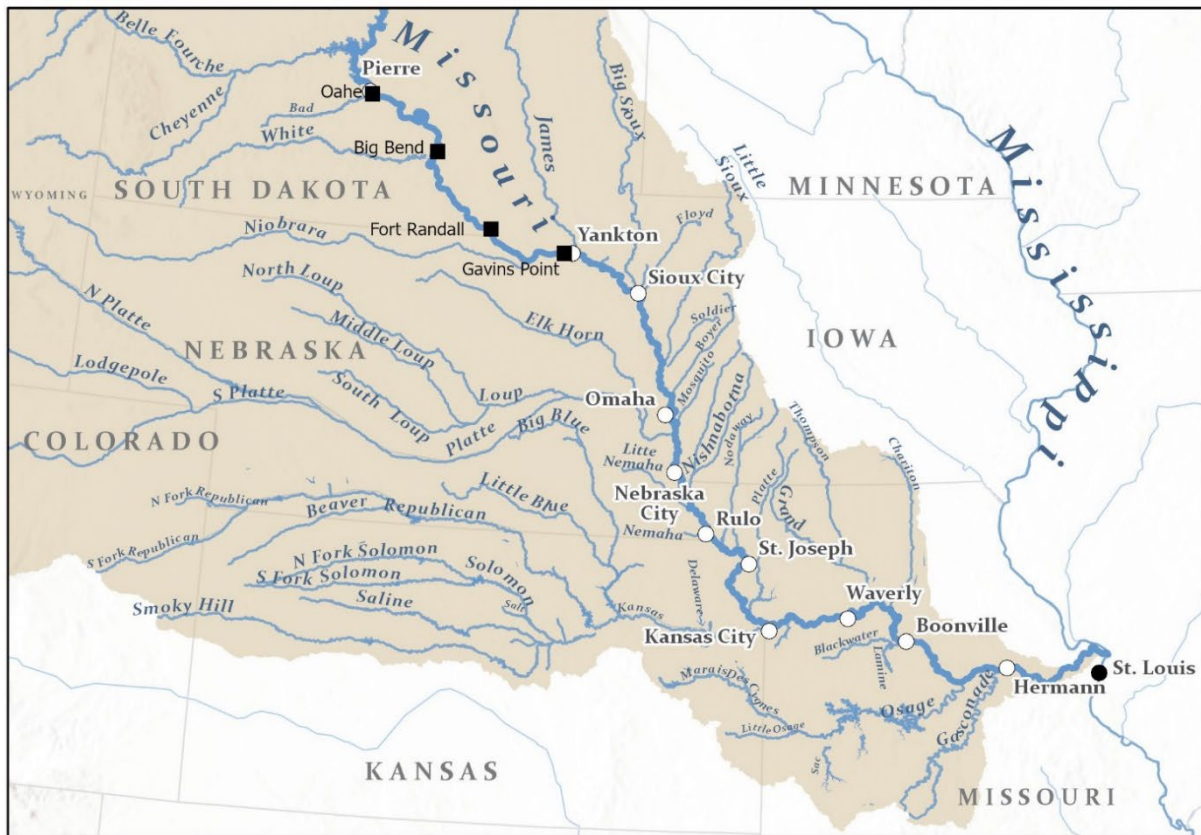# Missouri River
Flow Frequency Study
Yankton, South Dakota to Hermann, Missouri

Appendix A: Flow Frequency Datasets

U.S. Army Corps of Engineers
Northwestern Division
Omaha District, Kansas City District, and
Missouri River Basin Water Management

June 2023

Table A-1a. Seasonal Annual Peak Unregulated Flows, Omaha District Gages

Year	Unregulated Annual Peak Flows (cfs)							
	Gavins Point		Sioux City		Omaha		Nebraska City	
	Jan–Apr	May–Dec	Jan–Apr	May–Dec	Jan–Apr	May–Dec	Jan–Apr	May–Dec
1930	73,200	83,300	84,900	90,600	80,700	88,300	86,700	120,300
1931	38,800	76,400	39,100	83,200	36,100	82,400	54,700	104,800
1932	82,800	146,900	85,200	153,500	82,000	162,900	98,300	204,600
1933	81,300	125,100	83,200	124,600	97,200	121,800	100,500	147,500
1934	44,000	72,000	41,700	69,200	73,500	75,800	75,000	98,800
1935	43,100	134,400	42,400	129,700	42,300	126,300	46,200	167,700
1936	79,500	88,600	83,500	87,100	95,000	91,900	108,000	107,100
1937	61,900	137,800	62,100	138,200	73,300	136,800	75,900	147,700
1938	146,300	163,200	162,800	167,500	155,300	169,200	144,700	191,000
1939	217,700	86,900	211,400	104,800	207,400	97,600	205,100	107,000
1940	49,500	83,500	40,100	91,600	39,700	87,900	42,700	111,100
1941	41,600	152,300	43,100	158,400	42,900	154,300	48,000	158,300
1942	85,500	150,000	84,400	165,100	88,200	172,400	93,500	191,200
1943	284,200	172,300	274,400	176,100	268,500	181,800	266,500	204,000
1944	207,100	191,500	216,000	185,500	202,700	197,600	202,800	249,600
1945	120,000	104,800	145,500	127,600	140,400	124,500	144,700	169,800
1946	49,800	120,800	62,700	136,100	60,200	130,700	77,900	164,200
1947	280,500	206,500	296,300	240,200	278,500	230,800	276,400	284,700
1948	93,900	166,600	114,400	171,600	114,100	171,700	140,700	182,000
1949	192,800	100,100	198,900	101,800	195,800	107,200	207,200	133,800
1950	265,900	128,100	242,500	139,000	232,000	141,300	232,600	162,600
1951	152,000	110,000	219,800	130,100	205,900	137,700	210,600	214,300
1952	520,300	112,000	530,800	114,900	521,200	115,100	518,600	159,800
1953	70,300	236,000	80,700	233,800	80,700	238,600	94,000	263,600
1954	86,600	83,500	83,000	105,400	83,000	134,900	92,700	169,100
1955	74,200	92,500	72,900	90,100	75,400	97,200	80,900	125,900
1956	72,300	140,500	72,800	134,900	73,300	135,000	78,300	153,300
1957	37,800	142,000	39,700	145,400	41,300	156,100	49,800	238,400
1958	74,300	101,800	73,600	100,800	74,400	105,200	95,100	124,000
1959	139,000	127,800	137,500	127,900	136,100	138,000	147,000	174,400
1960	253,400	95,100	296,100	95,700	340,200	100,500	390,900	166,800
1961	30,600	104,600	33,500	105,900	47,200	116,400	56,200	146,600
1962	97,700	178,800	153,400	191,600	182,900	197,900	241,700	224,900
1963	56,300	143,700	54,600	143,500	56,900	146,900	81,200	182,400
1964	63,400	208,100	60,900	208,500	59,900	210,700	76,200	245,600
1965	113,700	167,500	124,000	174,100	130,900	174,900	141,800	227,900
1966	151,000	85,600	153,800	86,000	153,900	88,600	166,400	113,900
1967	88,300	249,900	87,900	251,200	88,500	266,900	95,100	344,100

Year	Unregulated Annual Peak Flows (cfs)							
	Gavins Point		**Sioux City**		**Omaha**		**Nebraska City**	
	Jan-Apr	**May-Dec**	**Jan-Apr**	**May-Dec**	**Jan-Apr**	**May-Dec**	**Jan-Apr**	**May-Dec**
1968	56,000	153,200	56,300	151,900	56,800	159,200	63,400	194,600
1969	162,200	148,600	228,200	150,200	254,100	160,100	261,100	185,000
1970	82,000	173,900	83,800	174,100	84,300	176,600	100,700	200,500
1971	123,400	163,900	126,600	171,500	130,700	181,400	153,000	223,700
1972	267,500	177,300	269,800	180,700	271,300	186,600	276,900	201,500
1973	61,300	132,900	76,200	127,100	90,900	126,800	109,000	163,600
1974	58,700	176,100	57,600	176,300	61,200	179,700	75,700	196,600
1975	122,000	182,500	120,400	182,300	142,700	188,400	162,500	210,400
1976	77,600	135,700	80,900	134,800	83,500	136,800	92,900	155,500
1977	53,900	96,100	54,100	96,900	55,300	105,400	65,200	124,800
1978	312,200	183,700	321,400	183,300	323,700	188,500	335,100	210,500
1979	185,000	108,700	190,500	111,400	192,700	114,800	207,100	140,500
1980	48,600	111,500	51,900	111,100	54,600	113,600	70,100	142,900
1981	37,700	142,900	37,500	137,700	39,700	145,600	45,500	162,900
1982	120,800	154,200	118,000	157,800	121,300	173,100	127,400	225,800
1983	63,600	115,800	83,600	149,100	119,100	181,900	134,200	245,900
1984	59,900	137,400	104,400	218,600	123,400	236,100	154,900	310,400
1985	56,300	79,300	69,700	80,800	81,500	85,100	111,000	119,800
1986	194,800	150,900	196,500	157,900	200,500	174,600	210,800	206,900
1987	230,300	71,500	237,000	72,700	247,300	87,900	305,300	135,300
1988	39,500	80,200	41,200	81,500	45,800	85,000	56,900	104,500
1989	76,800	94,900	76,400	94,000	78,300	98,100	83,400	117,400
1990	41,200	99,200	42,300	104,400	46,300	145,000	54,500	211,700
1991	34,800	169,300	32,800	167,200	41,000	180,500	49,500	232,700
1992	32,400	80,400	36,800	82,000	43,800	97,100	51,600	111,500
1993	94,800	130,500	110,200	179,800	130,700	211,400	195,000	309,000
1994	136,200	104,400	147,900	116,900	156,400	123,900	165,200	138,400
1995	77,700	168,500	109,000	177,700	118,300	190,600	134,600	225,900
1996	109,000	197,900	112,700	199,300	115,600	245,600	123,300	291,500
1997	267,700	193,300	288,600	199,000	294,500	215,000	301,200	250,600
1998	65,600	127,600	68,900	131,700	76,200	144,100	103,900	183,500
1999	66,300	139,800	77,400	150,000	93,800	171,200	128,700	216,400
2000	56,100	93,500	58,200	94,600	61,100	100,300	71,500	121,100
2001	107,300	68,400	125,800	82,400	131,600	93,200	150,600	127,100
2002	34,500	100,600	35,800	101,500	37,900	108,500	46,200	127,600
2003	98,200	105,100	98,900	108,100	99,800	116,200	107,200	135,600
2004	58,200	78,900	58,400	83,300	60,200	102,100	67,500	115,700
2005	27,400	118,800	31,700	120,000	37,300	126,400	51,400	151,700
2006	53,600	95,400	58,900	98,500	65,400	102,900	78,200	123,600
2007	68,200	115,900	80,400	122,500	91,900	128,600	110,500	157,200

Year	Unregulated Annual Peak Flows (cfs)							
	Gavins Point		**Sioux City**		**Omaha**		**Nebraska City**	
	Jan-Apr	**May-Dec**	**Jan-Apr**	**May-Dec**	**Jan-Apr**	**May-Dec**	**Jan-Apr**	**May-Dec**
2008	33,300	227,300	36,700	247,800	47,600	277,000	67,000	352,200
2009	210,200	114,100	215,100	118,600	215,300	131,900	227,100	161,200
2010	111,400	159,000	159,300	193,900	189,600	203,200	208,400	311,900
2011	174,500	353,500	202,000	354,500	209,200	369,600	217,800	407,800
2012	44,800	100,000	48,700	102,100	50,300	107,700	60,500	124,500
2013	53,000	155,000	54,000	161,000	59,800	171,400	71,900	194,900
2014	122,700	151,800	121,600	202,000	122,100	237,300	129,400	276,900
2015	55,800	144,700	54,100	148,000	56,800	159,000	73,700	214,300
2016	73,400	99,300	87,600	107,600	99,800	124,100	131,000	170,100
2017	75,400	125,100	80,900	131,900	87,900	138,600	103,000	174,700
2018	112,700	180,700	131,100	211,000	139,000	247,900	153,700	299,700
2019	309,500	217,100	350,900	269,500	361,700	274,100	407,800	344,200

Table A-1b. Perception Threshold Flows, cfs, Gavins Point (Yankton), Jan-Apr

Start Year	End Year	Low Threshold	High Thres	Description
1844	2019	0	inf	Total Record
1844	1871	280000	inf	Using downstream information, e.g. 1867 at Omaha, 1858 in KC, assume this value would have been detected even w/ attenuation from Yankton.
1872	1897	238000	inf	MRC stage records at Omaha start in 1872, 238000 is the Omaha 1875 flood, second largest at that gage to 1881.
1898	1929	187000	inf	187000 cfs selected for 1908 flood as the only historic event noted in the Master Manual. This was compared to 2003 UMRSFFS data.

Table A-1c. Historic Peak Flows, cfs, Gavins Point (Yankton), Jan-Apr

Year	Best	Low	High	Best Estimate and Range Source
1881	335000	335000	335000	Scaled from Fort Randall and Sioux City
1899	252600	252600	252600	2003 UMRSFFS >1908 estimate
1904	189900	189900	189900	2003 UMRSFFS >1908 estimate
1910	202100	202100	202100	2003 UMRSFFS >1908 estimate
1912	194000	194000	194000	2004 UMRSFFS >1908 estimate
1913	209600	209600	209600	2005 UMRSFFS >1908 estimate
1917	199700	199700	199700	2006 UMRSFFS >1908 estimate
1920	192800	192800	192800	2007 UMRSFFS >1908 estimate
1929	194000	194000	194000	USGS

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Table A-1d. Perception Threshold Flows, cfs, Gavins Point (Yankton), May-Dec

Start Year	End Year	Low Threshold	High Thres	Description
1872	2019	0	inf	Total Record
1872	1897	238000	inf	MRC stage records at Omaha start in 1872, 238000 is the Omaha 1875 flood, second largest at that gage to 1881.
1898	1929	187000	inf	187000 cfs selected for 1908 flood as the only historic event noted in the Master Manual. This was compared to 2003 UMRSFFS data.

Table A-1e. Historic Peak Flows, cfs, Gavins Point (Yankton), May-Dec

Year	Best	Low	High	Best Estimate and Range Source
1905	251500	251500	251500	2003 UMRSFFS >1908 estimate
1915	189700	189700	189700	2003 UMRSFFS >1908 estimate
1916	188000	188000	188000	2003 UMRSFFS >1908 estimate
1920	206800	206800	206800	2003 UMRSFFS >1908 estimate
1921	188700	188700	188700	2003 UMRSFFS >1908 estimate
1927	211300	211300	211300	2003 UMRSFFS >1908 estimate
1929	188700	188700	188700	2003 UMRSFFS >1908 estimate

Table A-1f. Perception Threshold Flows, cfs, Sioux City, Jan-Apr

Start Year	End Year	Low Threshold	High Thres	Description
1844	2019	0	inf	Total Record
1844	1871	300000	inf	KC info, 1867, 1858 floods
1872	1897	250000	inf	MRC stage data; Omaha 1875 historic peak (238,000 cfs), some attenuation possible; assumed just below 1899 flood (1962 est 258,300 cfs).
1898	1929	229000	inf	1917 flood (1962 study estimate); 2003 UMRSFFS data showed 1917 as second to 1899 (1898-1929)

Table A-1g. Historic Peak Flows, cfs, Sioux City, Jan-Apr

Year	Best	Low	High	Best Estimate and Range Source
1881	362000	362000	362000	Instantaneous Peak per 1946 DPR (daily value is 360,000)
1899	258300	258300	258300	1962 Levee Restudy (2003 UMRSFFS 254000)
1917	229000	229000	229000	1962 Levee Restudy (2003 UMRSFFS 201000)
1929	190000	190000	190000	USGS

Table A-1h. Perception Threshold Flows, cfs, Sioux City, May-Dec

Start Year	End Year	Low Threshold	High Thres	Description
1878	2019	0	inf	Total Record
1872	1897	250000	inf	MRC stage data started 1878 at Sioux City (1872 Omaha); June 1887 similar to April 1875 at Omaha at 230,000-240,000 cfs; Sioux City possibly higher due to attenuation. Assumed slightly lower than 1899.
1898	1929	229000	inf	Same as early spring, based on 1917 flood. Used 2003 UMRSFFS peaks larger than this value.

Table A-1i. Historic Peak Flows, cfs, Sioux City, May-Dec

Year	Best	Low	High	Best Estimate and Range Source
1905	252000	252000	252000	1962 Levee Restudy (2003 UMRSFFS 239,000 cfs).

Table A-1j. Perception Threshold Flows, cfs, Omaha, Jan-Apr

Start Year	End Year	Low Threshold	High Thres	Description
1843	2019	0	inf	Total Record
1843	1871	300000	inf	KC info, 1867, 1858 floods
1872	1897	230000	inf	MRC stage data; historic peaks in 1962 Levee Restudy Report
1898	1929	224700	inf	1899 flood; 2003 UMRSFFS data

Table A-1k. Historic Peak Flows, cfs, Omaha, Jan-Apr

Year	Best	Low	High	Best Estimate and Range Source
1843	360000	300000	400000	Flood at least 4' above flood stage; to as much as 0.5' below 1881 (308 report for 1844, potentially confused w/ 1843; 1881 was 7.2' above flood stage). High assumed lower than KC, and similar to 1881 as in Holt County, MO; historic RC.
1875	238000	238000	238000	1962 Levee Restudy Report
1887	230000	230000	230000	MRC stage records, hist RC.
1881	370000	370000	370000	308 Report, 1962 Report, Master Manual
1899	241700	224700	241700	2003 UMRSFFS, low from 1962 Report
1910	231900	231900	231900	2003 UMRSFFS

Table A-1l. Perception Threshold Flows, cfs, Omaha, May-Dec

Start Year	End Year	Low Threshold	High Thres	Description
1872	2019	0	inf	Total Record
1872	1897	230000	inf	MRC stage data; historic peaks in 1962 Levee Restudy Report
1898	1929	224700	inf	1899 flood (1962 Levee Restudy Report)

Table A-1m. Historic Peak Flows, cfs, Omaha, May-Dec

Year	Best	Low	High	Best Estimate and Range Source
1878	233000	233000	233000	1962 Levee Restudy Report
1908	232000	232000	232000	2003 UMRSFFS
1927	233900	233900	233900	2003 UMRSFFS
1929	198000	198000	198000	USGS

Table A-1n. Perception Threshold Flows, cfs, Nebraska City, Jan-Apr

Start Year	End Year	Low Threshold	High Thres	Description
1843	2019	0	inf	Total Record
1843	1877	300000	inf	Informed by 1867, 1858 floods at Kansas City, Omaha, and St. Joseph.
1878	1897	256000	inf	Based on 1884 flood; stage records available starting 1878.
1898	1929	256000	inf	Retained 1884 flood threshold. 2003 UMRSFFS data, peak estimates and stage data available.

Table A-1o. Historic Peak Flows, cfs, Nebraska City, Jan-Apr

Year	Best	Low	High	Best Estimate and Range Source
1843	360000	300000	430000	Assumed same as Rulo, St. Joseph
1881	400000	380000	400000	1962 Levee Report, low from 308 Report/1946 DPR
1884	256000	256000	256000	1962 Levee Report
1899	273000	273000	273000	2003 UMRSFFS, ~1962 Levee Report
1912	256400	225900	256400	1962 Levee Report, low from 2003 UMRSFFS
1917	263000	211100	315200	Avg from low of 2003 UMRSFFS, high of 1962 Levee Report

Table A-1p. Perception Threshold Flows, cfs, Nebraska City, May-Dec

Start Year	End Year	Low Threshold	High Thres	Description
1878	2019	0	inf	Total Record
1878	1897	256000	inf	Threshold based on 1884 early spring flood. Stage records available.
1898	1929	256000	inf	Retained 1884 flood threshold. 2003 UMRSFFS data, peak estimates and stage data available.

Table A-1q. Historic Peak Flows, cfs, Nebraska City, May-Dec

Year	Best	Low	High	Best Estimate and Range Source
1908	260200	260200	260200	2003 UMRSFFS
1915	237000	210200	263600	Avg from low of 2003 UMRSFFS, high of 1962 Levee Report
1916	245000	212300	276700	Avg from low of 2003 UMRSFFS, high of 1962 Levee Report
1921	296600	296600	296600	2003 UMRSFFS

Table A-2a. Annual Peak Unregulated Flows, Kansas City District Gages

Year	Unregulated Annual Peak Flows (cfs)					
	Rulo	**St. Joseph**	**Kansas City**	**Waverly**	**Boonville**	**Hermann**
1930	119,000	125,000	170,000	172,000	176,000	203,000
1931	107,000	111,000	135,000	142,000	219,000	267,000
1932	197,000	190,000	207,000	203,000	202,000	216,000
1933	150,000	150,000	150,000	157,000	161,000	200,000
1934	95,300	108,000	102,000	101,000	98,800	103,000
1935	167,000	161,000	277,000	274,000	341,000	503,000
1936	106,000	113,000	116,000	121,000	133,000	142,000
1937	146,000	149,000	155,000	157,000	173,000	228,000
1938	191,000	184,000	185,000	182,000	181,000	254,000
1939	205,000	198,000	197,000	190,000	196,000	237,000
1940	111,000	114,000	118,000	118,000	124,000	157,000
1941	159,000	171,000	286,000	278,000	279,000	289,000
1942	193,000	204,000	272,000	265,000	376,000	494,000
1943	266,000	257,000	397,000	381,000	419,000	579,000
1944	246,000	235,000	292,000	327,000	486,000	564,000
1945	182,000	192,000	275,000	271,000	298,000	404,000
1946	169,000	185,000	203,000	194,000	211,000	223,000
1947	287,000	284,000	374,000	377,000	538,000	588,000
1948	183,000	186,000	234,000	241,000	291,000	417,000
1949	205,000	199,000	237,000	228,000	239,000	291,000
1950	228,000	221,000	253,000	249,000	262,000	304,000
1951	241,000	243,000	623,000	599,000	585,000	673,000
1952	518,000	499,000	505,000	515,000	520,000	552,000
1953	259,000	255,000	250,000	256,000	255,000	256,000
1954	185,000	173,000	198,000	190,000	187,000	199,000
1955	127,000	150,000	171,000	175,000	199,000	198,000
1956	154,000	151,000	155,000	152,000	158,000	164,000
1957	246,000	250,000	271,000	269,000	269,000	308,000
1958	156,000	185,000	248,000	234,000	290,000	382,000
1959	200,000	205,000	212,000	210,000	226,000	243,000
1960	407,000	396,000	502,000	502,000	580,000	578,000
1961	151,000	152,000	189,000	204,000	265,000	421,000
1962	237,000	237,000	289,000	308,000	316,000	321,000
1963	196,000	190,000	204,000	208,000	201,000	204,000
1964	264,000	273,000	362,000	364,000	386,000	401,000
1965	260,000	311,000	374,000	383,000	397,000	428,000
1966	169,000	167,000	167,000	187,000	244,000	248,000
1967	353,000	353,000	505,000	491,000	523,000	574,000
1968	201,000	198,000	202,000	197,000	198,000	208,000

Year	Unregulated Annual Peak Flows (cfs)					
	Rulo	St. Joseph	Kansas City	Waverly	Boonville	Hermann
1969	263,000	267,000	270,000	269,000	353,000	404,000
1970	203,000	203,000	248,000	253,000	279,000	350,000
1971	228,000	231,000	250,000	249,000	249,000	273,000
1972	281,000	276,000	273,000	269,000	268,000	273,000
1973	181,000	204,000	430,000	422,000	433,000	510,000
1974	201,000	198,000	241,000	281,000	319,000	349,000
1975	217,000	216,000	265,000	260,000	278,000	326,000
1976	170,000	180,000	183,000	180,000	194,000	235,000
1977	127,000	126,000	238,000	280,000	286,000	293,000
1978	339,000	334,000	343,000	350,000	394,000	506,000
1979	241,000	260,000	341,000	335,000	392,000	417,000
1980	155,000	171,000	209,000	222,000	222,000	272,000
1981	167,000	163,000	213,000	213,000	314,000	451,000
1982	257,000	289,000	328,000	335,000	398,000	460,000
1983	250,000	253,000	302,000	295,000	359,000	521,000
1984	351,000	331,000	404,000	416,000	431,000	467,000
1985	125,000	129,000	243,000	241,000	322,000	648,000
1986	223,000	246,000	326,000	316,000	405,000	1,050,000
1987	310,000	325,000	442,000	441,000	444,000	480,000
1988	108,000	108,000	110,000	111,000	112,000	271,000
1989	131,000	173,000	242,000	237,000	259,000	253,000
1990	218,000	230,000	270,000	278,000	349,000	543,000
1991	240,000	245,000	253,000	256,000	254,000	259,000
1992	139,000	165,000	251,000	255,000	278,000	433,000
1993	416,000	454,000	722,000	802,000	902,000	955,000
1994	170,000	173,000	174,000	177,000	231,000	738,000
1995	242,000	277,000	381,000	407,000	535,000	869,000
1996	309,000	313,000	336,000	359,000	425,000	450,000
1997	308,000	301,000	300,000	307,000	376,000	424,000
1998	208,000	215,000	231,000	247,000	321,000	542,000
1999	241,000	246,000	374,000	397,000	420,000	513,000
2000	129,000	138,000	151,000	158,000	198,000	221,000
2001	161,000	158,000	265,000	269,000	394,000	513,000
2002	131,000	134,000	140,000	146,000	267,000	470,000
2003	156,000	162,000	169,000	165,000	175,000	186,000
2004	127,000	128,000	150,000	155,000	195,000	326,000
2005	157,000	160,000	254,000	269,000	310,000	363,000
2006	126,000	124,000	129,000	130,000	140,000	203,000
2007	243,000	231,000	419,000	412,000	503,000	571,000
2008	385,000	395,000	450,000	458,000	510,000	594,000

Year	Unregulated Annual Peak Flows (cfs)					
	Rulo	St. Joseph	Kansas City	Waverly	Boonville	Hermann
2009	228,000	226,000	275,000	283,000	384,000	466,000
2010	362,000	350,000	408,000	413,000	466,000	512,000
2011	479,000	453,000	446,000	442,000	493,000	475,000
2012	131,000	134,000	141,000	141,000	147,000	256,000
2013	206,000	215,000	282,000	323,000	484,000	586,000
2014	280,000	272,000	281,000	278,000	311,000	333,000
2015	244,000	254,000	344,000	407,000	422,000	683,000
2016	184,000	185,000	348,000	414,000	410,000	479,000
2017	190,000	198,000	264,000	268,000	309,000	701,000
2018	314,000	308,000	316,000	316,000	311,000	328,000
2019	405,000	426,000	520,000	539,000	588,000	698,000

Table A-2b. Unregulated Flow (cfs) Perception Thresholds, Kansas City Final

Start Year	End Year	Low Threshold	High Thres	Description
1844	2019	0	inf	Total Record
1844	1867	300000	inf	1858 biggest since 1844 (Chanute 1870)
1868	1869	300000	inf	Bridge stage information
1870	1872	300000	inf	No gaging
1873	1897	300000	inf	MRC and NWS stages
1898	1929	300000	inf	2003 UMRSFFS data

Table A-2c. Historic Peak Flows, Kansas City Final Curve

Year	Best	Low	High	Best Estimate and Range Source
1844	625000	575000	700000	USGS Web, range -8%/+12%; upper range also informed by coincident flows using peak estimates and the 1993 flood shape
1858	301000	280000	350000	Historic RC, stage from Chanute 1870, range from uncertainty w/ rating
1881	373000	350000	400000	USGS Web, ranges +/- ~6-7%
1883	271000	250000	300000	Historic RC, observed stage, range similar to 1892 (+/-12% either event)
1892	283000	250000	300000	Historic RC, observed stage, range similar to 1883 (+/-12% either event)
1903	548000	531000	574000	USGS Web, Range from 2003 UMRSFFS
1908	428000	386000	428000	2003 UMRSFFS, low UMRSFFS stage record
1909	361000	304000	361000	2003 UMRSFFS, low UMRSFFS stage record
1915	408000	357000	408000	2003 UMRSFFS, low UMRSFFS stage record
1917	351000	297000	351000	2003 UMRSFFS, low UMRSFFS stage record

Table A-2d. Unregulated Flow (cfs) Perception Thresholds, Waverly Final

Start Year	End Year	Low Threshold	High Thres	Description
1844	2019	0	inf	Total Record
1844	1883	375000	inf	Scaled between KC and Boon
1884	1897	315000	inf	Stage records
1898	1929	315000	inf	UMRSFFS data

Table A-2e. Historic Peak Flows, Waverly Final Curve

Year	Best	Low	High	Best Estimate and Range Source
1844	640000	600000	700000	Scale from Kansas City, Boonville, range +6% to +9% (nearest 100kcfs)
1881	370000	340000	400000	Scale from Kansas City, Boonville, range +/-8%
1903	560000	554000	600000	Scale from Kansas City, Boonville, kept the low above the Kansas City flow, high +7%
1908	425000	410000	425000	2003 UMRSFFS UNREG (low no depletions)
1909	358000	329000	358000	2003 UMRSFFS UNREG (low no depletions)
1915	424000	270000	424000	2003 UMRSFFS, low UMRSFFS stage record
1917	350000	219000	350000	2003 UMRSFFS, low UMRSFFS stage record

Table A-2f. Unregulated Flow (cfs) Perception Thresholds, Boonville Final

Start Year	End Year	Low Threshold	High Thres	Description
1844	2019	0	inf	Total Record
1844	1872	353000	inf	events in 1851, 1858
1873	1929	330000	inf	Stage records, threshold around 1904-1905

Table A-2g. Historic Peak Flows, Boonville Final Curve

Year	Best	Low	High	Best Estimate and Range Source
1844	710000	625000	795000	USGS web, 308 Report, 1946 DPR, +/-12%
1851	428000	390000	520000	Avg 6' & 8' below 1844 from Historic RC; range 8' below to +20%
1858	353000	315000	520000	Avg 8' & 10' below 1844 Historic RC, low 10' below (>KC, ~Chappell), high same as 1851
1881	363000	320000	400000	1946 DPR, range -12% to +10% (Hist RC info)
1883	338000	320000	400000	Historic RC, known stage similar to 1881, 1892
1892	334000	320000	400000	Historic RC, known stage similar to 1881, 1892
1903	591000	521000	649000	USGS web, low UMRSFFS stage, high +10%
1908	435000	403000	435000	2003 UMRSFFS, low UMRSFFS stage record
1909	454000	407000	454000	2003 UMRSFFS, low UMRSFFS stage record
1915	403000	341000	403000	2003 UMRSFFS, low UMRSFFS stage record
1917	383000	301000	383000	2003 UMRSFFS, low UMRSFFS stage record

1927	399000	381000	399000	2003 UMRSFFS, low USGS peak
1928	349000	224000	349000	2003 UMRSFFS, low USGS peak
1929	387000	344000	387000	2003 UMRSFFS, low USGS peak

Table A-2h. Unregulated Flow (cfs) Perception Thresholds, Hermann Final

Start Year	End Year	Low Threshold	High Thres	Description
1844	2019	0	inf	Total Record
1844	1872	500000	inf	Pre-stage records, floods of 1851 and 1858
1873	1897	350000	inf	Stage Records, floods of 1881, 1883, 1892
1898	1929	350000	inf	UMRSFFS Data, assumed as 1873-1897

Table A-2i.   Historic Peak Flows, Hermann Final Curve

Year	Best	Low	High	Best Estimate and Range Source
1844	800000	700000	900000	Midpoint of published estimates +/-12%
1851	595000	550000	650000	Avg 6-8' below 1844 w/ Historic RC ~+/-9%
1858	595000	550000	650000	Avg 6-8' below 1844 w/ Historic RC ~+/-9%
1881	390000	320000	444000	Historic RC, observed stage
1883	420000	350000	470000	Historic RC, observed stage
1892	430000	365000	500000	Historic RC, observed stage, Flow Meas
1903	676000	573000	720000	USGS Web, range from 2003 UMRSFFS
1904	407000	327000	407000	2003 UMRSFFS, low UMRSFFS stage record
1905	470000	396000	470000	2003 UMRSFFS, low UMRSFFS stage record
1908	455000	375000	455000	2003 UMRSFFS, low UMRSFFS stage record
1909	501000	432000	501000	2003 UMRSFFS, low UMRSFFS stage record
1912	370000	283000	370000	2003 UMRSFFS, low UMRSFFS stage record
1915	487000	421000	487000	2003 UMRSFFS, low UMRSFFS stage record
1917	460000	364000	460000	2003 UMRSFFS, low UMRSFFS stage record
1922	433000	364000	433000	2003 UMRSFFS, low UMRSFFS stage record
1924	376000	252000	376000	2003 UMRSFFS, low UMRSFFS stage record
1927	496000	468000	496000	2003 UMRSFFS, low UMRSFFS stage record
1928	443000	327000	443000	2003 UMRSFFS, low UMRSFFS stage record
1929	450000	407000	450000	2003 UMRSFFS, low UMRSFFS stage record

Table A-3a. Seasonal Annual Peak Unregulated Flows, Kansas City District Gages

Year	Unregulated Annual Peak Flows (cfs)			
	Jan–Apr		May–Dec	
	Rulo	St. Joseph	Rulo	St. Joseph
1930	81,000	84,400	120,000	125,000
1931	51,100	46,600	108,000	111,000
1932	96,600	94,000	198,000	190,000
1933	97,900	97,200	150,000	150,000
1934	64,400	74,700	95,600	108,000
1935	48,100	49,800	168,000	161,000
1936	102,000	109,000	106,000	113,000
1937	74,700	70,200	146,000	149,000
1938	144,000	136,000	192,000	184,000
1939	206,000	198,000	106,000	115,000
1940	43,400	42,200	112,000	114,000
1941	49,700	51,100	160,000	171,000
1942	89,800	91,800	194,000	204,000
1943	267,000	257,000	206,000	214,000
1944	202,000	196,000	246,000	235,000
1945	146,000	165,000	183,000	192,000
1946	72,600	81,900	170,000	185,000
1947	275,000	273,000	287,000	284,000
1948	147,000	180,000	184,000	186,000
1949	206,000	199,000	150,000	188,000
1950	229,000	221,000	181,000	169,000
1951	213,000	203,000	241,000	243,000
1952	519,000	499,000	172,000	173,000
1953	94,900	88,000	260,000	255,000
1954	91,200	87,400	186,000	173,000
1955	82,500	86,400	128,000	150,000
1956	79,000	77,000	155,000	151,000
1957	54,400	58,900	247,000	250,000
1958	98,600	98,600	156,000	185,000
1959	150,000	149,000	200,000	205,000
1960	409,000	396,000	172,000	175,000
1961	64,000	74,100	151,000	152,000
1962	237,000	227,000	238,000	237,000
1963	109,000	116,000	197,000	190,000
1964	76,300	77,500	265,000	273,000
1965	143,000	150,000	261,000	311,000
1966	170,000	167,000	119,000	121,000
1967	95,500	95,900	354,000	353,000
1968	65,500	64,000	202,000	198,000

Year	Unregulated Annual Peak Flows (cfs)			
	Jan–Apr		May–Dec	
	Rulo	St. Joseph	Rulo	St. Joseph
1969	263,000	267,000	218,000	222,000
1970	102,000	102,000	203,000	203,000
1971	162,000	157,000	229,000	231,000
1972	282,000	276,000	209,000	206,000
1973	136,000	173,000	181,000	179,000
1974	79,500	91,600	202,000	204,000
1975	175,000	172,000	217,000	216,000
1976	94,900	105,000	171,000	180,000
1977	65,700	65,300	128,000	126,000
1978	340,000	334,000	223,000	227,000
1979	242,000	260,000	145,000	153,000
1980	76,100	81,100	155,000	171,000
1981	46,100	47,700	168,000	163,000
1982	129,000	130,000	257,000	289,000
1983	134,000	157,000	251,000	253,000
1984	165,000	178,000	352,000	331,000
1985	115,000	119,000	126,000	129,000
1986	209,000	215,000	223,000	246,000
1987	311,000	325,000	179,000	246,000
1988	61,400	60,700	108,000	108,000
1989	85,700	82,400	131,000	173,000
1990	60,600	68,800	218,000	230,000
1991	55,200	65,200	241,000	245,000
1992	62,200	74,800	139,000	165,000
1993	192,000	190,000	417,000	454,000
1994	171,000	173,000	147,000	158,000
1995	146,000	159,000	243,000	277,000
1996	129,000	126,000	310,000	313,000
1997	309,000	301,000	272,000	274,000
1998	134,000	139,000	208,000	215,000
1999	154,000	173,000	242,000	246,000
2000	74,700	73,100	130,000	138,000
2001	161,000	158,000	143,000	156,000
2002	47,600	46,500	132,000	134,000
2003	109,000	106,000	157,000	162,000
2004	70,800	75,100	127,000	128,000
2005	56,800	58,600	157,000	160,000
2006	78,000	76,300	126,000	124,000
2007	123,000	114,000	244,000	231,000
2008	86,200	102,000	386,000	395,000

Year	Unregulated Annual Peak Flows (cfs)			
	Jan–Apr		May–Dec	
	Rulo	St. Joseph	Rulo	St. Joseph
2009	229,000	226,000	173,000	181,000
2010	220,000	223,000	363,000	350,000
2011	220,000	217,000	481,000	453,000
2012	83,800	98,400	131,000	134,000
2013	83,000	89,800	207,000	215,000
2014	131,000	127,000	281,000	272,000
2015	79,100	78,400	245,000	254,000
2016	139,000	142,000	185,000	185,000
2017	115,000	127,000	191,000	198,000
2018	157,000	154,000	315,000	308,000
2019	406,000	400,000	364,000	426,000

Table A-3b. Jan-Apr Unregulated Flow (cfs) Perception Thresholds, Rulo Final

Start Year	End Year	Low Threshold	High Thres	Description
1843	2019	0	inf	Total Record
1843	1883	300000	inf	No Rulo stage records, 1867, 1858, 1878, 1883 floods at downstream gages.
1884	1897	300000	inf	Stage data (MRC, Bridge) at Rulo
1898	1929	242000	inf	Selected to generate similar peaks as at St. Joseph from 2003 UMRSFFS data

Table A-3c. Jan-Apr Historic Peak Flows, Rulo Final Curve

Year	Best	Low	High	Best Estimate and Range Source
1843	360000	300000	430000	Similar to 1881 and 1844, best slightly below 1881, low as reasonable low for 1844, high 10% smaller than Kansas City 1843 estimate 6' below 1844.
1881	375000	350000	400000	Scaled from St. Joseph and Nebraska City, ranges +/-7%
1912	242000	242000	242000	2003 UMRSFFS UNREG

Table A-3d. May-Dec Unregulated Flow (cfs) Perception Thresholds, Rulo Final

Start Year	End Year	Low Threshold	High Thres	Description
1844	2019	0	inf	Total Record
1844	1872	300000	inf	No stage records Rulo or St. Joseph, 1867 and 1858 floods at downstream gages.
1873	1897	300000	inf	Stage records (St. Joseph, and/or Rulo), ~1883 flood.
1898	1929	251000	inf	Selected to generate similar peaks as at St. Joseph from 2003 UMRSFFS data

Table A-3e. May-Dec Historic Peak Flows, Rulo Final Curve

Year	Best	Low	High	Best Estimate and Range Source
1844	300000	250000	350000	USGS Web, uncertainty -14% and +9% (plots below historic RC)
1903	257000	241000	257000	2003 UMRSFFS, low no depletions
1908	278000	257000	278000	2003 UMRSFFS, low no depletions
1909	255000	224000	255000	2003 UMRSFFS, low no depletions
1917	251000	226000	251000	2003 UMRSFFS, low no depletions
1920	264000	249000	264000	2003 UMRSFFS, low no depletions
1921	277000	235000	277000	2003 UMRSFFS, low no depletions

Table A-3f. Jan-Apr Unregulated Flow (cfs) Perception Thresholds, St. Joseph Final

Start Year	End Year	Low Threshold	High Thres	Description
1843	2019	0	inf	Total Record
1843	1873	300000	inf	Slightly exceed April 1867, and June 1858 floods; also informed by Kansas City.
1874	1897	300000	inf	MRC stage data, same as 1843-1872
1898	1929	268000	inf	2003 UMRSFFS data, 1912 event, largest of period in early spring

Table A-3g. Jan-Apr Historic Peak Flows, St. Joseph Final Curve

Year	Best	Low	High	Best Estimate and Range Source
1843	360000	300000	450000	Best slightly below 1881, low as reasonable low for 1844, high slightly smaller than Kansas City 1843 estimate.
1881	370000	350000	425000	USGS Web, ranges +/- ~6-7%
1912	268000	268000	268000	2003 UMRSFFS UNREG

Table A-3h. May-Dec Unregulated Flow (cfs) Perception Thresholds, St. Joseph Final

Start Year	End Year	Low Threshold	High Thres	Description
1844	2019	0	inf	Total Record
1844	1872	300000	inf	Assumed flow for June 1858
1873	1897	300000	inf	MRC Stage Records, slightly exceeds 285,000 cfs in 1878, same as 1844-1872.
1898	1929	268000	inf	2003 UMRSFFS data, 1912 event

Table A-3i.   May-Dec Historic Peak Flows, St. Joseph Final Curve

Year	Best	Low	High	Best Estimate and Range Source
1844	350000	300000	380000	USGS Web, uncertainty -14% and +9% (plots below historic RC)
1883	306000	275000	325000	1962 Hydrology Study, range +/-8% (low similar to flow at Kansas City).
1903	268000	252000	348000	2003 UMRSFFS Stage Record flow increased 4kcfs to plot correctly, low is USGS web, high 2003 UMRSFFS unregulated flow
1908	308000	228000	308000	2003 UMRSFFS, low UMRSFFS stage record
1909	307000	215000	307000	2003 UMRSFFS, low UMRSFFS stage record
1917	318000	225000	318000	2003 UMRSFFS, low UMRSFFS stage record
1920	284000	199000	284000	2003 UMRSFFS, low UMRSFFS stage record

Table A-4.   Annual Peak Regulated Flows, Omaha District Gages

Year	Regulated Annual Peak Flows (cfs)			
	Gavins Point	**Sioux City**	**Omaha**	**Nebraska City**
1930	50,000	66,900	66,800	95,200
1931	41,500	41,700	39,000	46,200
1932	39,500	37,900	54,600	67,300
1933	56,500	57,600	53,600	55,600
1934	51,000	50,700	55,400	59,500
1935	53,000	58,600	51,100	84,300
1936	38,000	35,700	47,400	88,000
1937	32,500	30,900	41,100	52,900
1938	25,500	33,800	37,400	50,300
1939	45,500	59,100	56,400	73,700
1940	51,500	49,300	59,200	58,800
1941	32,500	32,000	52,000	55,900
1942	38,500	51,700	52,700	73,200
1943	57,500	76,900	124,400	117,900
1944	54,000	62,700	76,700	123,100
1945	40,500	46,000	78,400	92,100
1946	47,500	47,900	43,400	56,300
1947	70,000	81,900	89,900	142,800
1948	52,000	74,100	65,900	106,600
1949	43,000	53,300	103,300	113,200
1950	58,000	70,600	111,600	115,500
1951	56,200	115,900	102,300	170,000
1952	79,500	101,200	184,200	212,400
1953	60,000	58,800	86,800	109,800
1954	49,000	48,400	66,400	90,400
1955	63,000	62,900	52,500	49,800
1956	47,500	46,400	44,600	42,700
1957	36,500	40,200	50,700	109,400
1958	34,000	34,700	34,000	75,300
1959	39,000	38,400	58,100	79,200
1960	40,500	92,400	119,300	176,900
1961	37,500	37,900	42,600	54,400
1962	35,100	80,400	116,900	167,200
1963	45,500	46,400	58,100	80,300
1964	45,500	44,700	51,600	103,300
1965	49,500	59,100	82,100	115,100
1966	44,000	50,000	55,400	81,600
1967	48,500	53,400	86,300	193,300
1968	54,500	55,700	58,900	75,800
1969	54,000	114,700	139,800	142,700

Year	Regulated Annual Peak Flows (cfs)			
	Gavins Point	**Sioux City**	**Omaha**	**Nebraska City**
1970	53,000	54,400	56,200	63,600
1971	50,000	63,800	78,900	115,000
1972	50,000	61,100	72,800	89,400
1973	44,500	45,000	55,000	78,900
1974	47,000	50,600	53,700	72,900
1975	66,500	70,000	79,100	91,500
1976	46,500	50,200	56,400	71,200
1977	38,500	39,900	45,300	53,800
1978	63,900	70,800	89,700	158,800
1979	44,500	72,600	116,100	145,300
1980	40,000	42,600	47,500	58,600
1981	37,000	37,600	44,900	58,700
1982	75,900	87,700	97,300	109,900
1983	52,000	57,300	84,000	122,100
1984	47,400	139,800	152,800	217,100
1985	37,000	38,900	60,000	79,700
1986	68,300	76,600	98,200	128,300
1987	40,500	41,300	50,200	115,200
1988	42,000	42,400	45,400	49,800
1989	39,000	39,200	44,600	81,200
1990	36,500	36,300	70,600	115,500
1991	39,000	39,500	74,100	89,200
1992	28,900	32,500	46,100	52,900
1993	57,500	74,400	119,700	193,500
1994	37,000	45,800	56,000	89,000
1995	62,600	88,900	108,400	138,300
1996	57,800	80,200	139,300	167,400
1997	84,000	116,800	123,100	127,900
1998	65,800	76,100	83,400	90,700
1999	45,900	61,500	78,100	113,500
2000	38,000	42,800	49,200	63,000
2001	34,500	60,800	67,900	93,200
2002	35,500	37,200	43,100	53,300
2003	35,000	35,200	49,600	61,500
2004	29,500	32,800	46,200	74,800
2005	28,500	34,200	43,700	61,700
2006	34,000	36,100	40,800	46,500
2007	28,300	39,600	82,200	126,700
2008	31,000	35,800	71,800	134,300
2009	56,000	64,500	70,900	80,000
2010	57,400	95,000	114,500	186,800

Year	Regulated Annual Peak Flows (cfs)			
	Gavins Point	**Sioux City**	**Omaha**	**Nebraska City**
2011	164,000	195,300	221,800	239,600
2012	40,500	40,900	45,000	55,900
2013	33,500	37,900	63,900	90,600
2014	45,300	111,000	129,600	153,600
2015	36,500	39,500	69,400	112,400
2016	30,500	34,300	62,700	97,800
2017	42,800	57,200	82,600	120,200
2018	52,500	105,500	128,100	166,000
2019	106,800	162,100	204,900	343,000

Table A-5.   Annual Peak Regulated Flows, Kansas City District Gages

Year	Regulated Annual Peak Flows (cfs)					
	Rulo	**St. Joseph**	**Kansas City**	**Waverly**	**Boonville**	**Hermann**
1930	94,200	101,000	124,000	123,000	126,000	138,000
1931	45,100	55,700	111,000	120,000	214,000	254,000
1932	67,300	81,900	89,000	91,200	122,000	169,000
1933	50,600	57,000	57,400	65,200	88,600	183,000
1934	56,200	68,300	60,000	59,300	80,200	100,000
1935	93,400	97,700	138,000	143,000	244,000	299,000
1936	82,500	87,600	93,800	98,900	112,000	140,000
1937	47,100	52,800	70,100	73,200	118,000	164,000
1938	48,200	61,700	82,500	86,400	134,000	192,000
1939	70,200	91,900	106,000	99,900	135,000	240,000
1940	59,700	61,400	58,500	59,700	67,800	106,000
1941	50,900	82,900	105,000	99,700	142,000	249,000
1942	73,200	99,100	131,000	132,000	251,000	310,000
1943	117,000	111,000	174,000	172,000	270,000	346,000
1944	119,000	110,000	214,000	252,000	425,000	436,000
1945	93,900	126,000	196,000	208,000	248,000	272,000
1946	79,800	107,000	112,000	106,000	153,000	213,000
1947	146,000	151,000	190,000	199,000	367,000	355,000
1948	108,000	144,000	159,000	167,000	190,000	248,000
1949	120,000	164,000	170,000	164,000	173,000	218,000
1950	162,000	151,000	146,000	152,000	173,000	217,000
1951	191,000	207,000	472,000	470,000	480,000	496,000
1952	241,000	279,000	260,000	251,000	239,000	261,000
1953	111,000	110,000	116,000	109,000	123,000	137,000
1954	102,000	93,000	107,000	97,700	112,000	121,000
1955	50,100	76,500	83,000	91,800	117,000	165,000
1956	51,100	49,300	57,800	53,700	72,800	76,800
1957	119,000	124,000	132,000	129,000	130,000	165,000
1958	98,200	128,000	162,000	158,000	223,000	259,000
1959	102,000	126,000	131,000	134,000	154,000	176,000
1960	182,000	176,000	217,000	206,000	287,000	274,000
1961	72,300	99,000	140,000	193,000	249,000	285,000
1962	164,000	155,000	166,000	170,000	188,000	257,000
1963	103,000	112,000	110,000	118,000	133,000	151,000
1964	107,000	105,000	137,000	137,000	165,000	209,000
1965	125,000	178,000	207,000	231,000	249,000	280,000
1966	85,900	82,200	103,000	128,000	184,000	197,000
1967	183,000	180,000	254,000	248,000	264,000	310,000
1968	70,500	74,500	106,000	108,000	129,000	190,000
1969	145,000	150,000	176,000	182,000	221,000	357,000

Year	Regulated Annual Peak Flows (cfs)					
	Rulo	**St. Joseph**	**Kansas City**	**Waverly**	**Boonville**	**Hermann**
1970	71,400	75,000	116,000	122,000	201,000	291,000
1971	130,000	126,000	116,000	114,000	148,000	198,000
1972	94,700	111,000	124,000	122,000	147,000	193,000
1973	134,000	208,000	298,000	288,000	323,000	450,000
1974	87,600	105,000	162,000	211,000	259,000	249,000
1975	97,900	109,000	118,000	113,000	190,000	263,000
1976	79,100	98,500	119,000	115,000	168,000	193,000
1977	83,400	116,000	195,000	223,000	234,000	248,000
1978	170,000	181,000	183,000	189,000	247,000	337,000
1979	175,000	203,000	217,000	209,000	259,000	305,000
1980	71,800	91,800	153,000	160,000	174,000	200,000
1981	57,900	68,800	123,000	130,000	229,000	288,000
1982	141,000	172,000	185,000	197,000	265,000	415,000
1983	125,000	143,000	169,000	195,000	302,000	382,000
1984	258,000	240,000	268,000	276,000	297,000	291,000
1985	81,600	90,600	206,000	208,000	294,000	417,000
1986	159,000	177,000	201,000	190,000	338,000	541,000
1987	138,000	201,000	208,000	193,000	200,000	239,000
1988	53,300	55,900	74,300	72,800	106,000	167,000
1989	117,000	164,000	177,000	177,000	202,000	199,000
1990	121,000	135,000	131,000	192,000	286,000	379,000
1991	95,700	111,000	107,000	119,000	135,000	167,000
1992	81,200	122,000	146,000	162,000	230,000	297,000
1993	303,000	338,000	532,000	610,000	704,000	710,000
1994	94,500	102,000	102,000	124,000	209,000	446,000
1995	152,000	181,000	232,000	281,000	377,000	546,000
1996	180,000	189,000	182,000	199,000	302,000	309,000
1997	134,000	143,000	206,000	223,000	296,000	319,000
1998	127,000	150,000	180,000	218,000	295,000	367,000
1999	136,000	157,000	211,000	241,000	286,000	303,000
2000	68,600	73,400	81,900	92,700	127,000	146,000
2001	102,000	124,000	151,000	156,000	292,000	339,000
2002	53,100	58,700	82,900	108,000	239,000	345,000
2003	62,100	70,600	75,500	78,500	109,000	144,000
2004	95,500	99,200	104,000	118,000	156,000	223,000
2005	82,700	90,200	120,000	142,000	182,000	264,000
2006	48,900	46,900	71,800	76,200	102,000	155,000
2007	218,000	193,000	289,000	298,000	369,000	350,000
2008	165,000	171,000	197,000	206,000	291,000	354,000
2009	86,800	103,000	168,000	175,000	279,000	294,000
2010	243,000	232,000	231,000	240,000	299,000	307,000

Year	Regulated Annual Peak Flows (cfs)					
	Rulo	**St. Joseph**	**Kansas City**	**Waverly**	**Boonville**	**Hermann**
2011	312,000	285,000	274,000	277,000	320,000	301,000
2012	80,200	61,400	98,800	103,000	133,000	188,000
2013	103,000	132,000	157,000	204,000	354,000	436,000
2014	156,000	150,000	154,000	154,000	209,000	205,000
2015	129,000	153,000	212,000	266,000	276,000	453,000
2016	118,000	121,000	219,000	282,000	277,000	317,000
2017	141,000	151,000	180,000	185,000	212,000	482,000
2018	169,000	166,000	198,000	215,000	269,000	265,000
2019	340,000	271,000	353,000	347,000	363,000	400,000

Table A-6a. Seasonal Annual Maximum Stages at Omaha, Nebraska, Missouri River Commission Data, Series 1: 1872–1885 daily elevations

Year	Current Gage** Height (Feet)	Jan–Apr Max Stage (feet, Directrix*)	Date	Current Gage** Height (Feet)	May–Dec Max Stage (feet, Directrix*)	Date
1872	18.06	553.60	1872–04–27&28	25.76	561.30	1872–07–11 &12
1873	26.26	561.80	1873–04–12	27.26	562.80	1873–07–04
1874	18.36	553.90	1874–04–23	23.86	559.40	1874–06–15 to 18
1875	29.06	564.60	1875–04–28	26.36	561.90	1875–06–27 &28
1876	24.56	560.10	1876-06-21	26.06	561.60	1876–06–21
1877	27.06	562.60	1877–04–07	25.86	561.40	1877–07–09
1878	25.86	561.40	1878–04–28	28.86	564.40	1878–06–25 &26
1879	22.46	558.00	1879–04–16	28.26	563.80	1879–06–28
1880	26.46	562.00	1880–04–06	27.56	563.10	1880–07–01 &2
1881	34.86	570.40	1881–04–24&25	25.36	560.90	1881–06–15
1882	22.86	558.40	1882–04–11	25.66	561.20	1882–06–28
1883	24.26	559.80	1882–04–18	25.26	560.80	1883–07–11
1884	28.06	563.60	1884–04–06	25.66	561.20	1884–06–22
1885	21.86	557.40	1885–03–10	26.51	562.05	1885–06–17

*Corrected the originally published MRC water surface elevations to the same St. Louis Directrix Elevation as Series 3 and 4 data by adding 1.003 feet. Yellow highlighted portion of the table was collected near Farnham Street, was adjusted to the Union Pacific Railroad (UPRR) bridge by subtracting 0.21 feet in the original tables and needs no further adjustment (Year: 1879, Gage Height: 28.26; Year: 1880, Gage Height: 26.46). Blue highlights the largest events of the period plotted in Section 3.7.3. (Year: 1875, Gage Height: 29.06 ft; Year: 1878, Gage Height: 28.86; Year: 1881, Gage Height: 34.86).

**The published peak for 1881 is 34.22 feet by the National Weather Service, current gage datum, which results in identical water surface elevations at the current USGS gage and former MRC gage on the Union Pacific Railroad (UPRR) Bridge 0.6 miles downstream (existing railroad bridge is on the same alignment as the original). To adjust to current gage datum, giving gage height in feet, subtract the gage zero of 545.75 feet Directrix at the UPRR bridge, add 10 feet for the 1982 datum adjustment, then subtract 0.43 feet for the difference in gage zero elevations, which matches the NWS stage for 1881 on their website. Then add 0.64 feet (same factor as used in UMRSFFS, Appendix F, MRC historic measurement table) to account for water surface slope between gages 0.6 miles apart. This final correction of 0.64 feet is uncertain but is at least 0.21 feet based on slope of "HW 1881" on MRC gage table notes. Weather Bureau Technical Paper 23, 1954 on the 1952 Flood lists the gage height of 1881 as 24.6 feet, or 34.6 feet to current datum with the 1982 adjustment, which essentially assumes the 0.43 feet difference in gage datums accounts for the water surface slope between gages.

Table A-6b. Seasonal Annual Maximum Stages at Omaha, Nebraska, Missouri River Commission Data, Series 2: 1886-1889 daily elevations (6 am / 6 pm averages)

Year	Current Gage** Height (Feet)	Jan–Apr Max Stage (feet, Directrix*)	Date	Current Gage** Height (Feet)	May–Dec Max Stage (feet, Directrix*)	Date
1886	22.02	558.20	1886–03–22	22.52	558.70	1886–06–11
1887	28.32	564.50	1887–03–28	25.32	561.50	1887–06–27
1888	25.32	561.50	1888–04–19	25.92	562.10	1888–06–30
1889	19.92	556.10	1889–03–30	19.32	555.50	1889–06–12

*Corrected the originally published MRC water surface elevations to the same St. Louis Directrix Elevation as Series 3 and 4 data by adding 0.703 feet. Blue highlights the largest events of the period plotted in Section 3.7.3 (Year: 1887, Gage Height: 28.32 ft)

**See adjustment to current gage height in Table A-6a.

Table A-6c. Seasonal Annual Maximum Stages at Omaha, Nebraska, Missouri River Commission Data, Series 3 and 4: 1890-1899 daily elevations (6 am / 6 pm averages)

Year	Current Gage** Height (Feet)	Jan-Apr Max Stage (feet, Directrix*)	Date	Current Gage Height (Feet)	May-Dec Max Stage (feet, Directrix*)	Date
1890	19.62	555.8	1890–04–15	22.22	558.4	1890–06–13
1891	20.72	556.9	1891–04–11	24.22	560.4	1891–06–29
1892	20.12	556.3	1892–04–12	24.92	561.1	1892–07–03
1893	24.72	560.9	1893–04–12	22.52	558.7	1893–06–23
1894	24.62	560.8	1894–04–14	24.42	560.6	1894–06–18
1895	21.02	557.2	1895–04–06	21.62	557.8	1895–06–08
1896	22.92	559.1	1896–04–06	23.92	560.1	1896–06–15
1897	26.82	563.0	1897–04–15	22.22	558.4	1897–06–02
1898	22.02	558.2	1898–04–21	24.32	560.5	1898–07–03
1899	27.92	564.1	1899–04–25	23.82	560.0	1899–07–02

*Elevations are to the St. Louis Directrix in feet with gage zero at 545.75 feet (Weather Bureau gage). Blue highlights the largest events of the period plotted in Section 3.7.3 (Year: 1899, Gage Height: 27.92 ft).

**See adjustment to current gage height in Table A-6a.

Table A-7.   Flood Crests Exceeding 32 feet on the Missouri River at Kansas City, Missouri 1873 to 1929, and documented coincident historic peaks

Date of Missouri River Peak	KCMO Stage[5] (feet)	Height above 32' at KCMO (feet)	Estimated KCMO flow (cfs)	Kansas River flow[3] (cfs)	Date of Kansas River Flow
~June 1724	-	~<1826	-	Unknown	n/a
April 1785	-	~1844, >1826	~<625,000	Unknown	Unknown
~July 25, 1811	-	~<1826	~<362,000	Minor	n/a
~May 1, 1826	**~38**	**6**	**362,000[2]**	**~<165,000**	**Apr/May 1826**
1827	-	<<1826	-	>120,000	Spring 1827
~April 30, 1843	**~42**	**10**	**476,000[2]**	**~<100,000**	**Apr/May 1843**
June 15-16, 1844	**48.0**	**16.0**	**625,000[1]**	**~510,000**	**June 15-16 (KC)**
1845	>33	~<1826	>237,000	>120,000	June 23, 1845 (KC)
~June 5, 1851	~<35.7	<1858	<301,000[2]	<<1858	Unknown
June 1858	<35.7	<3.7	<301,000[2]	Minor	
~July 20, 1858	**35.7**	**3.7**	**301,000[2]**	**218,000**	**July 17-19 (TOP)**
April 29, 1867	33.0	1.0	237,000[2]	~<100,000	Feb, April, and June
June 10, 1877	32.7	0.7	231,000[2]	125,000	May 21, 1877 (TOP)
April 13, 1881	32.6	0.6	229,000[2]	<4,000	April 13, 1881
April 30, 1881	**37.8**	**5.8**	**373,000[1]**	**<4,000**	**April 30, 1881**
June 26-27, 1883	34.5	2.5	271,000[2,4]	Minor	
June 30-July 1, 1891	33.1	1.1	239,000[2]	41,000	June 1, 1891 (LEC)
May 21, 1892	35.0	3.0	283,000[2,4]	69,000	May 17, 1892 (LEC)
April 19-20, 1897	32.4	0.4	224,000[2]	68,000	April 26, 1897 (LEC)
April 28, 1899	33.1	1.1	239,000[2]	43,000	July 8, 1899 (LEC)
July 14, 1902	33.1	1.1	239,000[2]	89,000	July 15, 1902 (LEC)
June 2, 1903	**45.0**	**13.0**	**548,000[1]**	**337,000**	**June 1, 1903 (BS)**
July 8, 1904	35.0	3.0	283,000[2]	141,000	July 7, 1904 (LEC)
July 11-12, 1905	32.8	0.8	233,000[2]	63,000	July 10, 1905 (TOP)
July 20-21, 1907	33.5	1.5	248,000[2]	32,000	Aug 5, 1906 (TOP)
June 14-16, 1908	40.1	8.1	421,000[2]	244,000	June 9, 1908 (LEC)
July 13, 1909	36.8	4.8	329,000[2]	68,000	Nov 15, 1909 (TOP)
April 2, 1912	33.1	1.1	239,000[2]	Unknown	
April 17, 1912	33.2	1.2	242,000[2]	66,000	Mar 20, 1912 (TOP)
April 16, 1913	32.1	0.1	218,000[2]	44,000	May 13, 1913 (TOP)
May 30, 1915	35.0	3.0	283,000[2]	Unknown	
June 12, July 2 1915	33.8	1.8	255,000[2]	Unknown	
June 21, 1915	37.0	5.0	335,000[2]	120,000	June 20, 1915(LEC)
July 21, 1915	39.0	7.0	390,000[2]	<120,000	
June 9, 1917	36.5	4.5	322,000[2]	76,000	June 3, 1917 (BS)
May 21, 1920	32.6	0.6	229,000[2]	30,900	July 14, 1920 (BS)
June 28, 1924	32.3	0.3	222,000[2]	20,000	Oct 4, 1923 (BS)
April 21, 1927	34.8	2.8	279,000[2]	101,000	April 20, 1927 (BS)
June 4, 1929	33.4	1.4	254,000[1]	116,300	April 21, 1929 (BS)

[1]*Long established historic peak or USGS systematic peak, see Table A-8(a-c) for range of estimates.*
[2]*Estimated by the historic rating curve, see Section 3.8.3*

[3]*Dates at Topeka, Lecompton, Bonner Springs, or Kansas City, used annual peak if same day flow unknown*
[4]*USACE 1962, Levee Restudy Report, estimated 1883 and 1892 significantly higher at 367,000 cfs and 393,000 cfs, respectively, unreasonable by rating curve but closer to MRC 1883 flow measurements*
[5]*Stages 1873-1928 were computed from elevations in the "308 report" with a legacy gage zero of 705.8 feet MSL. Values are 0.1', 0.4', 0.2', and 0.2' lower than NWS website but are identical to USACE 1980 for 1883, 1897, 1899, and 1907, respectively, 0.1' lower than both documents for 1902 and 1912, and 0.2' lower than both documents for 1904, 1905, 1908, 1909, and 1917. Stages from the "308 Report" are shown; flows are within 6,000 cfs for published stages with the historic rating curve, except 1897 which is within 9,000 cfs.*

Table A-8a. June 1844 Flood Historic Peak Flow Estimates (cfs)

Gage	308 Report (1932/1935)	1946 Levee DPR	USGS Web	Best Estimate
Yankton				
Sioux City				
Omaha	0.5" below 1881	In channel		In channel
Nebraska City				
Rulo				300000
St. Joseph	350000	228000*	350000	350000
Kansas City	625000	625000	625000	625000
Waverly				640000
Boonville	710000	710000	710000	710000
Hermann	900000	900000	700000	800000
St. Charles	900000	900000		
St. Louis	1350000		1000000	

*The 1946 MRLS Levee DPR showed both 1844 and 1881 five feet lower than the published stages but showed 1903 at the correct stage. Flow for 1844 from the 308 Report was reduced at St. Joseph in the 1946 report, but the 1881 flow estimate wasn't altered. The stage discrepancies may be result of datum corrections for pre-1931 stages at St. Joseph.

Table A-8b. April 1881 Flood Historic Peak Flow Estimates (cfs)

Gage	308 Report	1946 Levee DPR	1962 Hydrology	USGS Web	Best Estimate
Yankton					335000
Sioux City	360000	360000	360000		360000
Omaha		372000	370000		370000
Nebraska City		380000	400000		400000
Rulo					375000
St. Joseph	425000	370000	370000	370000	370000
Kansas City		373000	481000		373000
Waverly					370000
Boonville		363000			363000
Hermann		444000			390000
St. Charles					
St. Louis				822000	

Flow at the Fort Randall Dam site was estimated by USACE at 325,000 cfs.

Table A-8c. May-Jun 1903 Flood Historic Peak Flow Estimates (cfs)

Gage	308 Report	1946 Levee DPR	1962 Hydrology	USGS Web	2003 UMRSFFS Unreg	Best Estimate
Yankton					151000	
Sioux City					152700	
Omaha					152900	
Nebraska City					223300	
Rulo					257000	257000*
St. Joseph	252000	252000	263300	252000	348000	264000*
Kansas City	548000	548000	563000	548000	574000	548000
Waverly			563000		571000	550000
Boonville	612000	591000	649000	612000	539000	591000
Hermann	730000	676000	669000	676000	573000	676000
St. Charles						
St. Louis				1020000	833000	

*from 2003 UMRSFFS stage record at St. Joseph, and unregulated with depletions at Rulo

Table A-9. 2003 UMRSFFS Unregulated Flows, Kansas City, Waverly, Boonville, Hermann, with regional adjustment to a skew of 0.17 (cfs)

AEP (percent)	Kansas City*	Waverly*	Boonville*	Hermann*
0.2	716000	717000	865000	1110000
0.5	638000	639000	763000	971000
1	581000	581000	689000	871000
2	525000	526000	618000	775000
5	453000	453000	526000	652000
10	398000	398000	457000	561000
20	341000	341000	386000	470000
50	257000	257000	284000	338000
80	196000	196000	212000	247000
90	171000	171000	183000	211000
95	153000	153000	162000	186000
99	126000	126000	131000	148000
Mean	5.5337	5.4577	5.4141	5.4139
St. Deviation	0.1658	0.1554	0.1430	0.1430
Skew (station)	0.287	0.347	0.165	0.051
Adopted skew	0.17	0.17	0.17	0.17

*These flows were not published in the 2003 UMRSFFS, Appendix E. Flow values above were obtained from a November 2000 draft spreadsheet in the project files and validated against flows back calculated using HEC-SSP by two methods: 1) Bulletin 17B computations of the annual peak flow data in the 2003 report plates E-7 to E-10, which provided the station skews above, and 2) statistics in Table E-13 of the 2003 report.
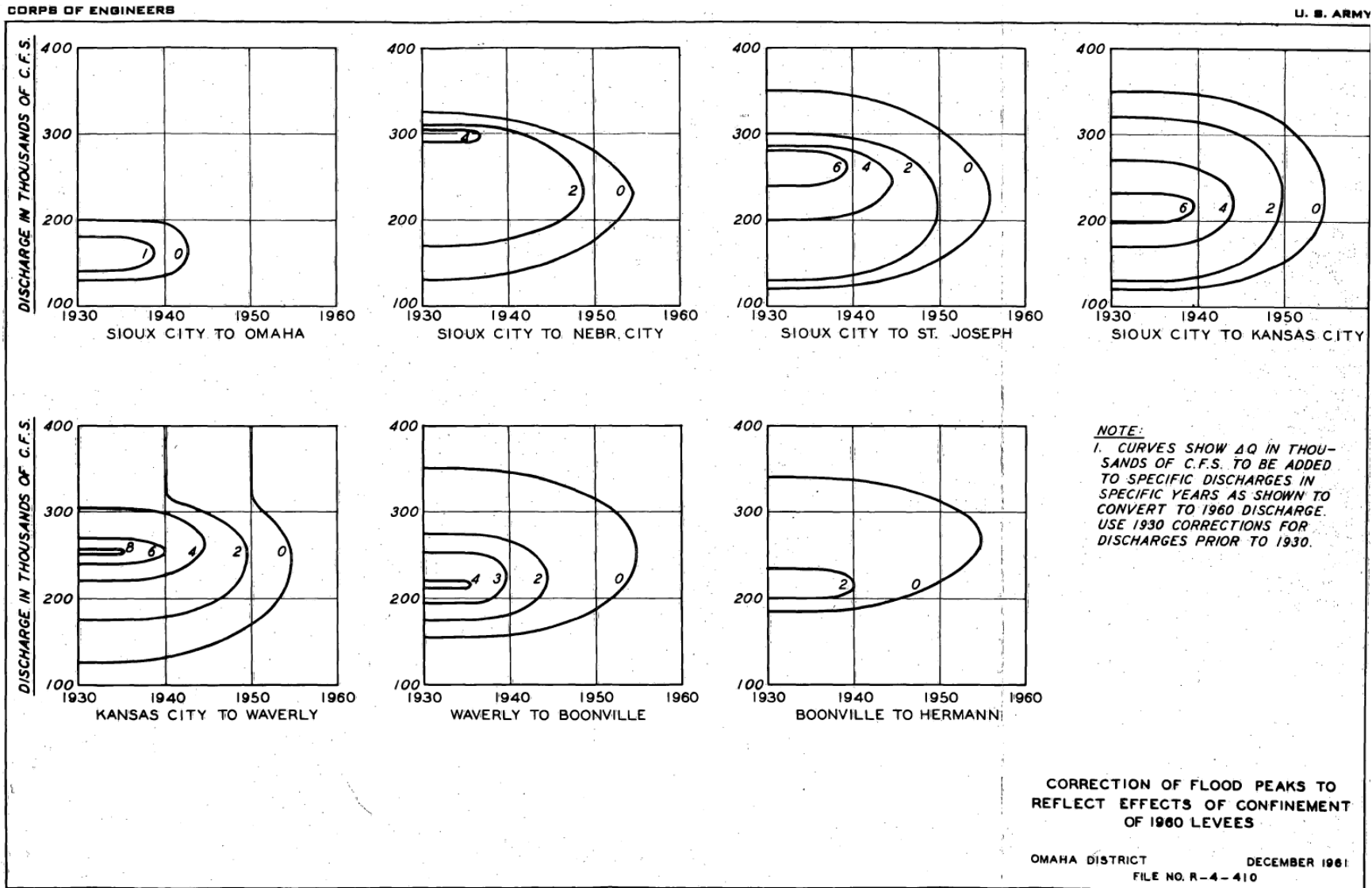
Figure A-1. Correction of Flood Peaks to Reflect Effects of Confinement of 1960 Levees, Plate 20 of USACE 1962, Levee Re-study Report
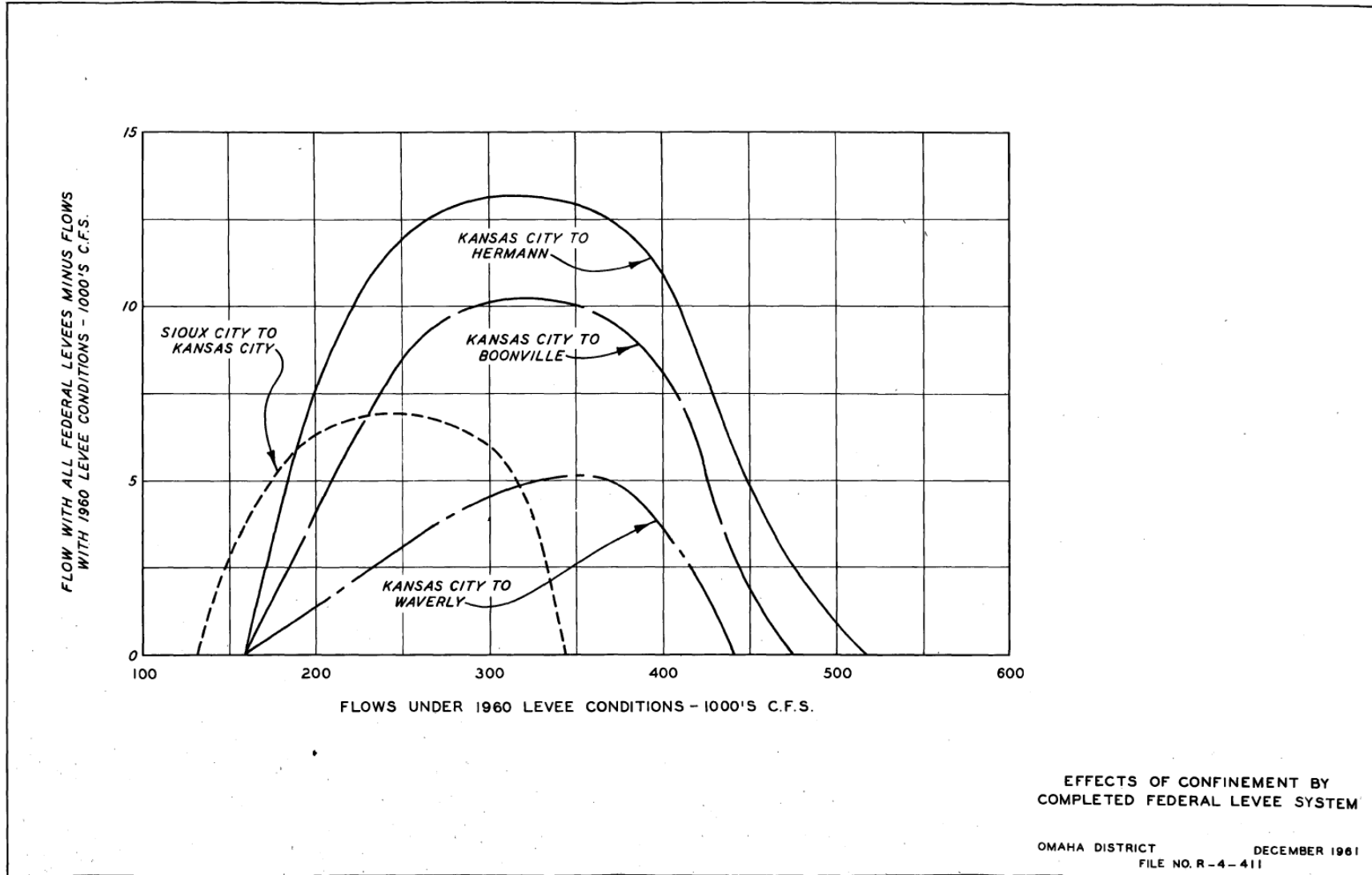
Figure A-2. Effects of confinement by completed Federal Levee System, Plate 21 of USACE 1962, Levee Re-study Report
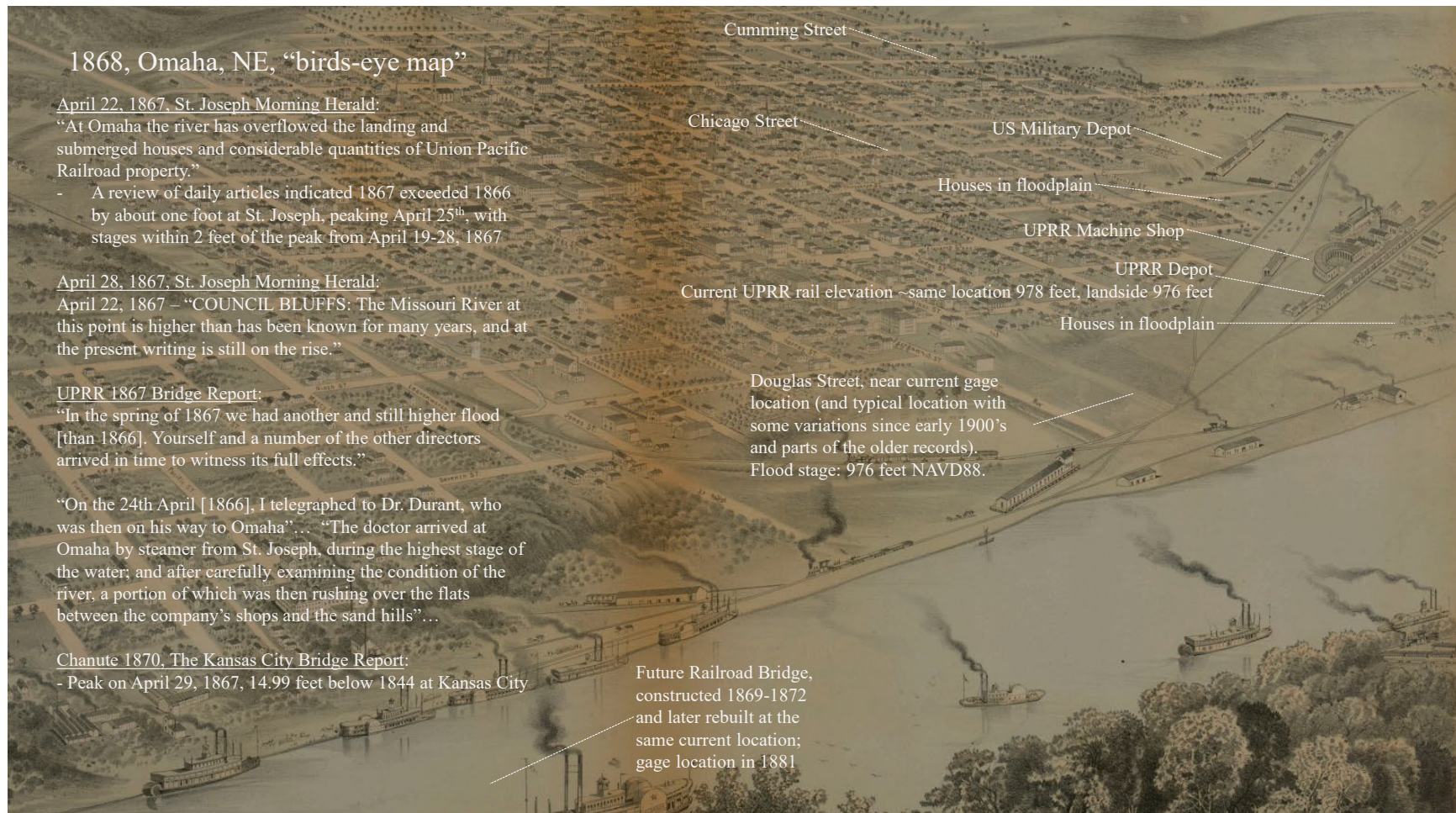
Figure A-3. Summary of 1867 and 1866 flood information at Omaha, NE
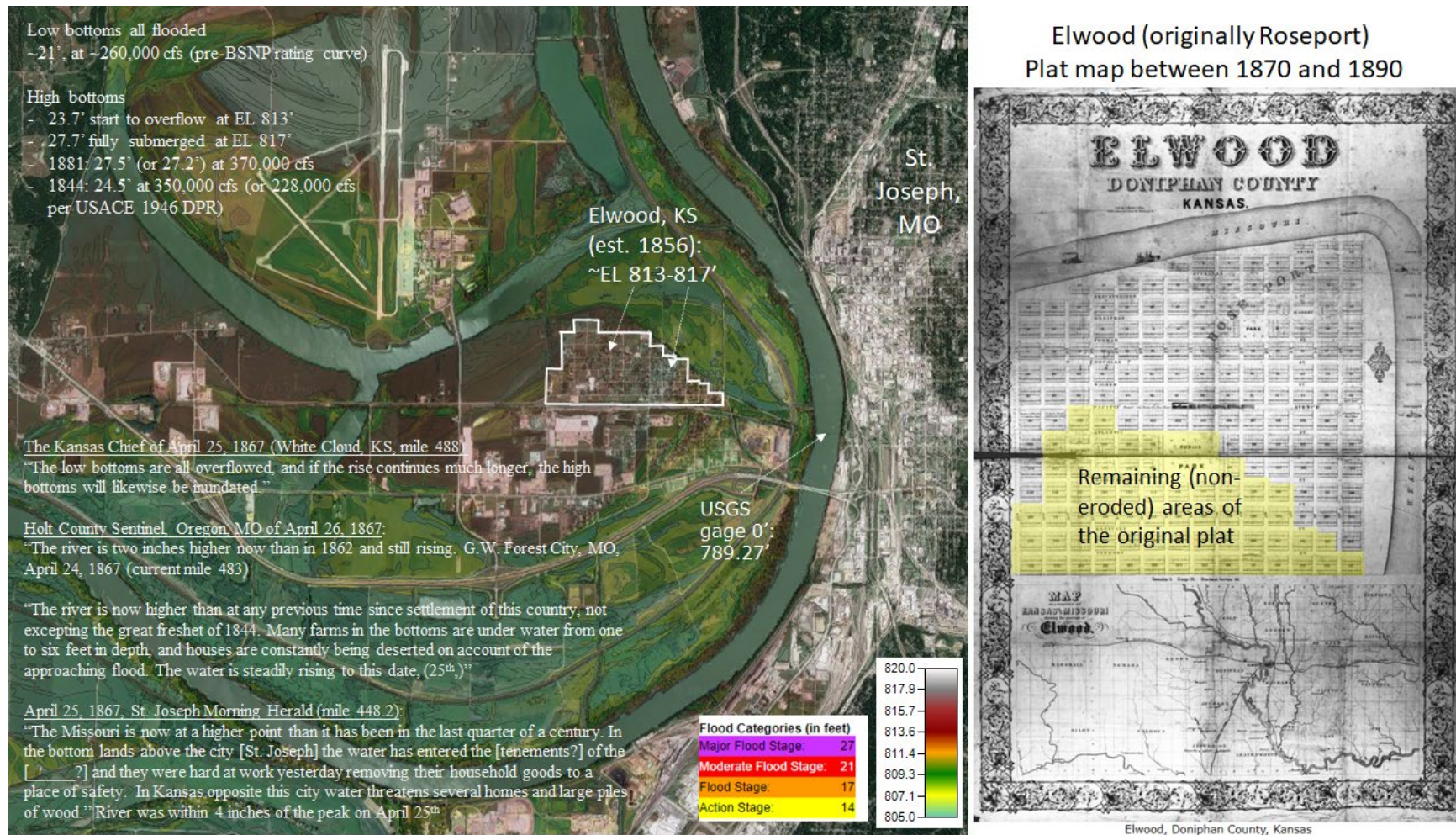
Figure A-4. Summary of 1867, 1862, and 1866 floods at St. Joseph, MO and Elwood, KS
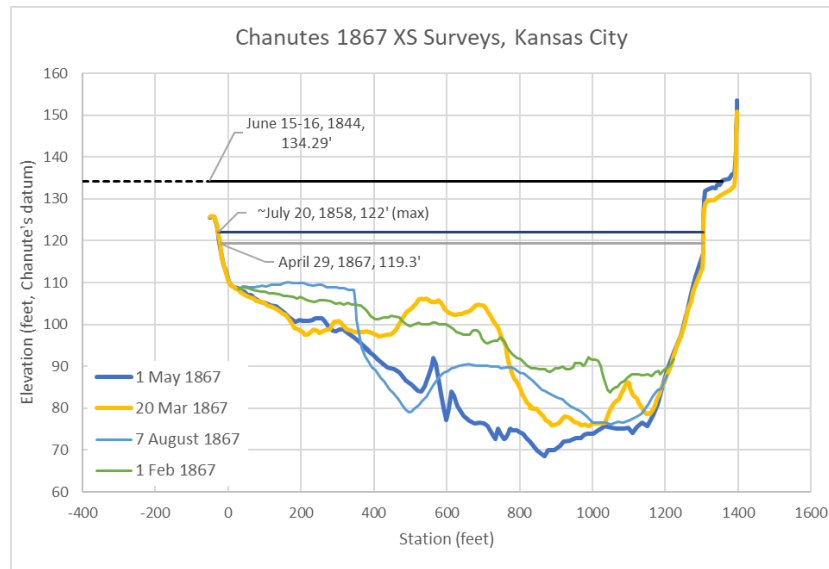
Cross Section Survey	Water Surface (feet)	Area (square feet)	Velocity (ft/s)	Velocity or Assumed Flow Description	Flow (cfs)	Percent Flow in Channel
				1867 Estimates		
Avg Mar/May 1867 XS	119.3	37200	8.07	Upper, Avg XS	300000	100
1 May 1867 XS	119.3	42000	7.15	Upper, May XS	300000	100
1 May 1867 XS	119.3	42000	5.8	Best est, May XS	244000	100
Avg Mar/May 1867 XS	119.3	37200	6.38	Avg XS, Historic Rating Curve	237000	100
20 Mar 1867 XS	119.3	32400	7.8	Best est, March XS	253000	100
20 Mar 1867 XS	119.3	32400	6.17	Lower, March XS	200000	100
Avg Mar/May 1867 XS	119.3	37200	5.37	Lower, Avg XS	200000	100
				1858 Estimates		
1 May 1867 XS	122	45500	6.6	Match Historic RC	300000	100
Avg Mar/May 1867 XS	122	40750	7.4	Match Historic RC	302000	
20 Mar 1867 XS	122	36000	8.4	Match Historic RC	302000	100
				1844 - Channel Estimates (no floodplain)		
1 May 1867 XS	134.29	62200	7.8	Min expected	485000	78%
1 May 1867 XS	134.29	62200	8.6	Max expected	535000	86%
1 May 1867 XS	134.29	62200	8.2	best	510000	82%
20 Mar 1867 XS	134.29	52900	7.4	best	391000	63%
20 Mar 1867 XS	134.29	52900	7.8	Min expected	413000	66%
20 Mar 1867 XS	134.29	52900	8.6	Max expected	455000	73%
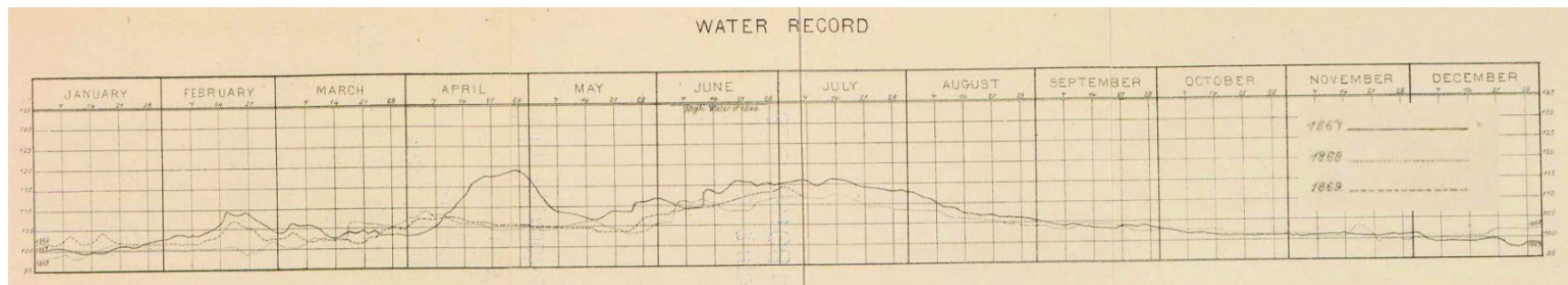
Figure A-5. Data from Chanute, 1870 at Kansas City, MO including water levels 1867–June 1869

Note: 1867 Cross Section Surveys digitized and shown with elevations of 1867, 1858, and 1844 floods, and flow estimates using these data.

1867 Flood, Kansas City:

Chanute 1870: "accurately measured a velocity of 12 feet/s in April 1867" in Kansas City.

Best estimate: 240,000 cfs – reasonable for max (pre-BSNP).

This is consistent w/ Blevins 2006 Figure 8, Waverly also being between the Kansas and Grand Rivers like Kansas City, and 1867 being mostly in channel.
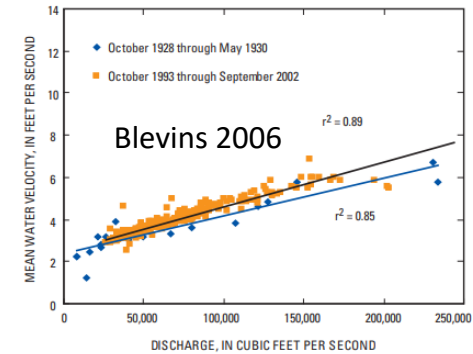

Figure 7. Relation between mean water velocity and discharge in the Missouri River at Waverly, Missouri, as recorded in U.S. Geological Survey discharge measurement notes.
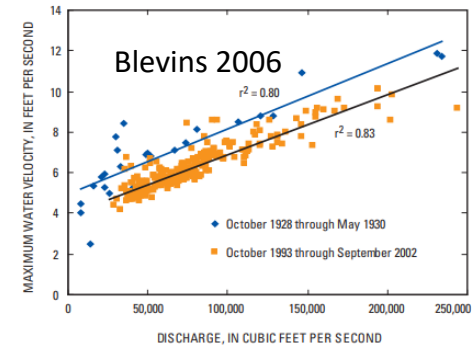

Figure 8. Relation between maximum water velocity and discharge in the Missouri River at Waverly, Missouri, as recorded in U.S. Geological Survey discharge measurement notes.

"The large historical decrease in suspended sediment and turbidity seems inconsistent with the common assumption that the Missouri River flows much faster than it did before bank stabilization. However, comparison of modern velocity measurements with available measurements made before bank stabilization indicate that while mean velocities are similar, maximum velocities in the lower Missouri River were substantially larger before bank stabilization than velocities measured today. For example, the 25 predevelopment discharge measurements made at Waverly, Missouri, (fig. 1) between October 1928 and May 1930 have mean water velocities that are only 0.2 to 0.8 ft/s (foot per second) slower than mean velocities measured at this same site between October 1993 through September 2002 (fig. 7). However, maximum water velocities before bank stabilization were actually 1.1 to 1.6 ft/s faster than modern maximum velocities (fig. 8). The maximum velocity measured at this same site with a logline by William Clark on June 17, 1804, was 12.5 ft/s (Moulton, 1986), which is close to the maximum high-water velocity of 11.9 ft/s measured in 1929 before bank stabilization. These data refute the hypothesis that the Missouri River was substantially slower before bank stabilization and help explain how the river could suspend such large quantities of sediment and sustain such high turbidity values (fig. 7). Slightly lower mean velocities and substantially higher maximum velocities before bank stabilization indicate the range and spatial variation of water velocity was likely greater before bank stabilization." – Blevins, 2006

Figure A-6. Data from Chanute, 1870 at Kansas City, MO Compared to Pre- and Post-Navigation Project (BSNP) Velocities at Waverly, MO from Blevins, 2006

1843 – Flood information near Omaha / Council Bluffs

Description of the flooding:
"In the spring of 1843, when Captain Burgwin's cantonment of Fort Croghan was inundated by the Missouri river, it appears that the sub-agency establishment [at Hardins Farm] was also flooded" – Babbitt 1916

"a blacksmith shop is in progress of erection at the mills, the tools having been removed from the river on account of the high waters" – R.S. Elliot, sub-agent, 1843

"April 17, 1843, from "Fort Croghan, I. T." **Captain Burgwin reported the greatest rise in the Missouri river known within seventeen years**; that his camp was threatened by the flood and he had prepared for removal "to the Bluffs, which are about six miles from me". [distance likely over-estimated]

"May 9 [1843]"… "Here we found only a few soldiers, dragoons; their camp and officers having been forced to move across the prairie to the bluffs, five miles. After we had put out some freight for the sutler, we proceeded on until we stopped for the night a few miles above, on the same side of the river. **The soldiers assured us that their parade ground and so-called barracks, had been four feet under water**, and we saw fair and sufficient evidence of this."… "We landed for the night under trees covered by muddy deposits from the great overflow of this season." – James Audubon

Location of the Fort:
"I have just received a letter from Mr. Hardin in which he states that the fort"… "was only 3/4 of a mile from it [his farm]." - see "Council Point", now "Lake Manawa"

"The great naturalist rode four miles to call upon an obscure army officer whom he knew he could see in a short time by waiting at the boat." – Logbook of the Omega

"Fort Croghan was not a blockhouse or fortification; but merely a military cantonment located, originally, near the old Indian farm upon which Mr. Davis Hardin resided while and after acting as farmer for the Pottawattamie"… "The old blockhouse appears to have been used by the troops by whom Fort Croghan was founded, and was no doubt considered a part of that fort or cantonment." [Other sources confirm the Fort was not at the Blockhouse, which existed at the time.]

"A. D. Jones, now of Omaha, who in early days resided in Council Bluffs and made the first survey of the town in 1852, insists that 'Camp Fenwick—Fort Croghan was on the east side of the river not far from the southwest corner of the present corporate limits of the city of Council Bluffs." – Babbitt 1916
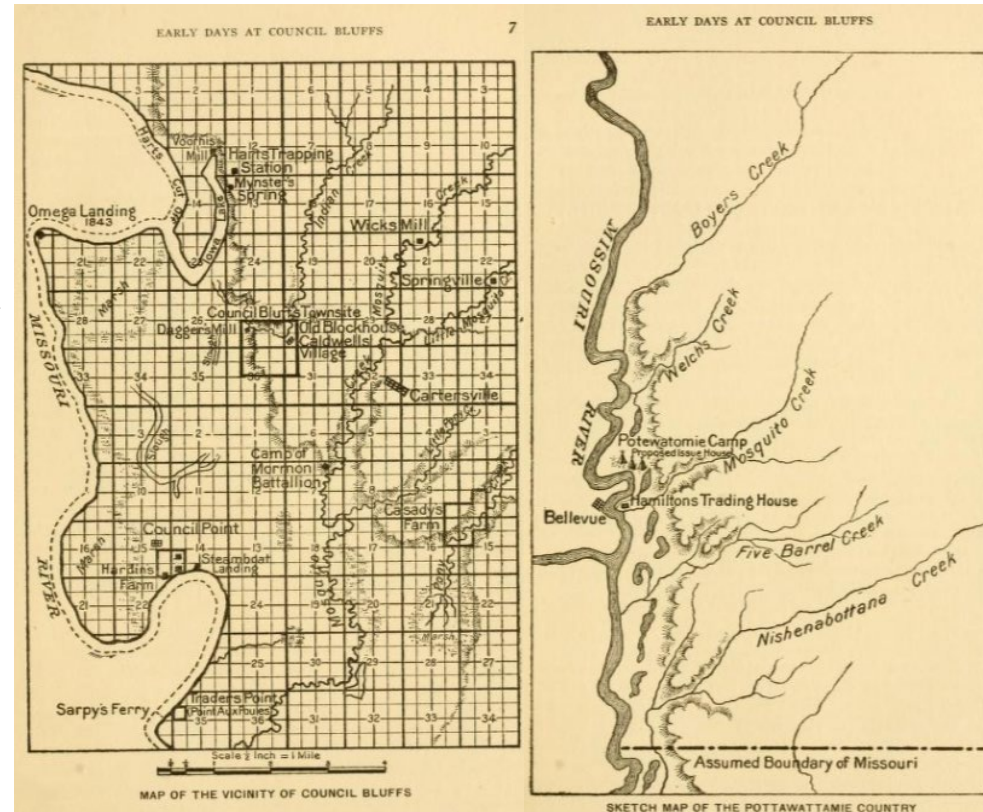
All information shown is included in Charles H. Babbitt's "Early Days at Council Bluffs", 1916

Figure A-7. Summary of Flood Information, April 1843 at Council Bluffs Across from Omaha, NE, from Fort Croghan
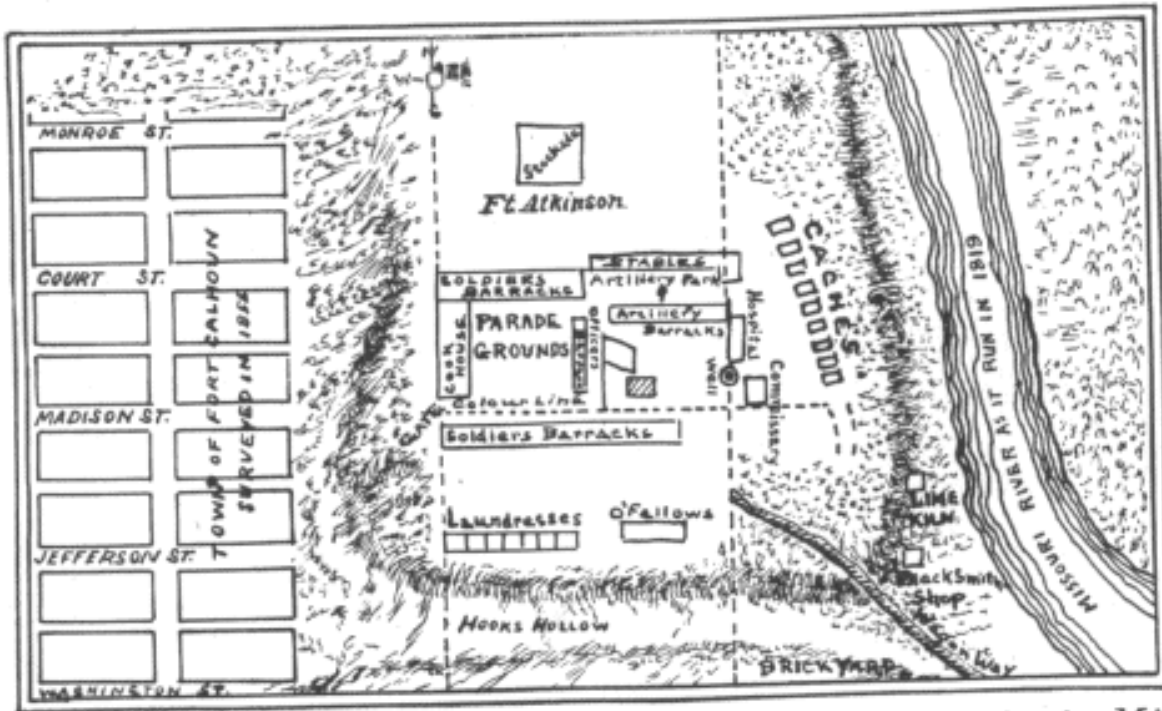
PLAN OF FORT ATKINSON, NEBRASKA, 1819–1827. *(Drawing by Miss Martha Turner.)*

From Fort Atkinson State Historic Website
Present Fort Calhoun, NE

1826 Flood: James Kennerly, Sutler at Fort Atkinson, wrote of rising waters through April, and on April 26 "now in my yard and 10 feet from store door", and "finding water 5 or 6 feet deep in the Quarters [of the first regiment]."

Possible reference to the black smith shop?
Possible quarters were remnants of the original 1820 camp?

Figure A-8. Sketch of Fort Atkinson, present Fort Calhoun, NE, and 1826 Flood Information
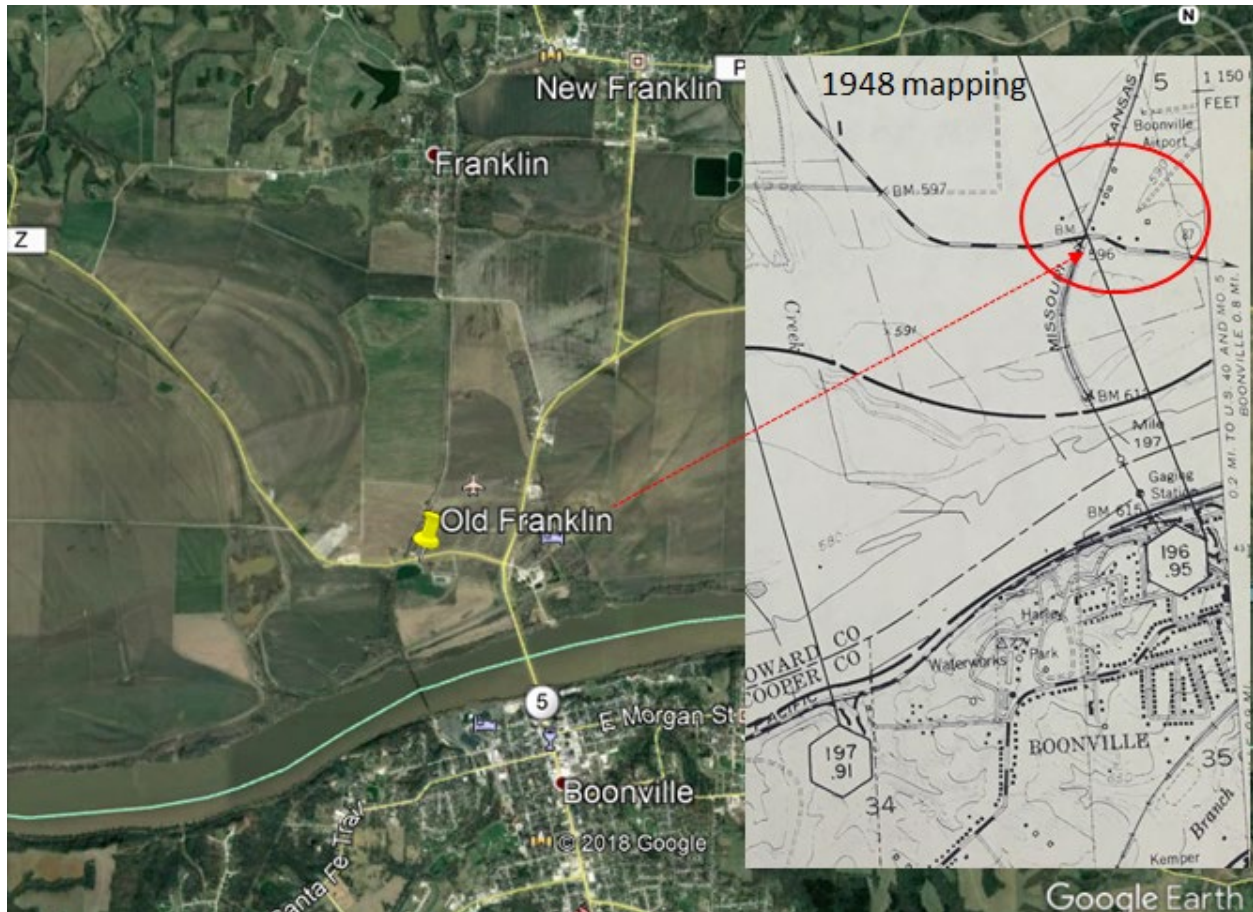
From USACE 2021, Kansas City Levees. Location of the original Franklin Town site in relation to Boonville; LiDAR and historic floodplain mapping was consulted to produce elevation ranges for the town shown on the historic rating curve, main report, knowing building foundations were still visible until after the 1993 flood. The town was relocated starting in 1827 due to bank erosion; 1844 was reported to destroy any remaining buildings. Little damage was done in 1826.

Figure A-9. Sketch of Franklin, MO at the Boonville Gage, Pertinent to the 1826 Flood