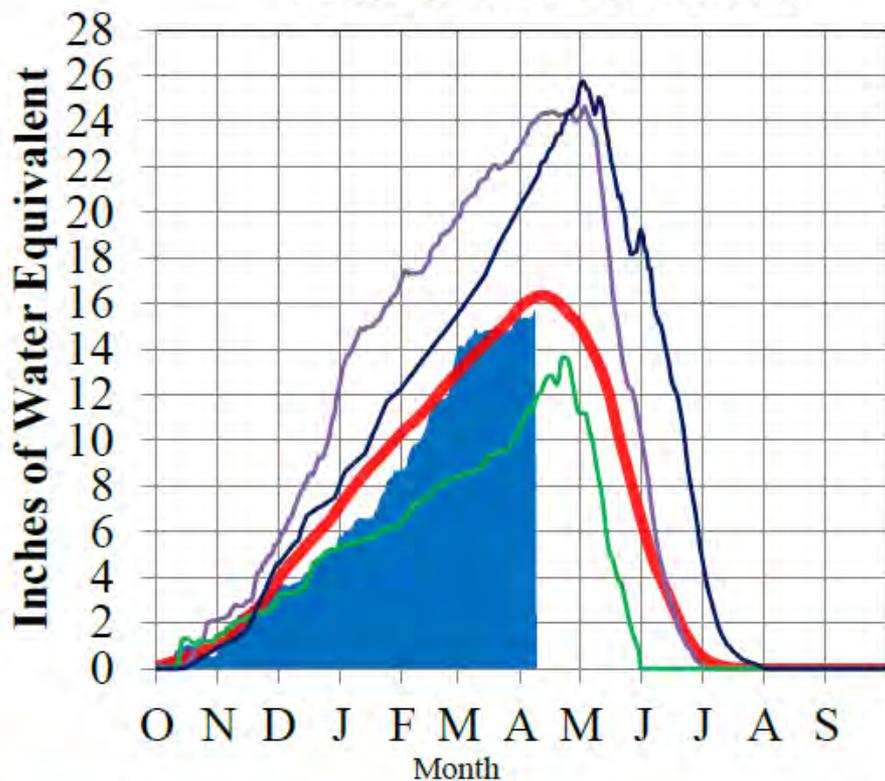
MISSOURI RIVER MAINSTEM SYSTEM STORAGE ZONES AND ALLOCATIONS



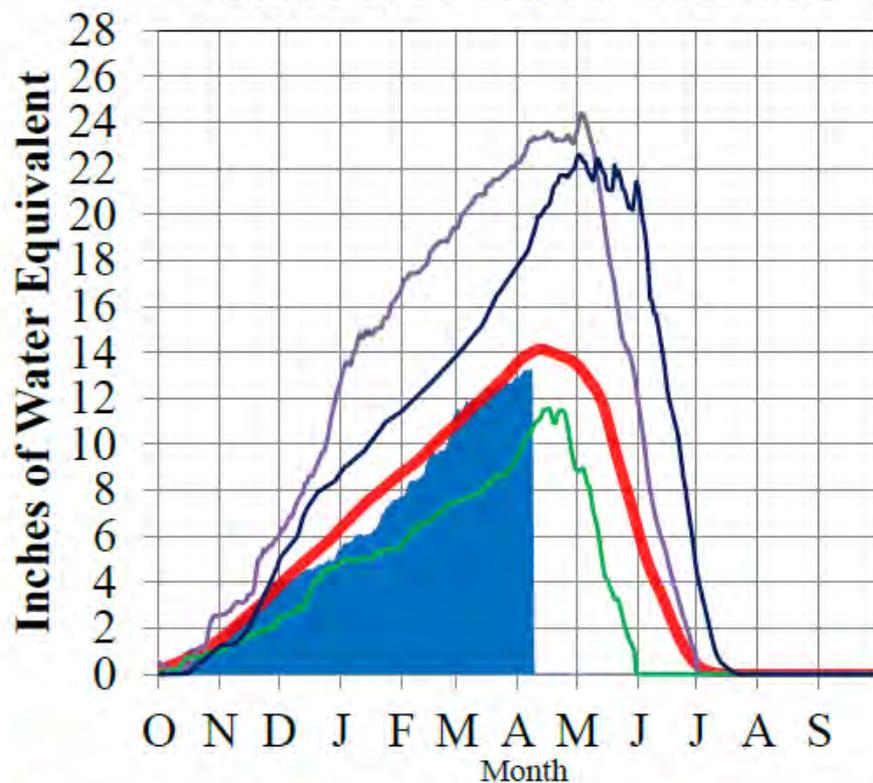
Missouri River Basin – Mountain Snowpack Water Content 2018-2019 with comparison plots from 1997*, 2001*, and 2011

April 8, 2019

Total above Fort Peck



Total Fort Peck to Garrison



■ 2018-2019 ■ 1981-2010 Ave ■ 1997 ■ 2001 ■ 2011

■ 2018-2019 ■ 1981-2010 Ave ■ 1997 ■ 2001 ■ 2011

The Missouri River Basin mountain snowpack normally peaks near April 15. On April 8, 2019 the mountain Snow Water Equivalent (SWE) in the “Total above Fort Peck” reach was 15.8”, 97% of the April 8 average. The mountain SWE in the “Total Fort Peck to Garrison” reach was 13.3”, 93% of the April 8 average.

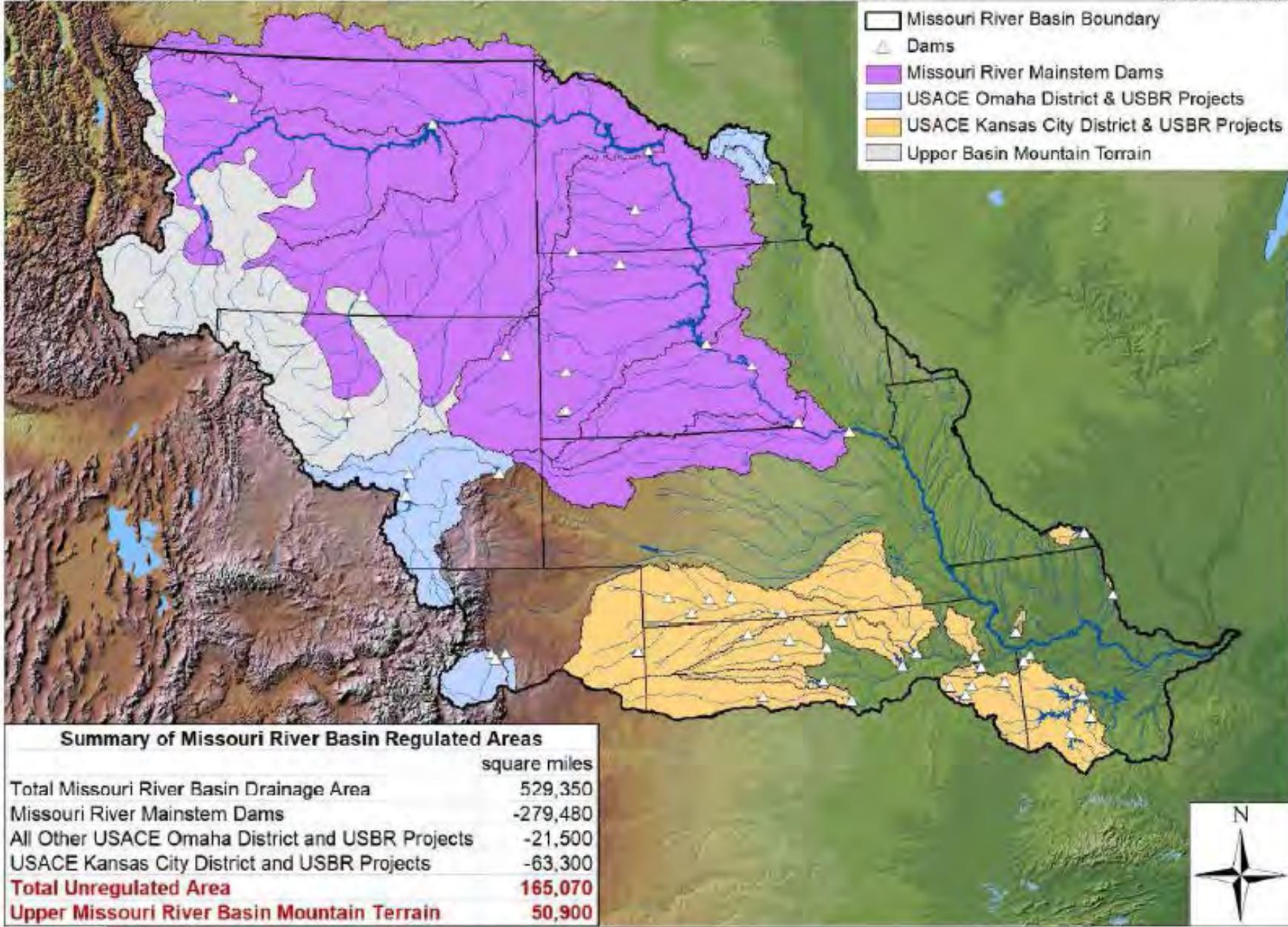
*Generally considered the high and low year of the last 20-year period, respectively.

Provisional data. Subject to revision.

Missouri River Basin Regulated Watersheds

Background: North America Relief Map

USACE RWO March 2018



Summary of Missouri River Basin Regulated Areas

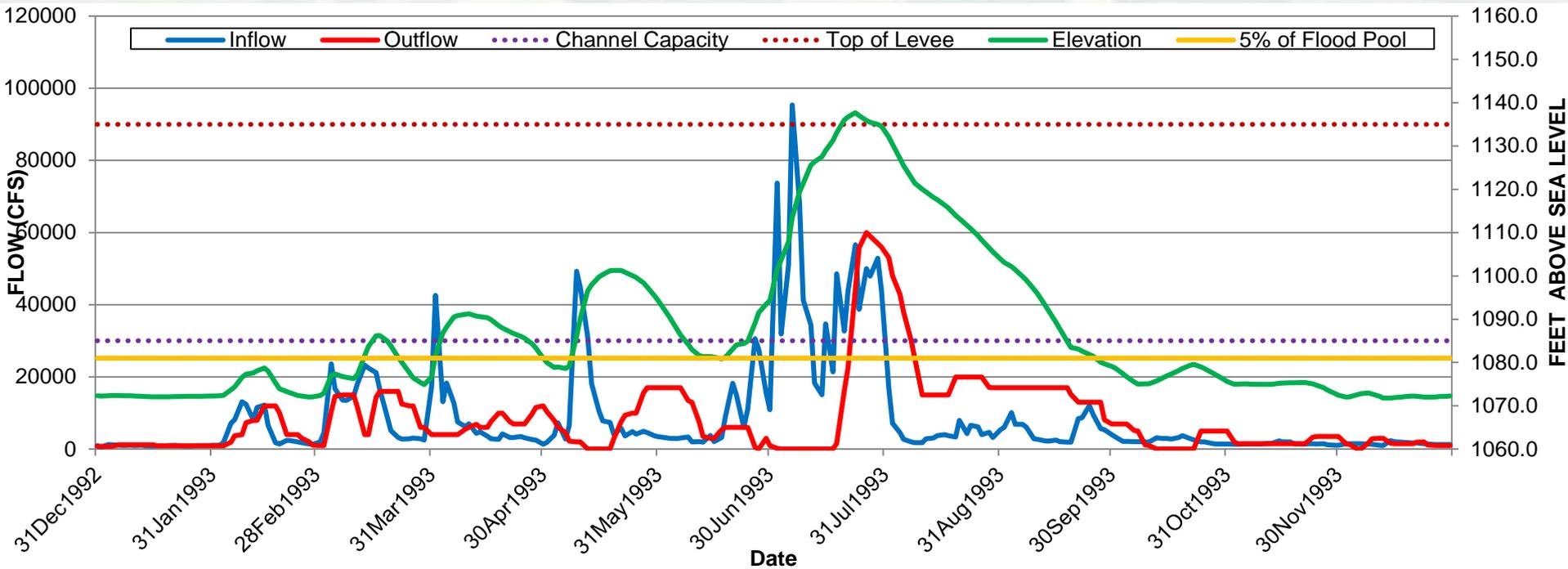
	square miles
Total Missouri River Basin Drainage Area	529,350
Missouri River Mainstem Dams	-279,480
All Other USACE Omaha District and USBR Projects	-21,500
USACE Kansas City District and USBR Projects	-63,300
Total Unregulated Area	165,070
Upper Missouri River Basin Mountain Terrain	50,900

0 125 250 500 750 1,000 Miles

A photograph of a river with a dam. The water is brown and turbulent, cascading over the dam. The background is a dense forest of green trees. There are orange buoys on a line across the river. The text "Questions and Discussion" is overlaid on the water.

Questions and Discussion

1993 Flood



Date	Time	Elev.	Outflow (cfs)	Release Location
1 July	11:00	1096.33	100	control tower
17 July	15:45	1131.40	5000	control tower
17 July	21:30	1131.74	0	
19 July	12:00	1135.70	10,000	control tower
19 July	15:15	1135.74	20,000	control tower & spillway (0.8)
20 July	17:00	1136.32	25,000	control tower & spillway (1.3)
22 July	02:30	1137.13	30,000	control tower & spillway (1.3)
22 July	09:00	1137.32	45,000	control tower & spillway (1.8)
22 July	22:00	1137.75	50,000	control tower & spillway (2.9)
23 July	18:00	1137.35	60,000	spillway (4.0)

Lake peaked at 1137.77 during the overnight period of 23-24 July



How is Tuttle Creek Operated?

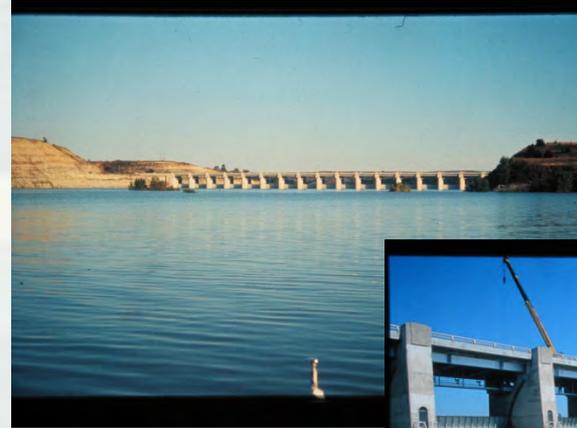
- **Surcharge Operation** (>1136.0 feet msl)
 - ▶ Flood control balances upstream and downstream flood risk
 - ▶ **Emphasizes preservation of structure**
 - ▶ Releases are determined by current pool elevation, and amount of water entering reservoir; **downstream channel condition is irrelevant**
 - ▶ **Surcharge** = to fill or load to excess... temporary abnormal lake condition intended to buffer the amount of water going through the spillway



Volume Equivalents

Surcharge Area vs Normal Flood Control Pool

- **1993 Flood Event**
 - ▶ 1136.0-1137.8 = 1075.0-1082.5
 - ▶ 1.8 feet = 7.5 feet
- **Flowage Easement Zone**
 - ▶ 1136.0-1140.0 = 1075.0-1089.5
 - ▶ 4.0 feet = 14.5 feet
- **Induced Surcharge Zone**
 - ▶ 1136.0-1142.0 = 1075.0-1095.0
 - ▶ 6.0 feet = 20 feet
- **Full Surcharge Zone**
 - ▶ 1136.0-1156.85 = 1075.0-1125.5
 - ▶ 20.85 feet = 50.5 feet (equiv of 1973 flood event)



Flood Control to Surcharge transition

- Prevents a sudden, large increase in lake discharges when surcharge operations are imminent due to a rapidly rising pool

- ▶ Is based on rate of rise in the upper flood pool
- ▶ Insures releases will not exceed what would have naturally occurred
- ▶ Spillway Preset Gate Settings
 - Set at 0.4 feet for initial opening, then 0.8 feet per preset up to a gate setting of 6.0 feet
 - Gates can be manually stopped at any level
- ▶ Once lake is projected to exceed 1142.0 (gate opening of 6 feet), gates are traveled to wide open setting and there is no induced surcharge at that point
- ▶ While in surcharge operation (i.e. pool is above 1136.0 msl), once a gate setting is reached, it will not be reduced
 - Once lake falls below 1136.0 msl, Phased operation is resumed until flood pool is evacuated
 - Spillway or Outlet Works can be used between elevation 1116.0 and 1136.0
 - Outlet works only below elevation 1116.0
 - 1993 Peak spillway gate setting was 4.0 feet
 - ▷ Spillway gate maximum opening is 26.5 feet

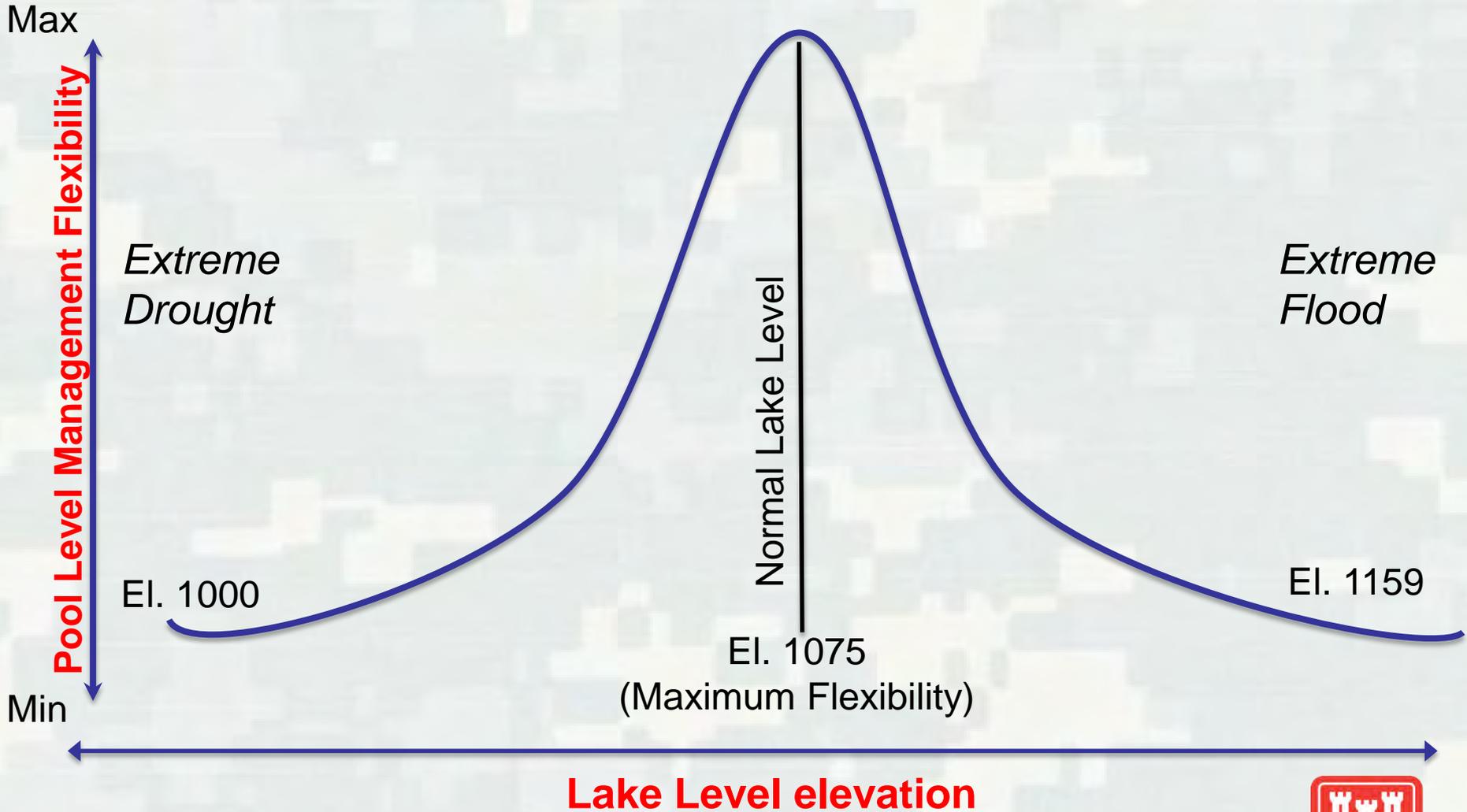


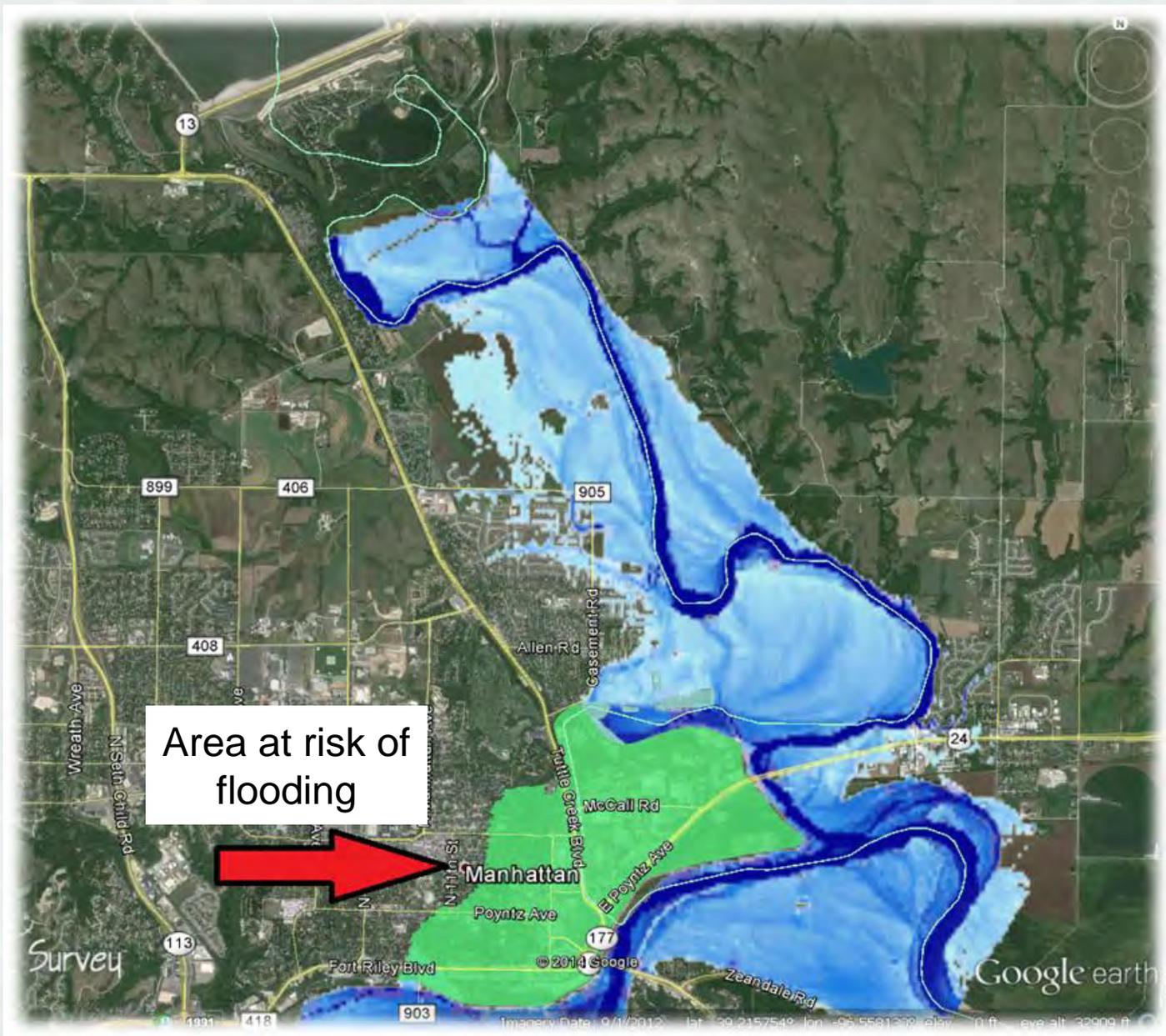
~Were operational plans adhered to during 1993 event? Yes

~What did the Corps learn from the 1993 flood? Many of our dams attained record pools and all functioned as designed



Tuttle Creek Lake Water Release Flexibility

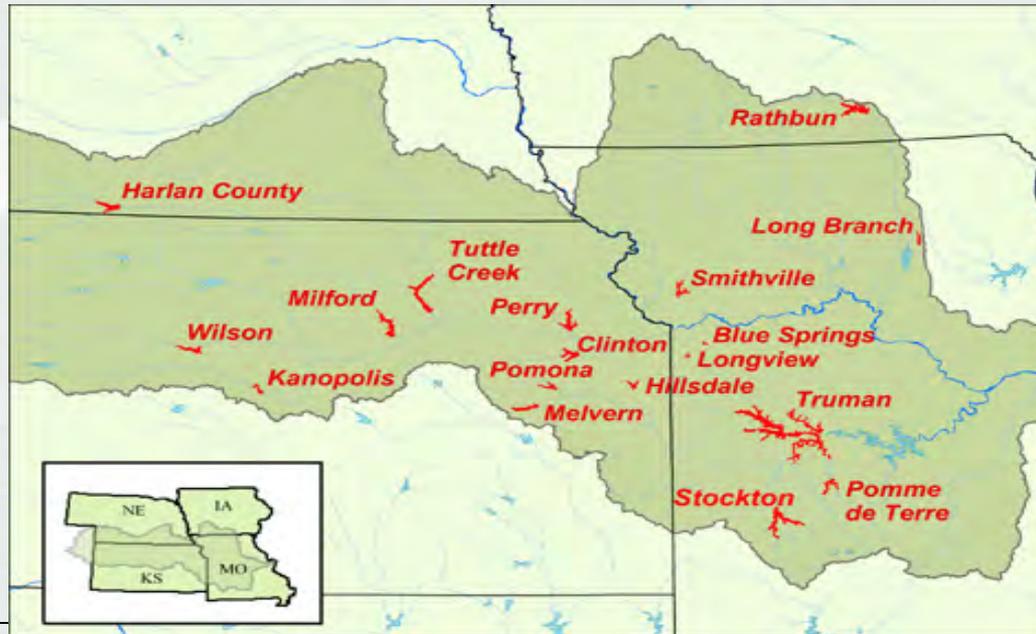




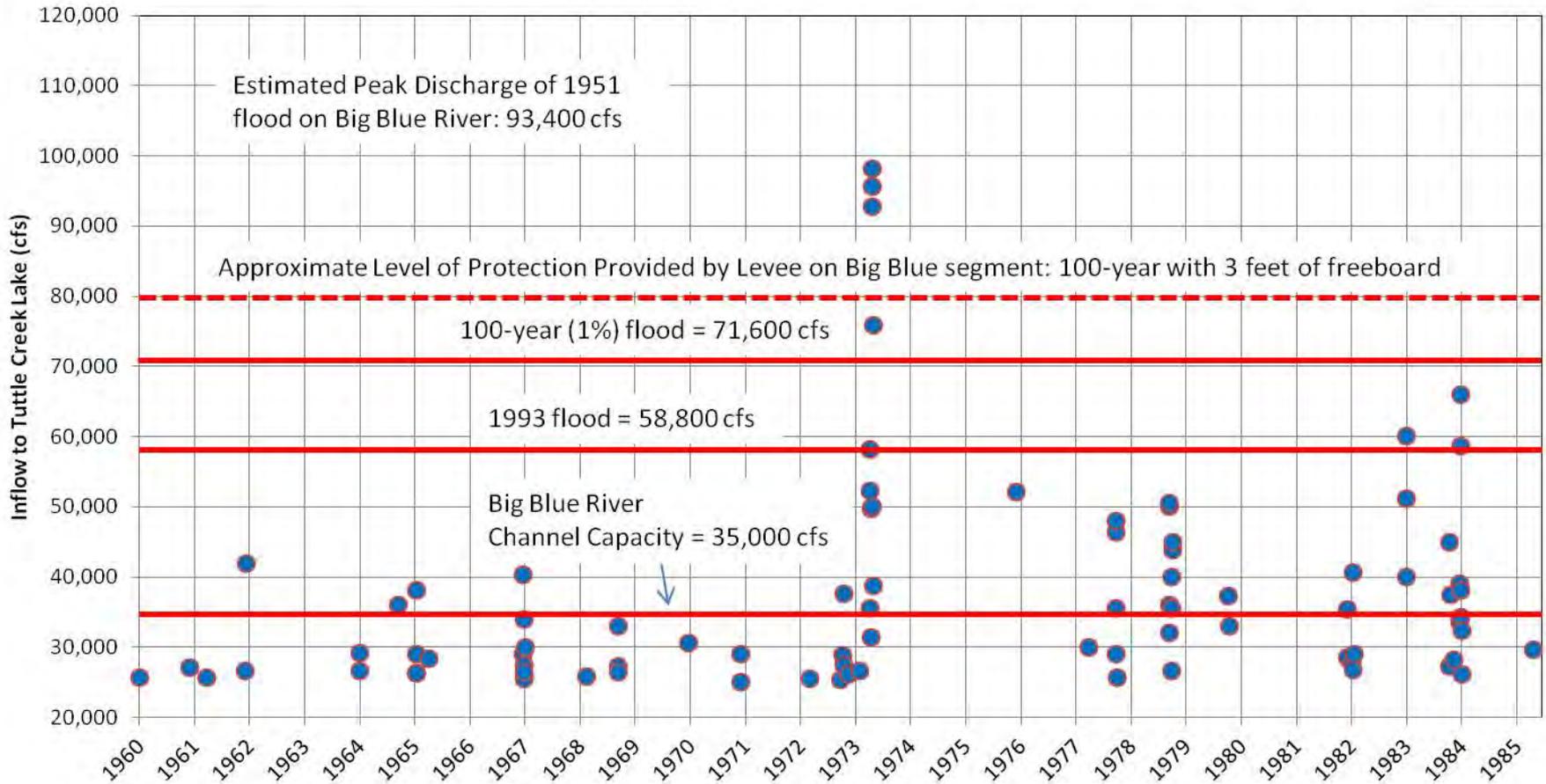
Modeled 1993 Flood Flow w/o Tuttle Creek = 36 feet at 96,000 cfs **BUILDING STRONG®**

1993 Parallel Balance and Water Storage used

- Bureau of Reclamation Lakes, percent of flood control pool used
 - ▶ Republican Basin: *Bonny 0.0%, *Swanson, 1.2%, *Enders 0.0%, *Hugh Butler 0.0%, *Harry Strunk 20.5%, *Keith Sebelius 0.0%, *Lovewell 100.4%
 - All of these lakes are above Milford (tandem lakes)
 - ▶ Smoky Hill Basin: *Webster 28.5%, *Kirwin 12.9%, Waconda 94.1%, *Cedar Bluff 0.0%
 - Waconda is the only lake that discharges below Kanopolis Lake and not tandem to the Kansas River
 - ▶ 918,200 acre/feet of flood control storage used in all Bureau Lakes combined
- U.S. Army Corps of Engineers Lakes, percent of flood control pool used/surcharge space used
 - ▶ Kansas River Basin: *Harlan County 16.2%, Milford 126.5%/200,800 ac/ft, Wilson 79.4%, Kanopolis 91.5%, Tuttle Creek 104.7%/90,700 ac/ft, Perry 101.4%/7,000 ac/ft, Clinton 38.3%
 - ▶ 4,435,900 acre/feet of flood control storage and 298,500 acre/feet of surcharge space occupied



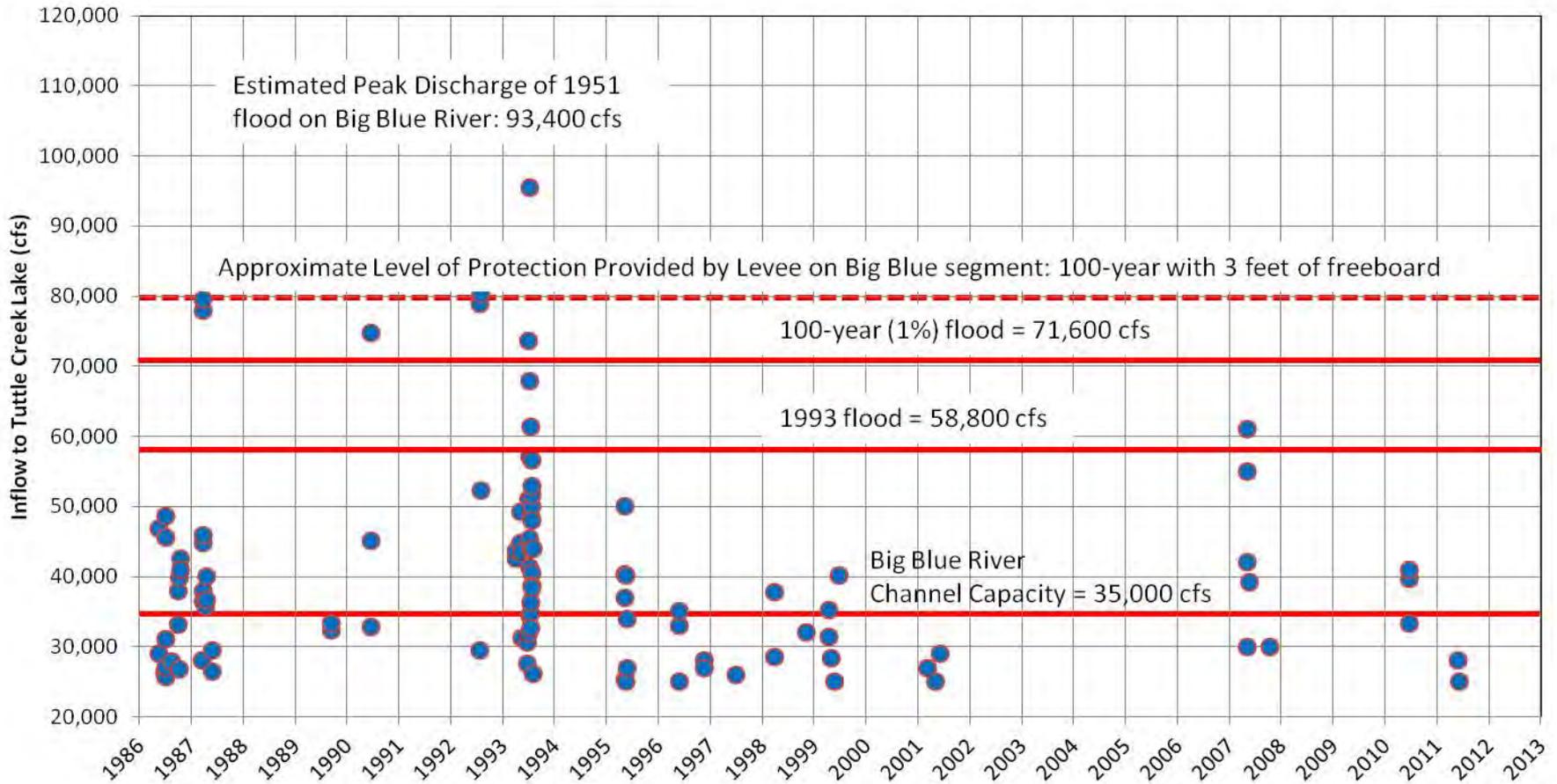
Tuttle Creek Flood Control Benefits 1960-1985



BLUE DOTS are Big Blue River flow readings coming into Tuttle Creek



Tuttle Creek Flood Control Benefits 1986 - 2013



BLUE DOTS are Big Blue River flow readings coming into Tuttle Creek
*1993 estimated peak inflow 96,000 cfs



Project Authorized Purposes

An aerial photograph showing a dam structure across a river. A paved road curves around the dam, and a concrete boat launch extends into the water. A white RV is parked on the road near the launch, and a red car is parked further down the road. The surrounding landscape is a mix of trees and open fields under a cloudy sky.

Milford, Tuttle Creek, and Perry

- ▶ Flood Control
- ▶ Water Supply
- ▶ Water Quality
- ▶ Fish and Wildlife
- ▶ Recreation
- ▶ Navigation on the Missouri River
- ▶ Private hydropower possible.

Tuttle Creek Dam Project Benefits

- **Authorized Annual Benefits**

\$55 million

- ▶ Flood Control \$46 Million
 - ▶ Recreation & Other \$6.5 Million
 - ▶ Navigation \$2.5 Million
-
- Since 1962: \$8.35 Billion Flood Damage Prevented (2016)
 - Next 50 years \$3-5 Billion in Flood Damage Prevention
 - No other benefits included

