Flood Frequency of a Regulated River – The Missouri River

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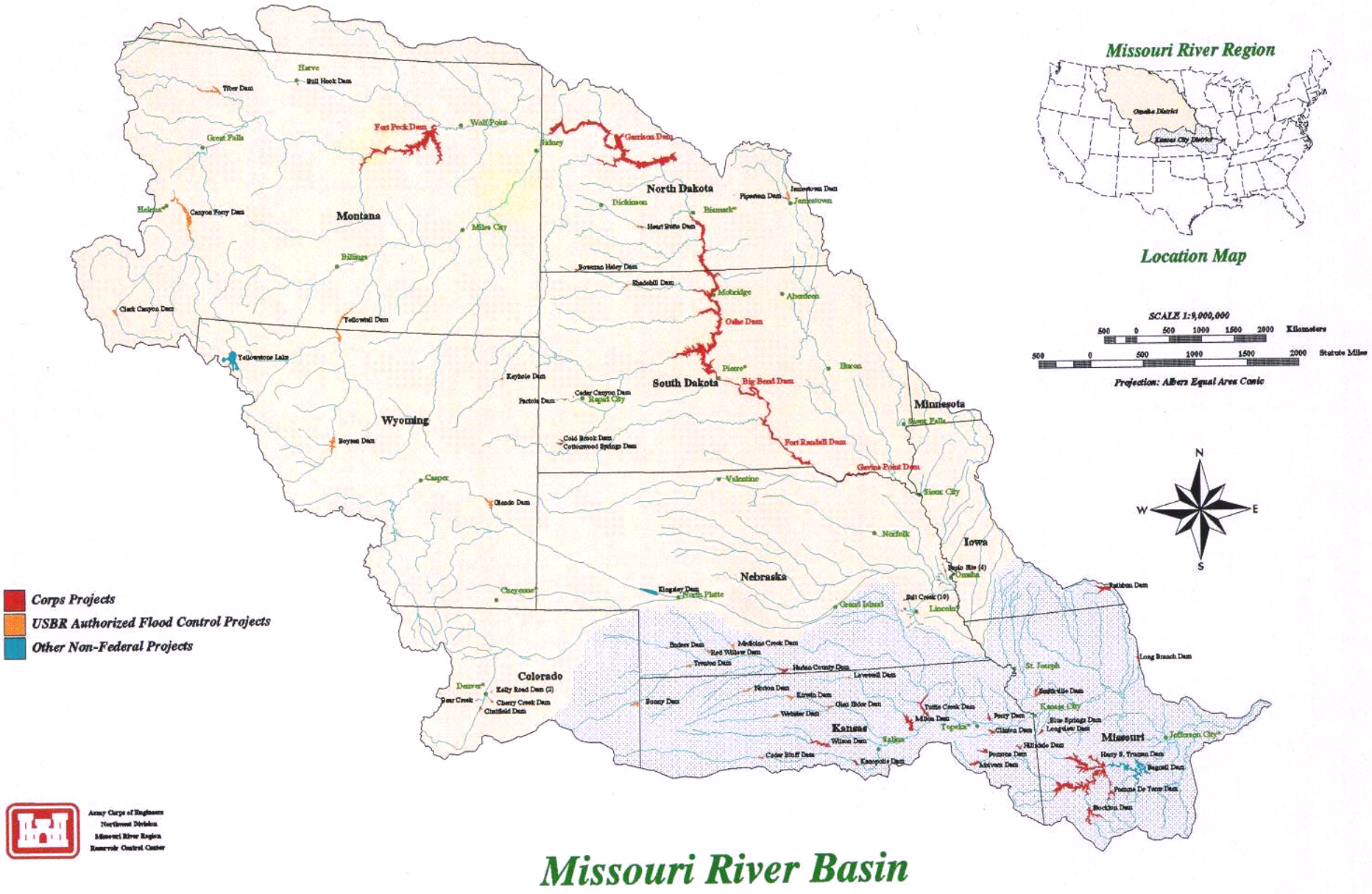
30 January 2013

US Army Corps of Engineers
BUILDING STRONG®



Army Corps of Engineers
Northwest Division
Missouri River Region
Reservoir Control Center

Missouri River Basin

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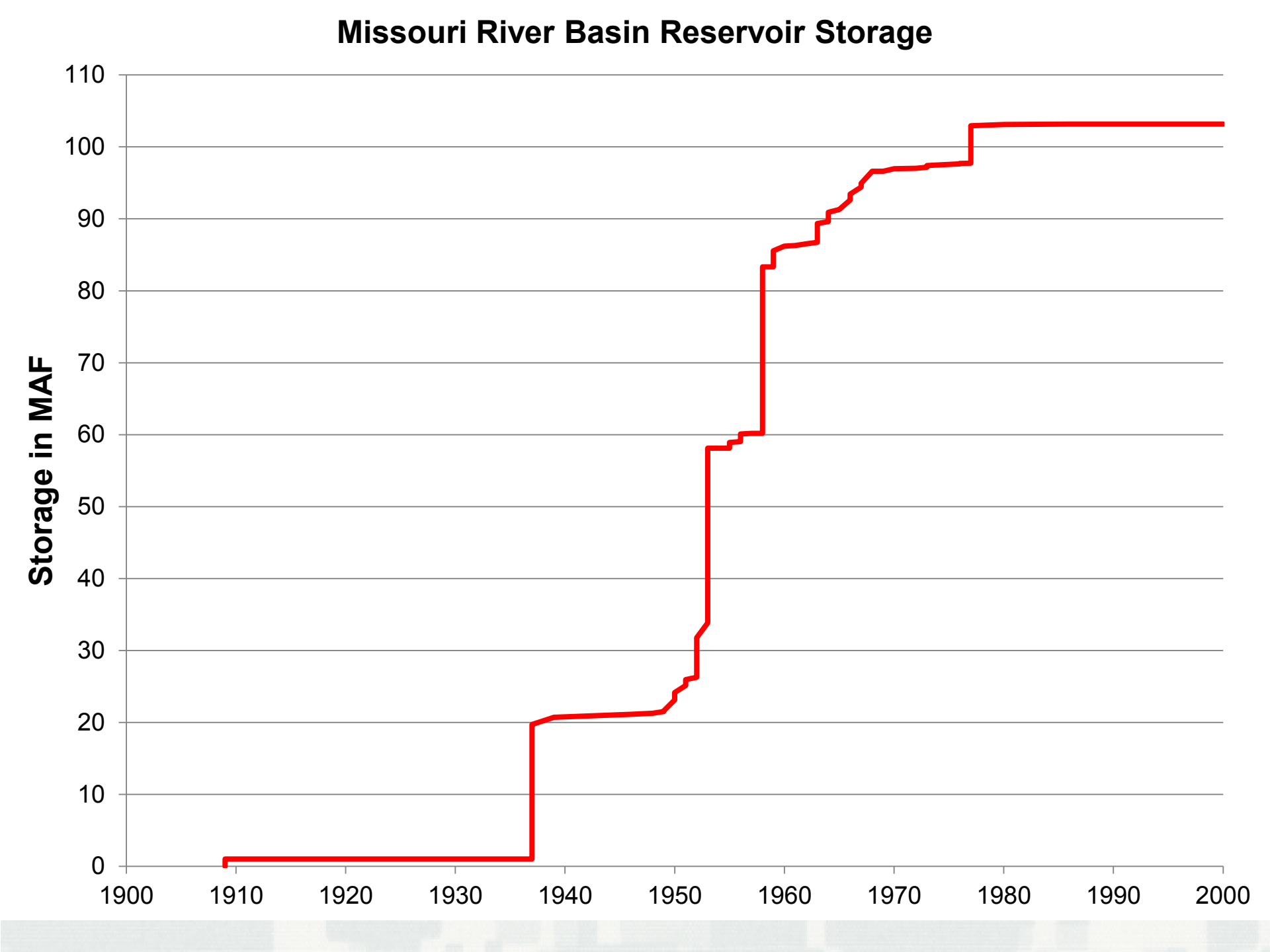
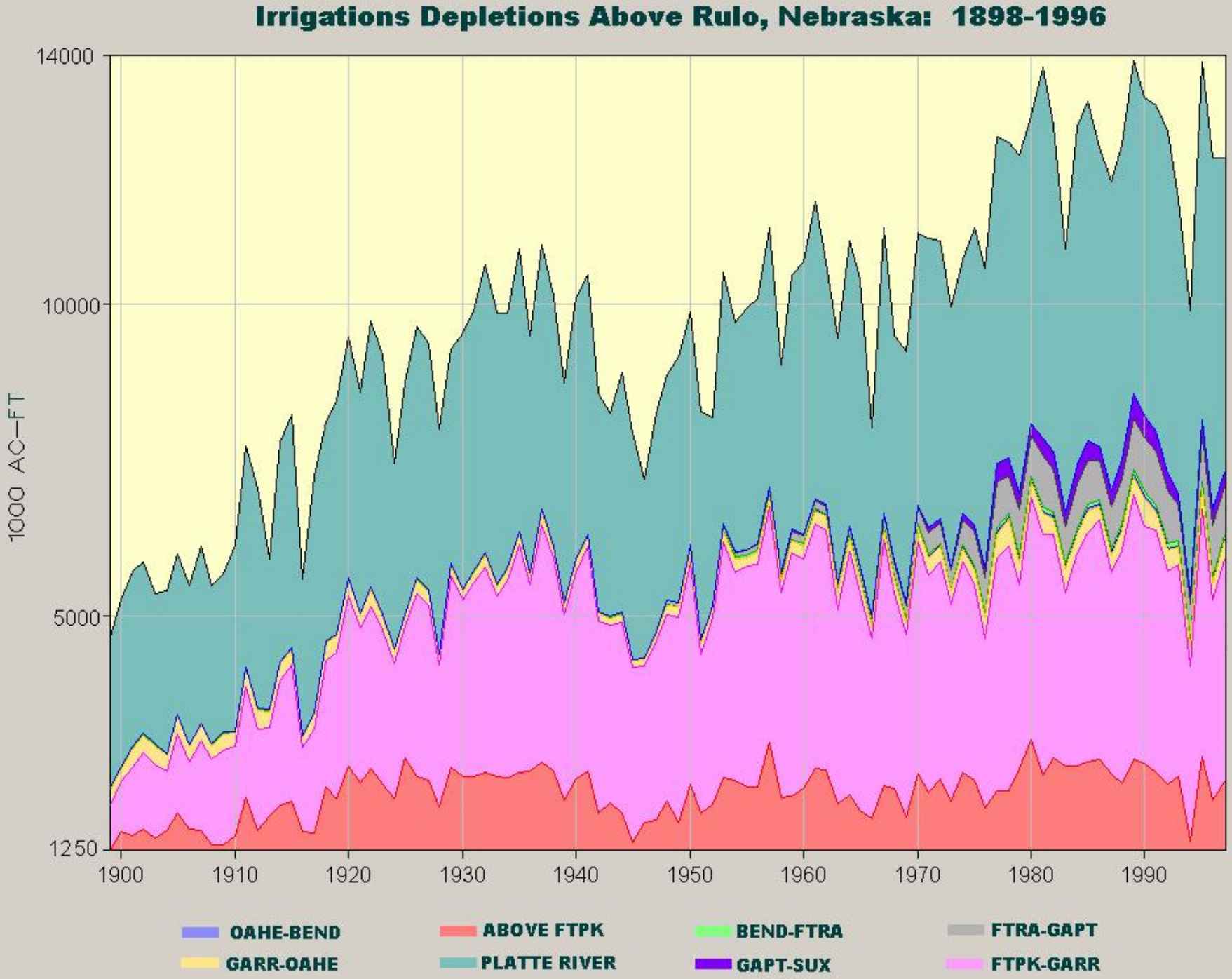
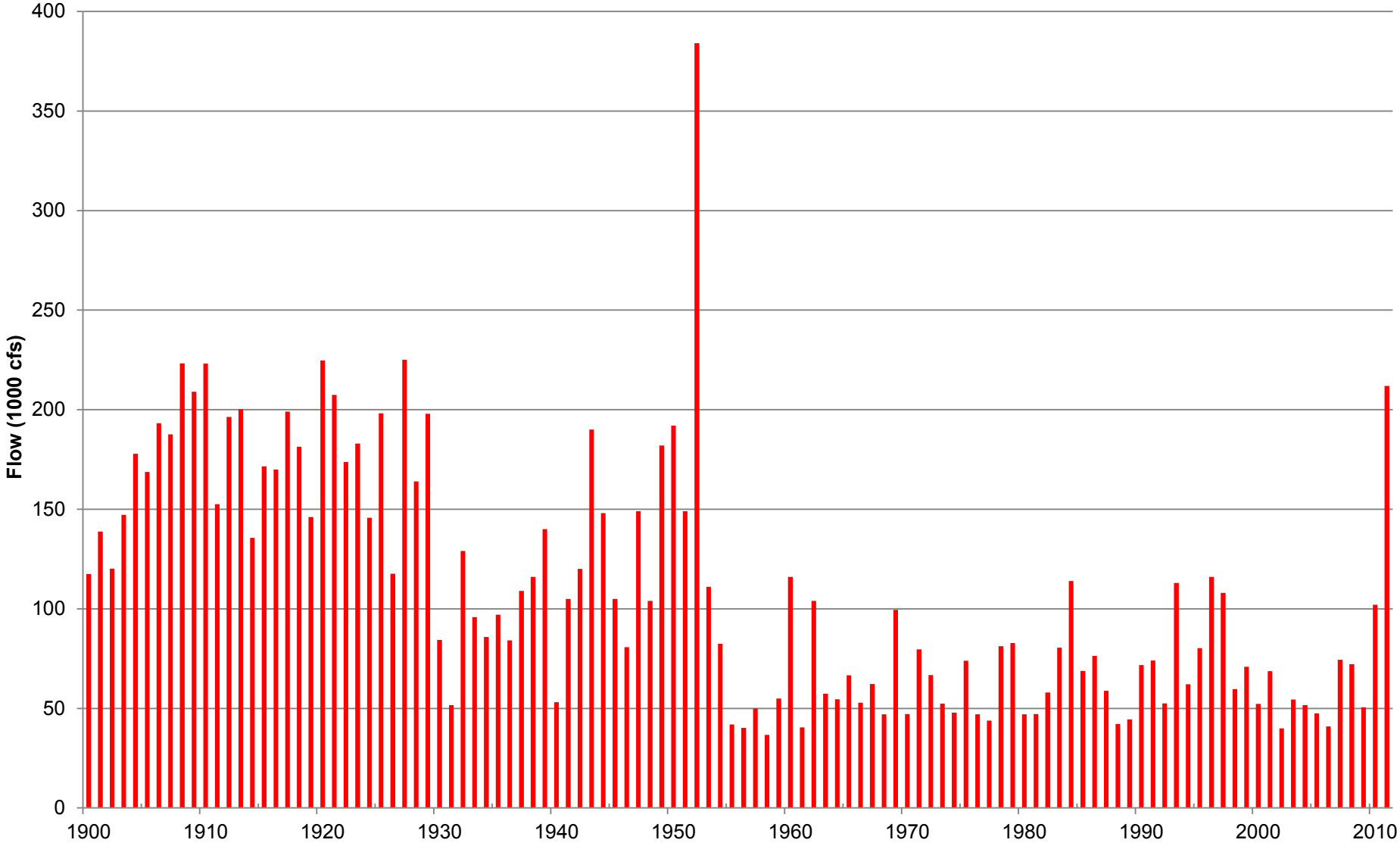
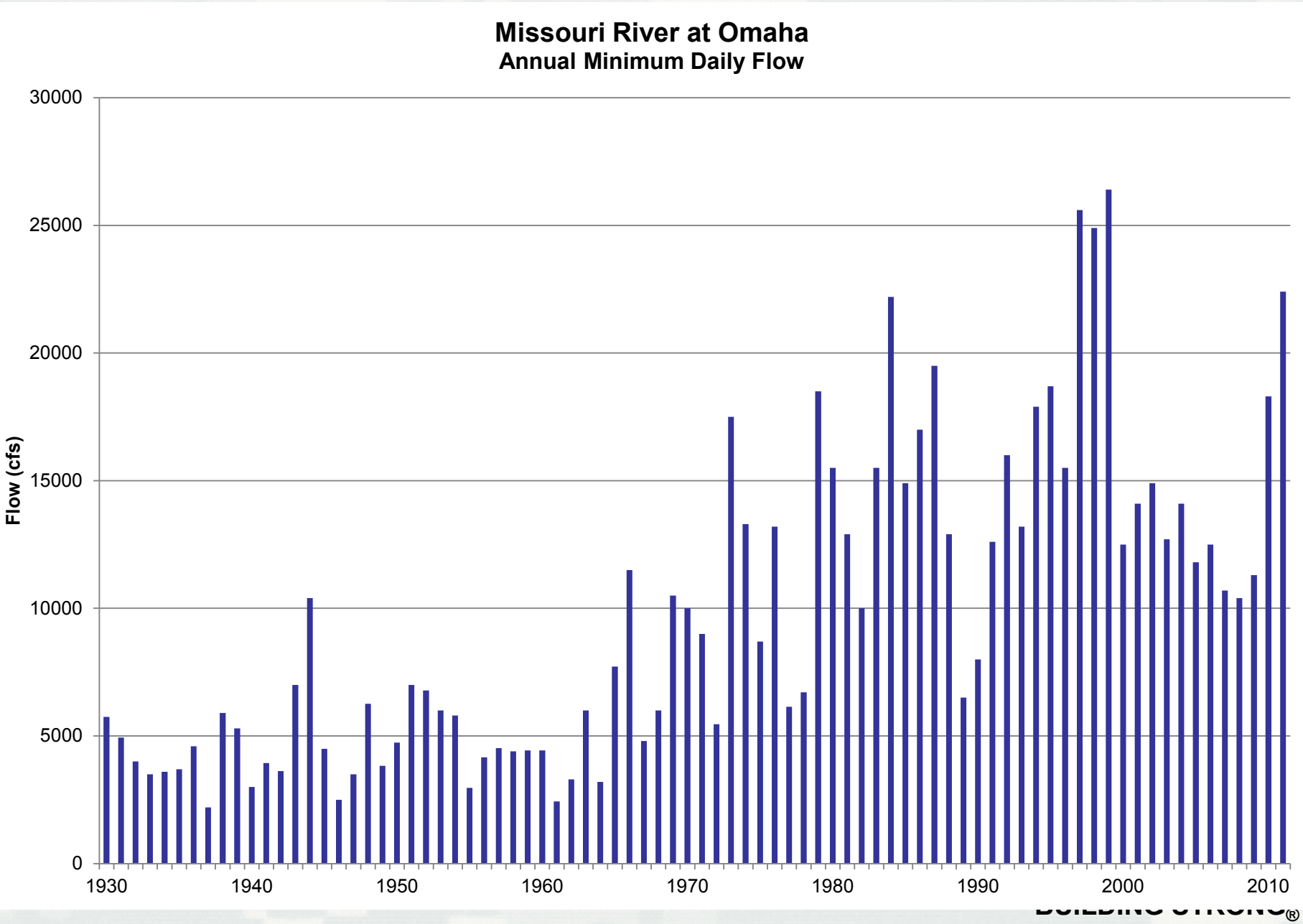

Missouri River Basin Reservoir Storage
Storage in MAF
110
100
90
80
70
60
50
40
30
20
10
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000


Irrigations Depletions Above Rulo, Nebraska: 1898-1996
14000
10000
5000
1250
1000 AC-FT
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
OAHE-BEND
ABOVE FTPK
BEND-FTRA
FTRA-GAPT
GARR-OAHE
PLATTE RIVER
GAPT-SUX
FTPK-GARR

Missouri River at Omaha
Annual Maximum Daily Flow

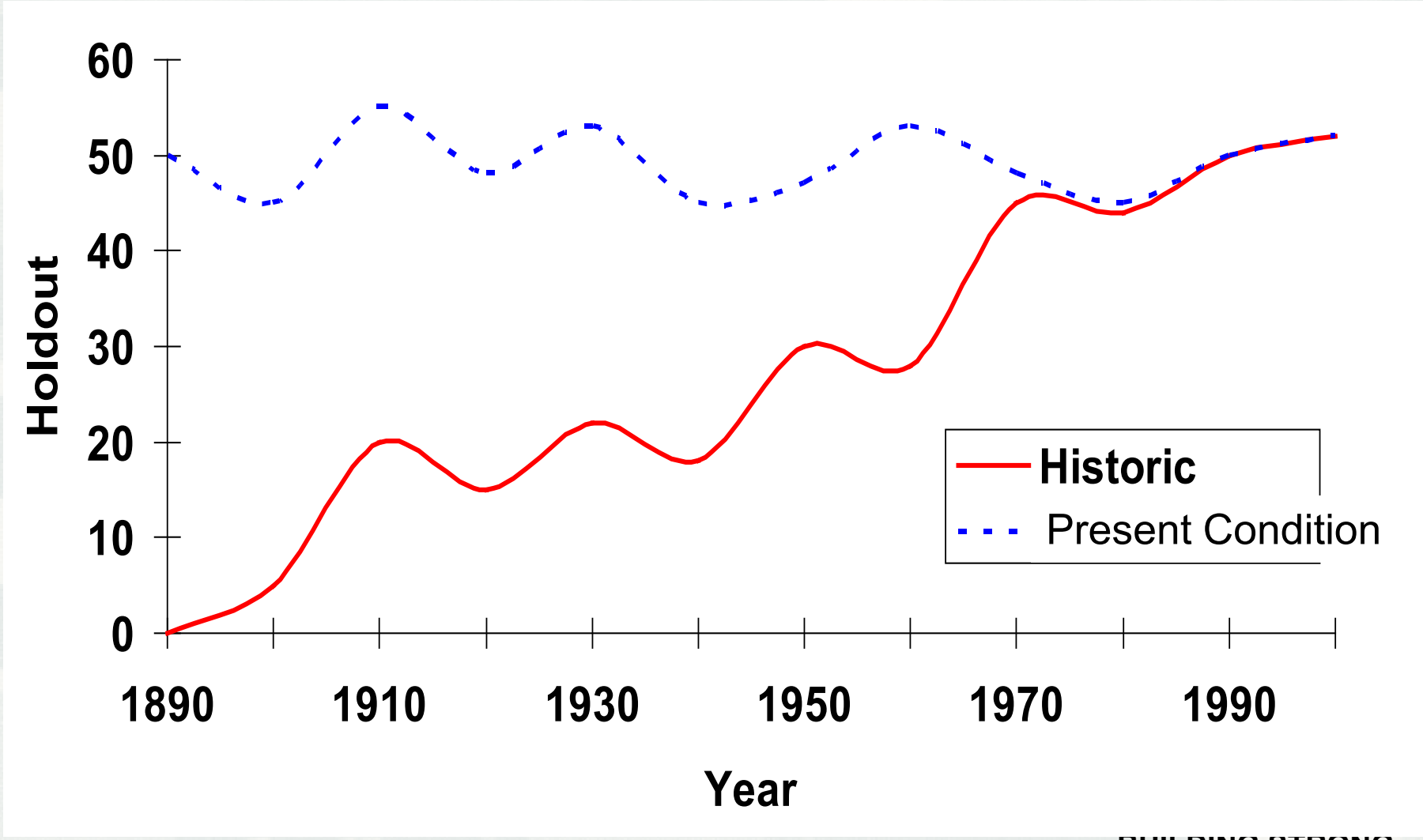


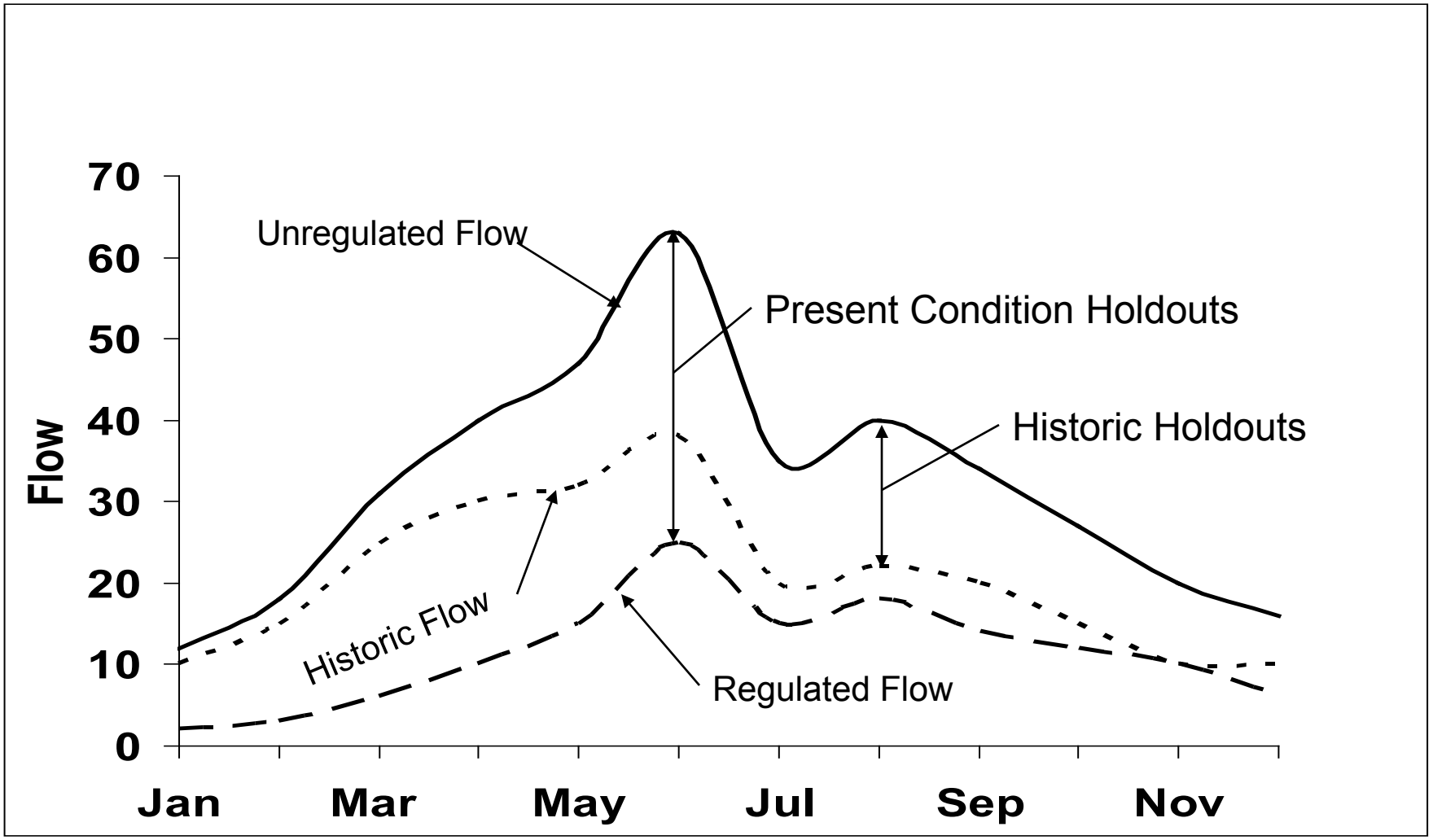


DEFINITIONS

- **Unregulated Flow** = Historic Flow + Historic Holdouts
- **Regulated Flow** = Historic Flow - (Present Condition Holdouts - Historic Holdouts)
- or, **Regulated Flow** = Natural Flow - Present Condition Holdouts
- **Holdouts** = Res Storage Change + Irrigation + M&I + GW Depletion + Reservoir Evaporation + ...

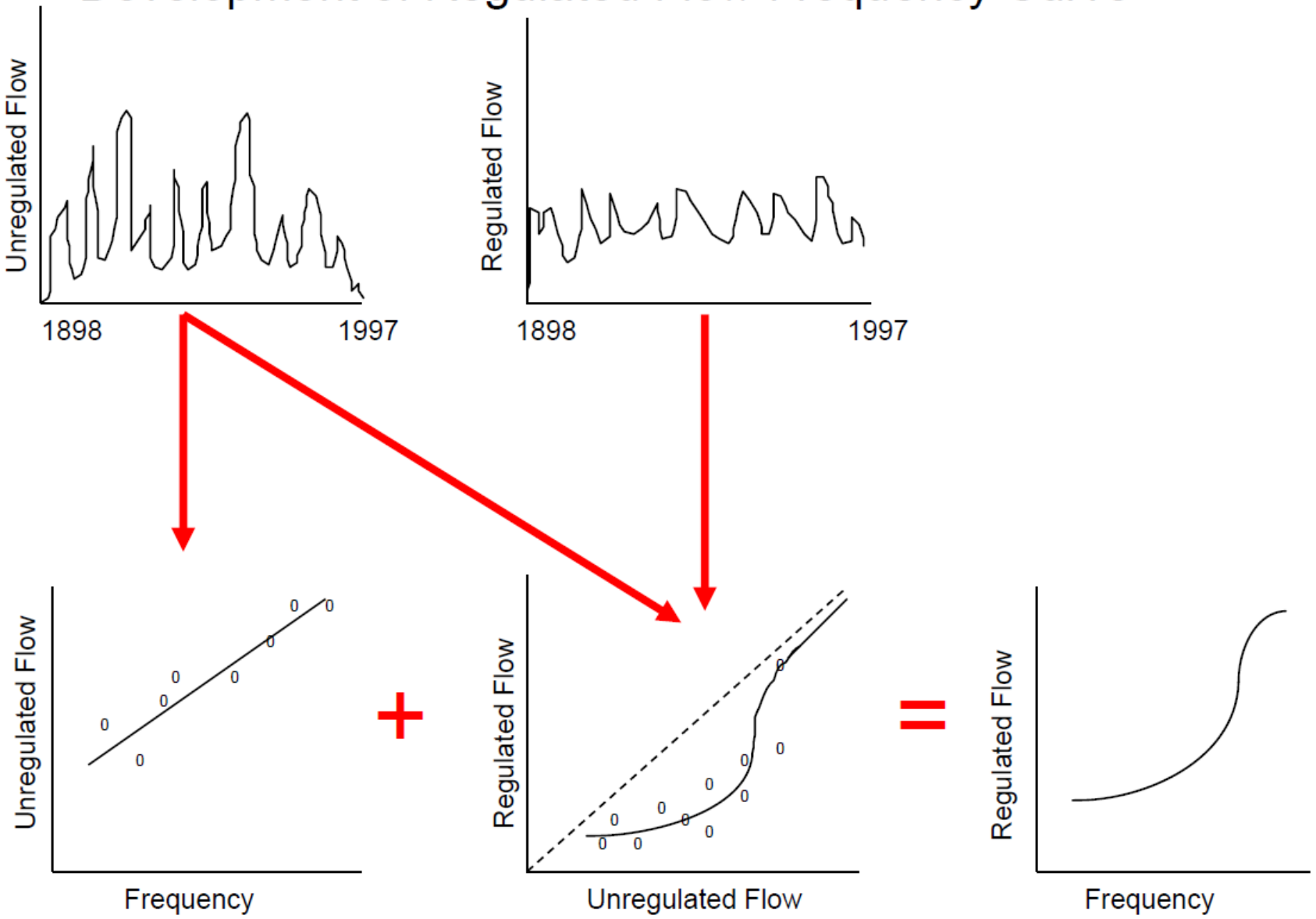
Comparison of Holdouts





Definition Sketch of Unregulated and Regulated Flow

Development of Regulated Flow Frequency Curve



METHODS

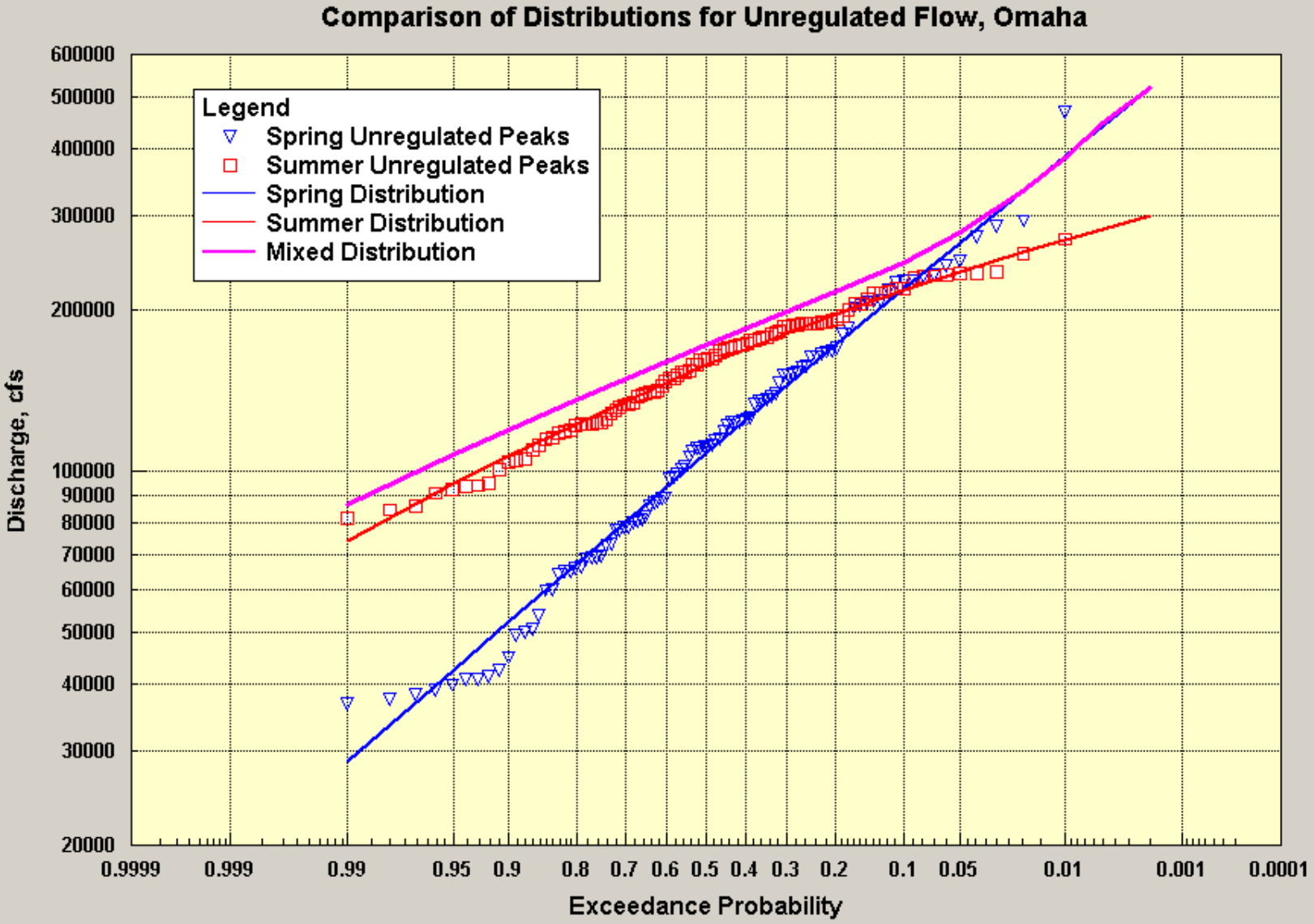
- **Unregulated Flows (Historical Holdouts)**

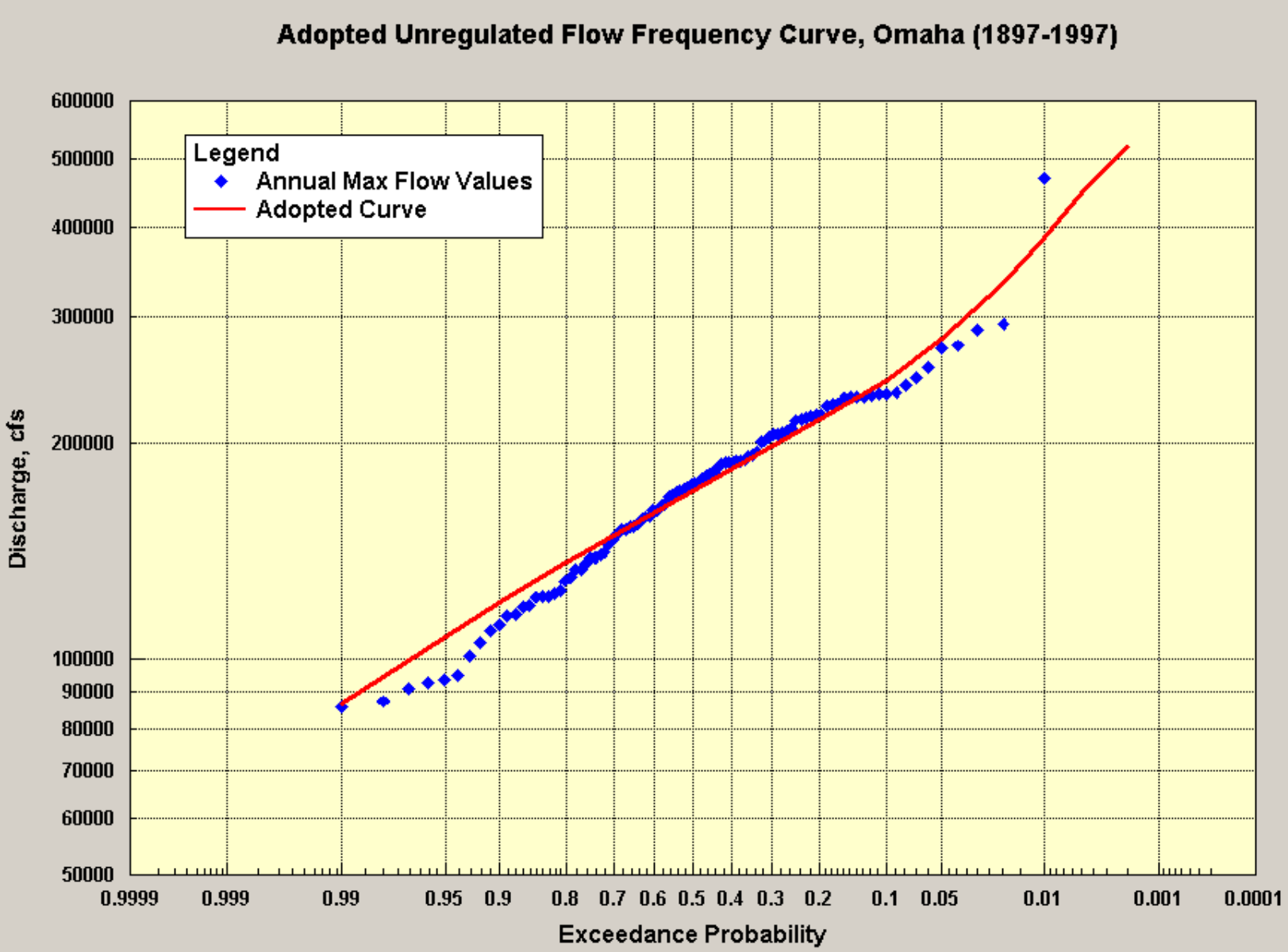
  Unregulated Flow Development Model (UFDM)

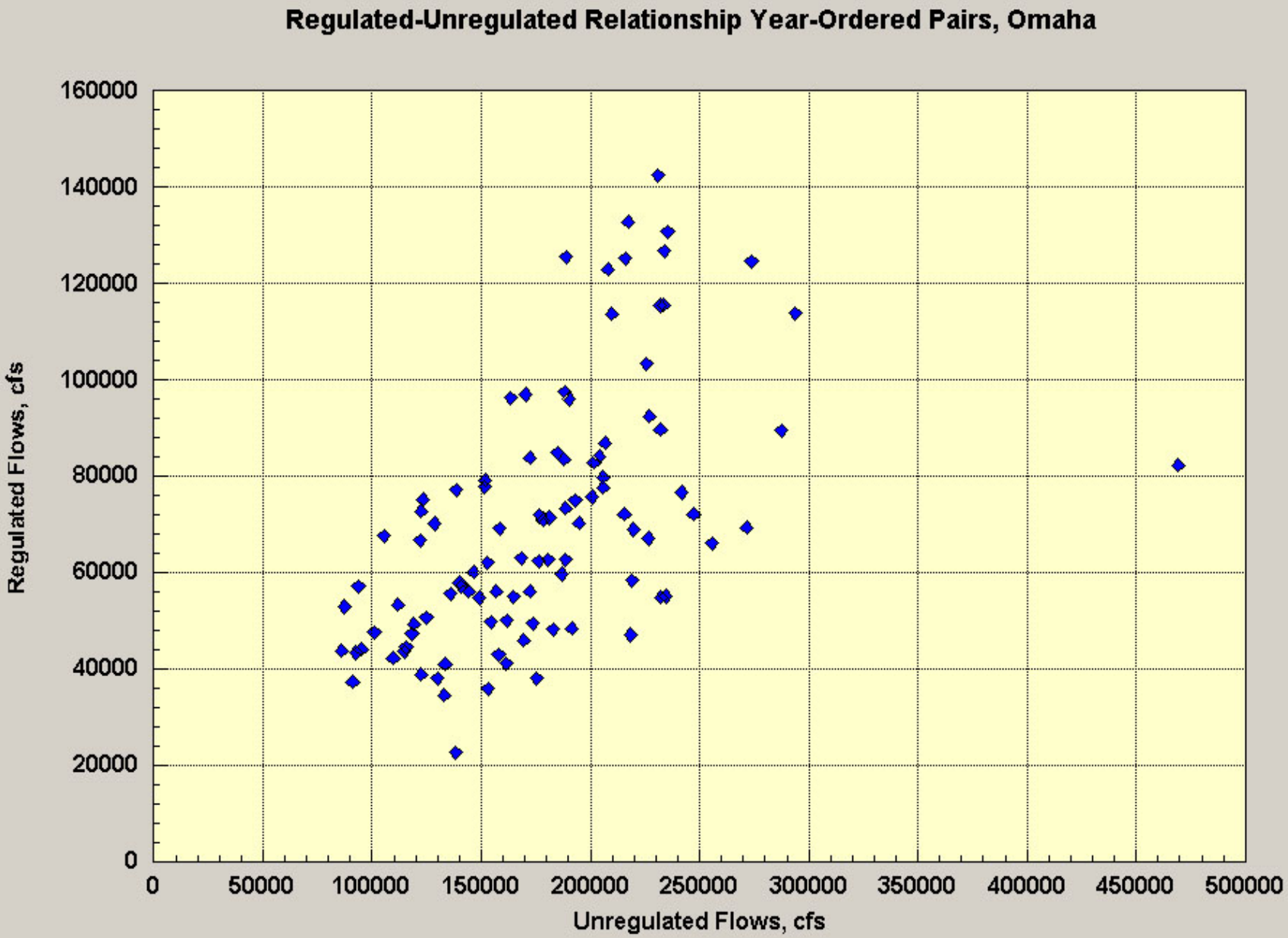
- **Regulated Flows (Present Condition Holdouts)**

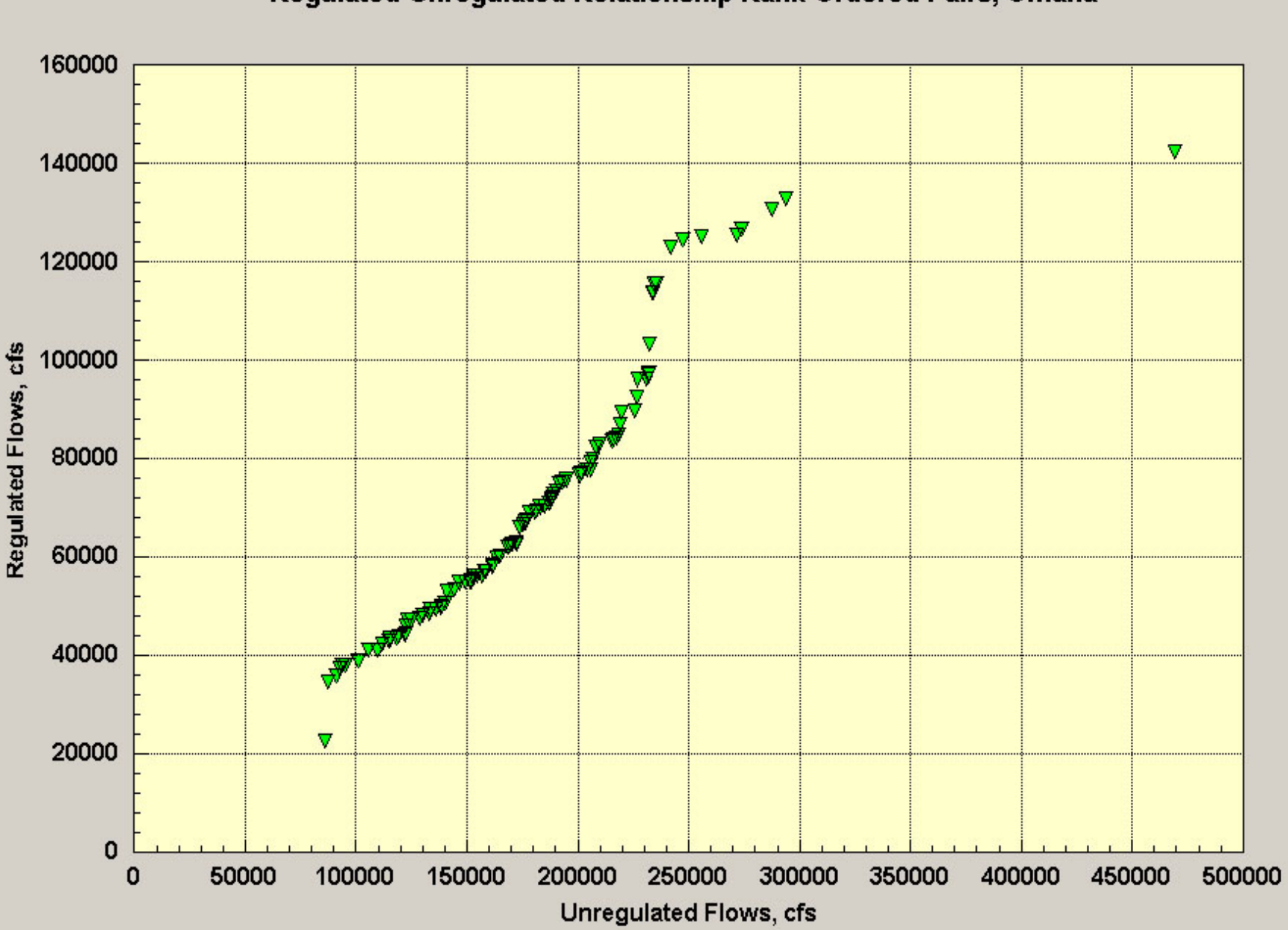
  Daily Routing Model (DFRM)

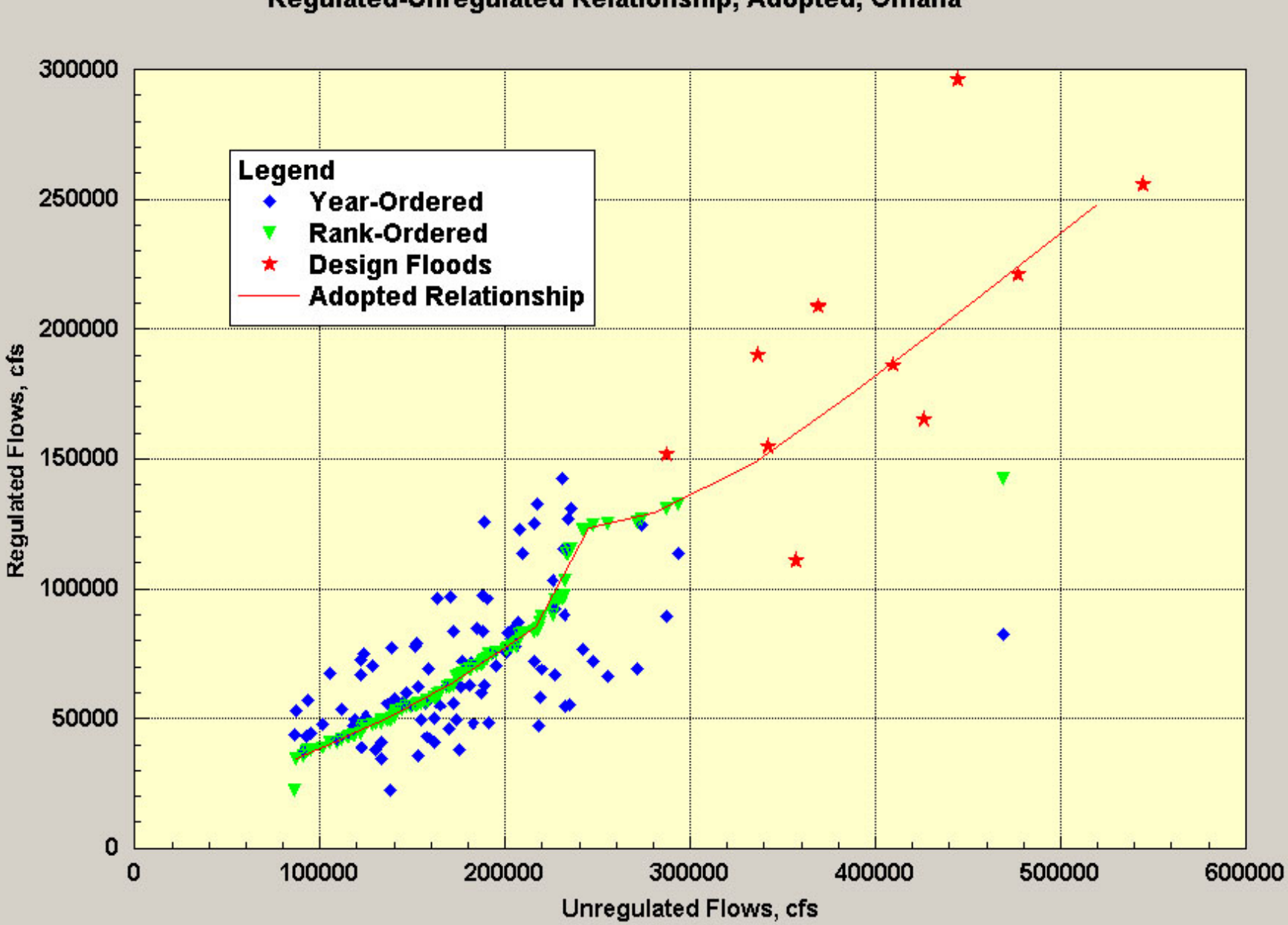
Year	Annual Peak Discharge in cfs					
	Sioux City	Sioux City	Omaha	Omaha	Neb City	Neb City
	Regulated	Unregulated	Regulated	Unregulated	Regulated	Unregulated
1898	62000	175000	63000	168400	79600	206400
1899	64100	254000	76600	241700	142000	273000
1900	49900	131400	66600	122000	69900	177600
1901	59200	150600	56100	144200	75800	182100
1902	49300	132700	50700	124800	68700	166800
1903	53700	152700	62000	152900	125200	223300
1904	57200	180400	84900	184700	74500	184000
1905	56400	239000	38000	175300	84800	244500
1906	51700	184300	75600	200800	82600	195700
1907	52700	184300	70200	194900	94000	231300
1908	64800	188000	89700	232000	107500	260200
1909	71200	174500	132800	217200	126100	236000
1910	49400	204600	115400	231900	98200	207000
1911	48100	141500	69100	158400	94400	175300
1912	62500	194500	84200	204100	181200	225900
1913	62300	200700	122900	208000	106000	205600
1914	64700	158900	57100	140900	101800	239000
1915	64100	181100	70900	178200	92700	210200
1916	65600	186900	71900	176600	86800	212300
1917	63500	201400	86900	206800	94900	223600
1918	57000	183300	73400	188500	85500	211400
1919	40400	141800	79200	151900	83400	150500
1920	40100	201100	115500	233500	133300	270300
1921	46200	180200	72100	215500	126100	296600
1922	38100	163500	62700	180500	80100	216200
1923	64400	157200	96000	190000	106300	230700
1924	61500	134800	77700	151400	125800	213200
1925	55200	173900	77600	205800	79200	218000
1926	37300	114700	72600	122300	78000	156700

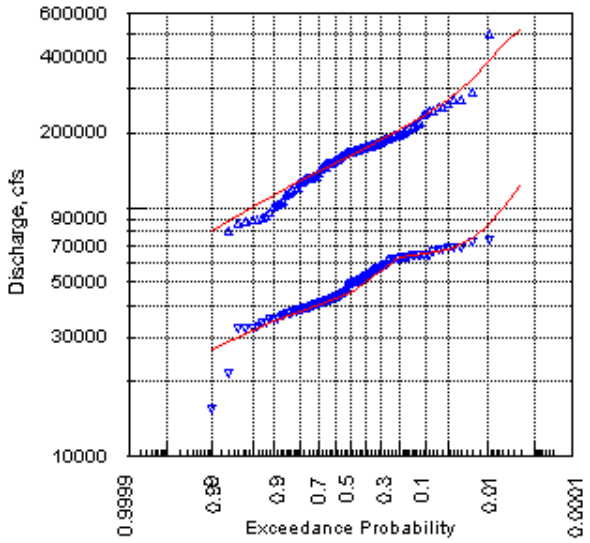

Comparison of Distributions for Unregulated Flow, Omaha
Legend
Spring Unregulated Peaks
Summer Unregulated Peaks
Spring Distribution
Summer Distribution
Mixed Distribution
Discharge, cfs
600000
500000
400000
300000
200000
100000
90000
80000
70000
60000
50000
40000
30000
20000
0.9999
0.999
0.99
0.95
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.05
0.01
0.001
0.0001
Exceedance Probability


Adopted Unregulated Flow Frequency Curve, Omaha (1897-1997)
Legend
Annual Max Flow Values
Adopted Curve
Discharge, cfs
600000
500000
400000
300000
200000
100000
90000
80000
70000
60000
50000
0.9999
0.999
0.99
0.95
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.05
0.01
0.001
0.0001
Exceedance Probability

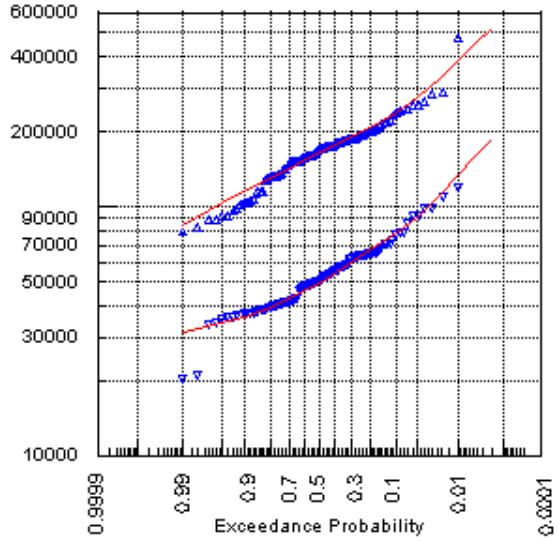

Regulated-Unregulated Relationship Year-Ordered Pairs, Omaha
Regulated Flows, cfs
160000
140000
120000
100000
80000
60000
40000
20000
0
0
50000
100000
150000
200000
250000
300000
350000
400000
450000
500000
Unregulated Flows, cfs


Regulated-Unregulated Relationship Rank-Ordered Pairs, Omaha
Regulated Flows, cfs
160000
140000
120000
100000
80000
60000
40000
20000
0
0
50000
100000
150000
200000
250000
300000
350000
400000
450000
500000
Unregulated Flows, cfs

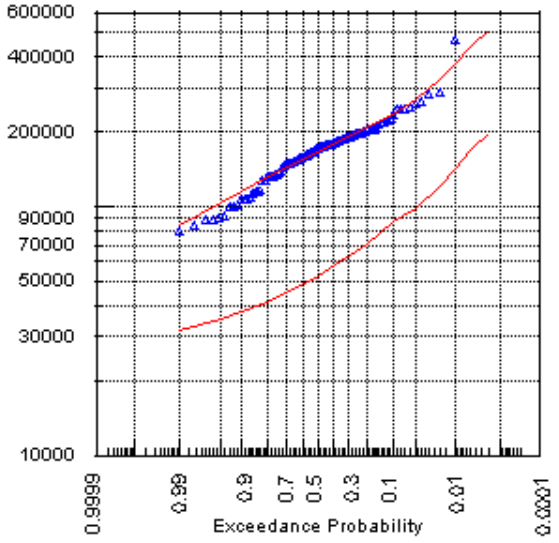

Regulated-Unregulated Relationship, Adopted, Omaha
Legend
Year-Ordered
Rank-Ordered
Design Floods
Adopted Relationship
Regulated Flows, cfs
Unregulated Flows, cfs
0
50000
100000
150000
200000
250000
300000
0
100000
200000
300000
400000
500000
600000



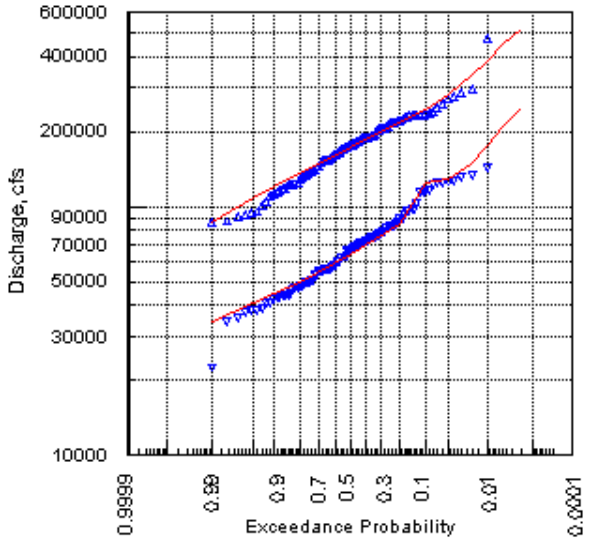
a) Yankton, South Dakota



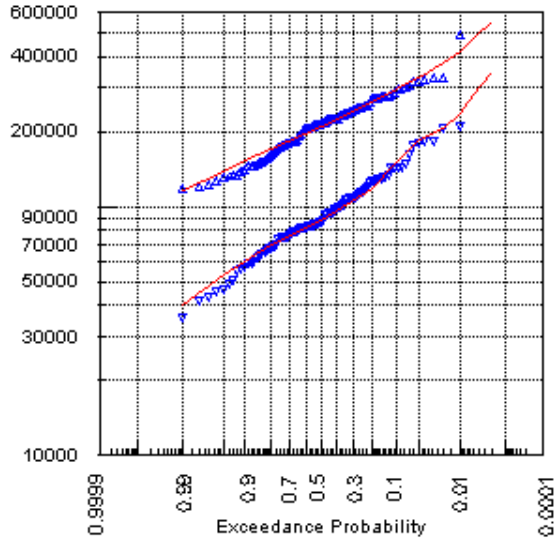
b) Sioux City, Iowa



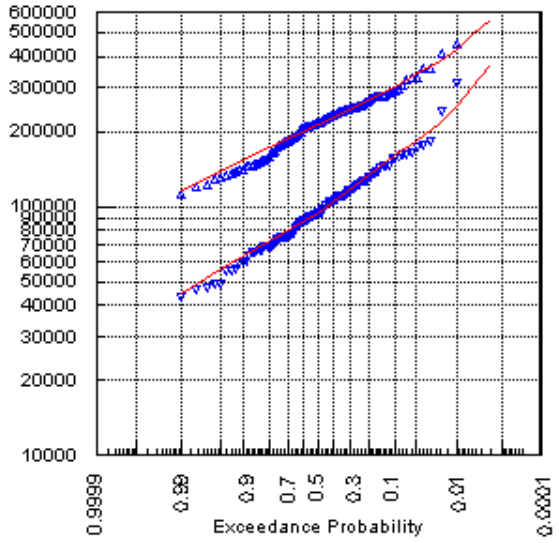
c) Decatur, Nebraska



d) Omaha, Nebraska



e) Nebraska City, Nebraska

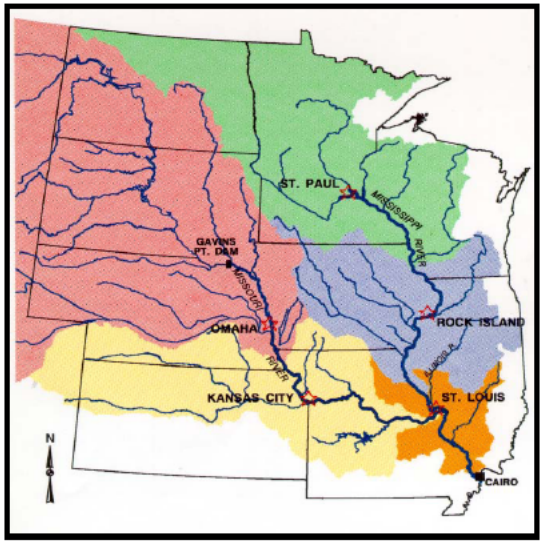


f) Rulo, Nebraska

Unregulated Flows

Regulated Flows

Upper Mississippi River System Flow Frequency Study



Final Report

January 2004

Upper Mississippi River System
Flow Frequency Study

Hydrology and Hydraulics
Appendix F
Missouri River

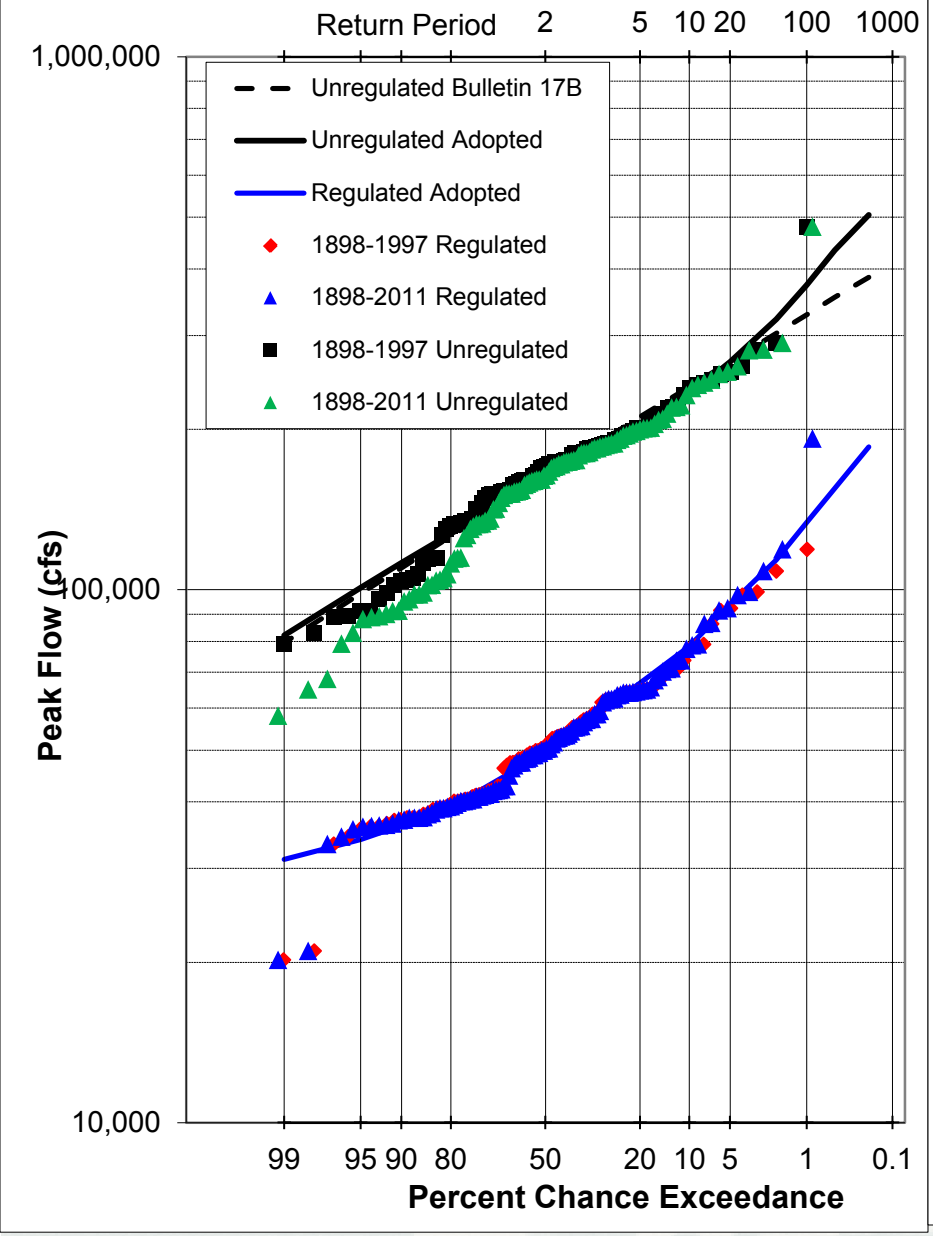
U.S. Army Corps of Engineers
Omaha District

November 2003

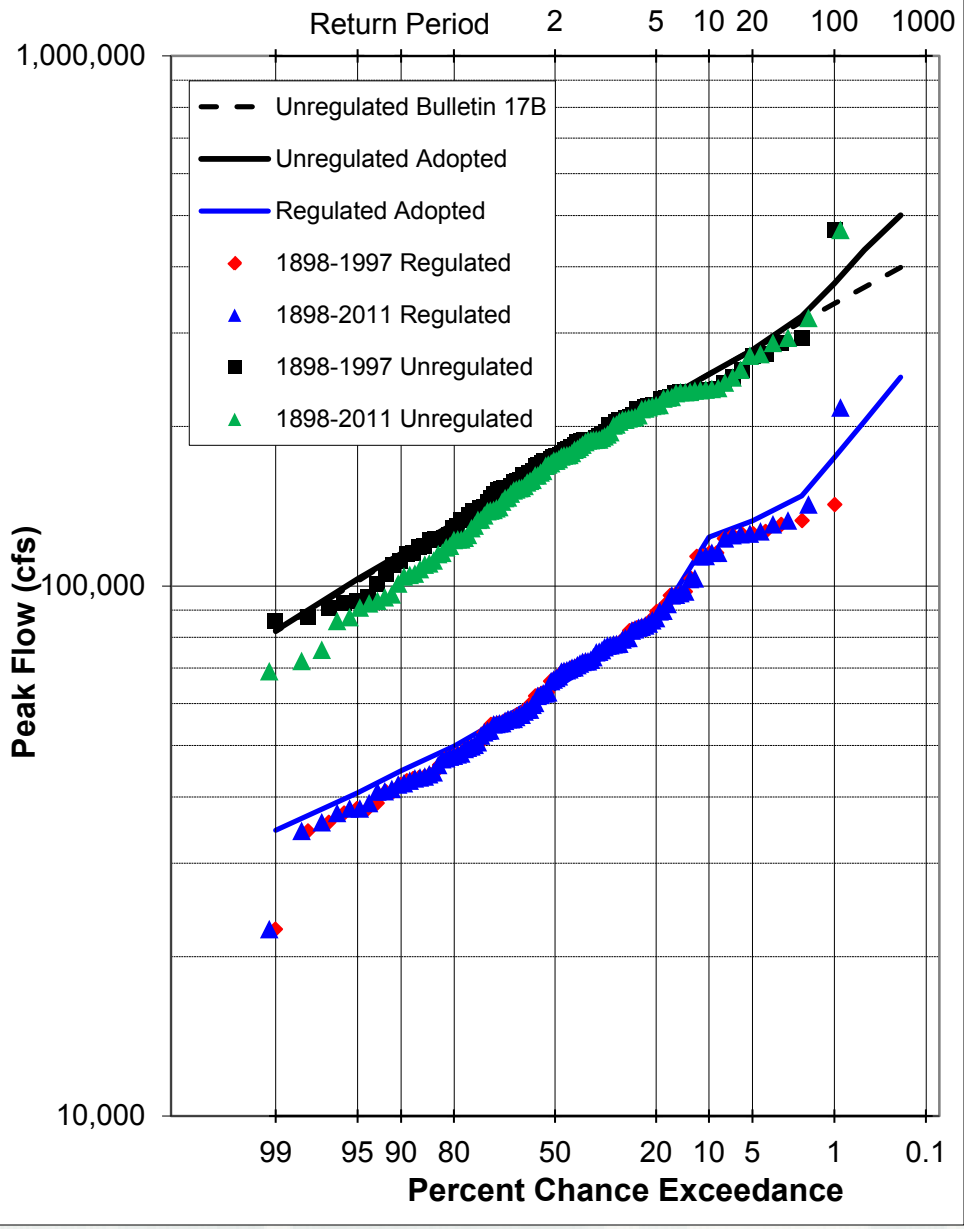
US Army Corps
of Engineers
Omaha District

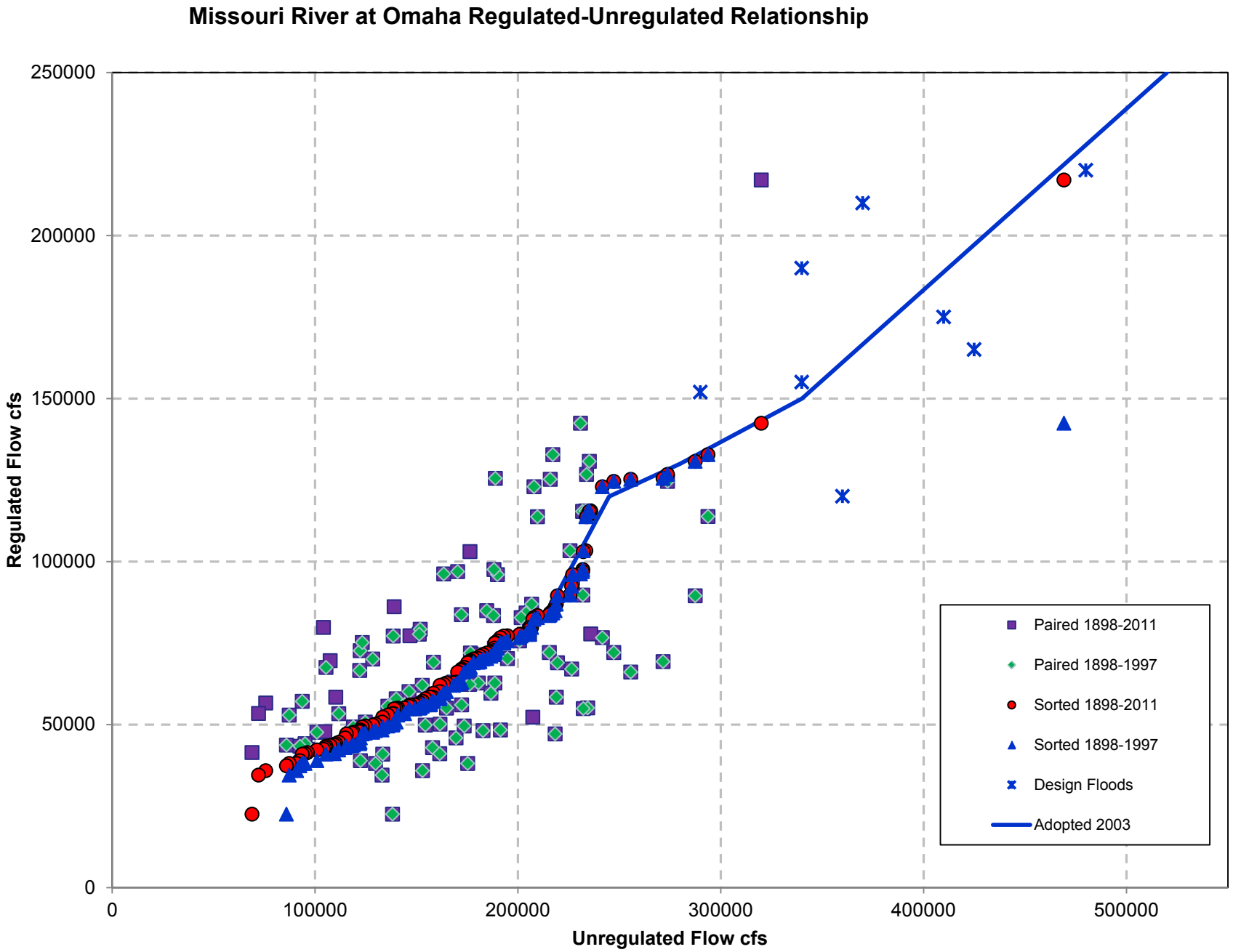
Gavins Point Dam June 16, 2011 – Release=150,000 cfs

Missouri River at Sioux City



Missouri River at Omaha




Missouri River at Omaha Regulated-Unregulated Relationship
Regulated Flow cfs
Unregulated Flow cfs
0
50000
100000
150000
200000
250000
0
100000
200000
300000
400000
500000
Paired 1898-2011
Paired 1898-1997
Sorted 1898-2011
Sorted 1898-1997
Design Floods
Adopted 2003

Questions/Discussion