UPPER MISSISSIPPI RIVER SYSTEM
FLOW FREQUENCY STUDY

HYDROLOGY AND HYDRAULICS APPENDIX
APPENDIX B

ST. PAUL DISTRICT

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INTRODUCTION

Purpose

The purpose of the Upper Mississippi River and Lower Missouri River Flood Frequency Study is to update the discharge frequency relationships and water surface profiles on the Mississippi River and Illinois River above Cairo, Illinois, and the Missouri River downstream from Gavins Point Dam (see plate 1). This study is the cooperative effort of five Corps Districts including Omaha, Kansas City, St. Paul, Rock Island, and St. Louis. The Hydrologic Engineering Center (HEC), the Institute of Water Resources (IWR) and a distinguished cast of leaders in the field of hydrology from other agencies and institutions provided technical guidance. This appendix outlines the Hydrology and Hydraulic studies completed for the St. Paul District portion of the study.

SCOPE

Objectives

The objective of this hydrologic analysis was to update existing discharge frequency relationships for the Upper Mississippi River mainstem streamflow gaging stations within the St. Paul District. Establishing these discharge frequency relationships first involved determining a stationary and homogeneous period of record for each of the main stem gaging stations. Stationary means uninfluenced by changes in climate and homogeneous means uninfluenced by land use, reservoir storage and other floodplain improvements. Once a stationary record is determined, the annual peak discharges for this period were selected for use in the discharge frequency analysis. The Technical Advisory Group (TAG) developed the methodology for the discharge frequency analysis. The scope of work for the TAG was prepared by (HEC).

Previous Studies

The Technical Flood Plain Management Task Force of the Upper Mississippi River Basin Commission prepared the previous study, “Part I, Flow Frequency Estimates, Mississippi River, Mile 202-840”. This last update of Mississippi River mainstem frequency relationships was completed in February of 1978. Since that update, several significant floods have occurred throughout the basin and it’s tributaries including the flood of 1993. This event established new records in many locations within the Upper Mississippi River basin. The 1978 study required updating to reflect this additional data and the impacts it may have on flow frequency throughout the Upper Mississippi River Basin.

Report Format

The report is organized into a main report that gives a general overview of the Mississippi River Basin and study approach including flood distribution selection, quality assurance/quality control, public involvement and coordination. Each of the five COE Districts within the Upper Mississippi River Basin (MVP, MVR, MVS, NWO and NWK) will have an appendix summarizing their hydrologic and hydraulic analysis. Appendix A is developed by the Hydrologic Engineering Center (HEC) and provides a detailed summary of the technical procedures adopted for the study and the efforts made to assure regional consistency of the frequency relationships and flood profiles between the districts.

Acknowledgements

The Corps of Engineers and the St. Paul District would like to thank the numerous Federal, State, and Local government agencies for their involvement and the public for their support and comments throughout the course of this very complex and comprehensive investigation. Without your support this study would not have been successful.

HYDROLOGY

BASIN DESCRIPTION

Watershed Characteristics

This study encompasses the entire Mississippi River watershed area of about 714,000 square miles above the mouth of the Ohio River at Cairo, Illinois. The portion of the study area within the St. Paul District includes about 79,400 square miles above Lock and Dam 10 at river mile 615.1 miles above the mouth of the Ohio River at Cairo, Illinois. The area of the Upper Mississippi River within the St. Paul District is comprised of six major hydrologic units representing a diverse landscape and wide range of hydrologic conditions. The principal drainage units displayed in **Plate B-1** include the Headwaters of the Mississippi River area above St. Paul, Minnesota River, St. Croix River, Chippewa River, the Black and Root River drainage unit and the Wisconsin River.

Watershed characteristics vary considerably from the Mississippi River's origin at Lake Itasca in the headwaters area, which is dominated by lakes and forest to the prairie pothole region of the Minnesota River basin, which has been extensively drained and is dominated by agriculture. Mean annual runoff varies from about 3.6 inches in the western portion of the Minnesota River basin to about 9.5 inches in the St. Croix River basin.

Climatology

The Upper Mississippi River in the St. Paul District lies in the continental humid zone. Mean annual precipitation varies from about 23 inches in the western portion of the Minnesota River Basin to about 32 inches in the southern extremes of the district and the lower Wisconsin River. Mean annual snow depths vary from 36 inches in the western and southern portions of the District to 50 plus inches in the northern regions. Temperatures vary from lows in the winter months of – 20 to -30°F to highs in the summer months in the 90s to low 100s °F.

Flood History

Flooding in the Upper Mississippi River within the St. Paul District boundaries is primarily caused by spring snowmelt runoff or a combination of snowmelt and spring rainfall. Flood peaks occur from late March to well into June in years where late spring rainfall can exacerbate spring flooding. The largest floods on record have typically peaked in mid to late April. The four highest flood peaks on record beginning with the largest are 1965, 1969, 1997 and 1952. These flood peaks are listed in **Table B-1**.

Water Resources Development

Water resources development In the Upper Mississippi River within the St. Paul District began in the late 19th century and continues to be important to commerce and well being of the inhabitants of the Upper Midwest. The two most significant projects within the St. Paul District are the Mississippi River Headwaters Reservoirs and the navigation locks which extend from the Falls at St. Anthony to L/d 10 at McGregor Iowa (see **Plate B - 1**). The Headwaters reservoirs were authorized in the late 1800s for purposes of flow augmentation for river navigation during periods of low flows. With the construction of the Locks and Dams system in the 1930s, the need for Headwaters reservoir releases to assist navigation was virtually eliminated. Although the original Headwaters authorization has not changed, they are currently regulated for recreation, some local flood control and other purposes.

FLOOD FREQUENCY ANALYSIS

Methodology

An investigation of flood frequency distribution estimation methods (see Appendix A) resulted in a recommendation by the Technical and Interagency Advisory Groups (TAG and IAG) to use the basic methodology described in Bulletin 17B for obtaining at-site estimates of flood distributions for the Upper Mississippi Basin Flood Frequency Study. The Bulletin recommends the log-Pearson III distribution with method of moments to estimate flood quantiles (e.g., the 1% chance annual peak flow). The TAG and IAG also recommended regionalization of the flood statistics to obtain consistent flood quantile estimates. Regional shape estimation also involves estimating average skew values for statistically homogenous regions and substituting this average value for the at-site value when estimating the flood-frequency distribution.

Flood regions may be defined by the confluence of major rivers (e.g., Kansas and Missouri, Illinois and Mississippi, Mississippi and Missouri), a change in climatology or some other feature that is manifested in the observed flow series. A statistical approach was proposed by the Technical Advisory Group (TAG) to obtain regional boundaries (see Hydrologic Engineering Center, 2000). The approach taken was to identify boundaries based on channel characteristics, statistical variation of flood characteristics, and climate across the study area. Once regions with statistically similar flood characteristics were defined, a regional skew coefficient (a regional shape parameter) was obtained as an average of the at-site gage estimates within the region. The flood frequency distribution is computed from the at-site mean and standard deviation combined with the regional skew coefficient used as the adopted skew coefficient. Flood distributions in between gages are obtained by a linear smoothing relationship of the mean flow and the standard deviation with drainage area.

DATABASE

Stream Flow Records

The systematic record of observed stream flows varies in length with the longest period of record available extending back to 1867 at St. Paul. Daily streamflow and annual instantaneous peak flow records maintained by the USGS exist at the stations of St. Paul and Winona in Minnesota, Prescott, Wisconsin and McGregor, Iowa. **Table B - 1** lists the instantaneous peaks for the USGS stations on the Mississippi River mainstem within the St. Paul District. The table does not list the entire systematic record for each site, but only the records since 1898. The records prior to 1892 have been found to be unreliable by the USGS as documented in the Water Resources Data records published by the USGS. The records prior to 1898 also were omitted for additional reasons discussed in a subsequent section titled “Land Use Impacts”.

In addition to these stations maintained by the USGS, the Corps has stage records at LaCrosse, Wisconsin, which were used to generate a daily streamflow record at this site for the previous 1978 frequency update. This station was not used for this study due to additional uncertainty in interpreting discharges from a rating curve that has likely changed with time and the station statistics derived from this series of discharges did not agree with statistics from other regional Mississippi River mainstem stations when plotted versus drainage area.

The Upper Mississippi River experienced a major flood in 2001. The unpublished peak discharge estimate for this flood at St. Paul is 142,000 cfs, which is the third highest flood on record since 1898. This flood event was not included as part of the period of record for this large basin study as it occurred after the regionalization of statistics and supporting analysis. The estimated discharge was preliminary at the time this analysis was being completed and the effort was too far along to go back and include this event. A sensitivity analysis was performed at the St. Paul gage to determine the impacts on that frequency curve if the estimated peaks for latest 3 years of record (1999, 2000 and 2001) were included. The analysis indicates the 1% quantile flood peak would increase by about 2000 cfs. The inclusion of 2001 flood does result in a station skew of –0.214 that is less negative than the station skew for the record through 1998 of –0.269. This demonstrates how sensitive the skew parameter is to individual events either on the low or high end of the range of discharges in the systematic record. The influence of the 2001 flood on this frequency curve analysis is discussed later in the final frequency curve selection.

Historic Data

Historic information (recording of stages that are not part of the systematic record) will not be included in the data set used to estimate station statistics because it is not reflective of runoff conditions represented by the systematic record since 1898. Also, information dating back to the mid-1800s is not homogeneous with the data for the period from 1898-1998 due to the many changes that occurred with respect to landuse during the mid to late 1800s. The gages being analyzed have systematic records in excess of 100 years without the historic information. The use of historic data may introduce more uncertainty into the frequency curve at St. Paul than exists using the systematic discharge record and regionalized statistics.

The St. Paul gage has a historic period dating back to 1851 when a stage was documented. This stage has no discharge estimate associated with it, but is thought to be less than the 1965 flood of record. The use of this historic information extends the record length at St. Paul to 148 years from the 101-year systematic record recommended for this frequency curve analysis. Use of the historic period lowers the 1-percent flood peak by about 3000 cfs from 148,000 cfs to 145,000 cfs when a regionalized skew is applied to the estimate. This minor change does not warrant a deviation from the system-wide approach being proposed for this study using consistent period of records for all gages. Consequently, the Corps Districts, HEC, TAG and the IAG (see HEC, 2000) agreed that historic information was not useful in estimating the flood frequency distributions in the UMRB mainstem analysis.

Climate Impacts

Flood frequency analysis typically assumes that annual flood events are independent, random events and there are no trends or persistence exhibited in the annual flood data. A review of the annual flood peaks at the St. Paul gage indicates that 9 of the top 10 floods have occurred since 1950. In addition, a plot of the cumulative long-term departure from the period of record mean flow shows an upward trend during the period beginning about 1950. This upward trend is also reflected in plots of Devils Lake and Lake Superior elevations for this same period. The task force for the UMRB Flow Frequency Study turned to the U.S. Army Institute for Water Resources (IWR) to do an investigation of how climate variability and change may affect flood probability.

Table B-1. Upper Mississippi River Annual Instantaneous Peak Discharges

YEAR	ST. PAUL	PRESCOTT	WINONA	McGREGOR
1898	35800	82700	83000	
1899	36800	51600	95600	
1900	25800	33500	72200	
1901	19800	39600	96900	
1902	19800	36700	47200	
1903	43000	68700	136000	
1904	51800	50600	75300	
1905	59800	82400	125000	
1906	50600	74000	118000	
1907	50600	75200	115000	
1908	73000	93900	119000	
1909	48900	53100	75300	
1910	35800	45500	63600	
1911	40000	42000	32600	
1912	39000	65100	95600	
1913	15800	29000	67400	
1914	40500	67800	107000	
1915	31100	40000	73200	
1916	73500	96800	160000	
1917	68600	85500	116000	
1918	22500	31300	80800	
1919	54500	68700	110000	
1920	53100	88800	157000	
1921	19500	29300	44700	
1922	46000	88800	145000	
1923	13200	22500	60000	
1924	12900	17800	54400	
1925	16800	19800	38000	
1926	14500	23400	57100	
1927	35000	51600	62600	
1928	33000	54000	80800	
1929	45800	49600	78300	
1930	22000	33700	41100	
1931	9670	22400	31600	
1932	17600	30300	62600	
1933	14400	19800	38600	
1934	40000	15000	55500	
1935	12600	36200	76200	
1936	37500	52500	94900	
1937	23300	31000	49200	54700
1938	38800	60700	93400	101400
1939	35600	65000	93900	96900
1940	23700	33800	51700	52100
1941	39400	67600	86700	96400
1942	30300	42400	103000	123000
1943	58200	80200	135000	137000
1944	56900	84700	105000	122500
1945	53400	87500	115000	127700
1946	41000	65500	92700	101200
1947	46500	63100	79400	85500
1948	46900	63100	77100	84000
1949	43200	53800	65200	73100

Table B-1 (cont.)
Upper Mississippi River
Annual Instantaneous Peak Discharges

YEAR	ST. PAUL	PRESCOTT	WINONA	McGREGOR
1950	53900	101000	122000	123300
1951	92800	128000	178000	185700
1952	125000	155000	190000	197500
1953	47000	67700	82800	86200
1954	43500	82800	156000	165500
1955	25700	45200	64400	73700
1956	34900	62700	91700	105000
1957	78400	94000	95800	95800
1958	18200	28400	43500	55800
1959	22200	35300	41900	72300
1960	43300	54000	70000	83100
1961	22600	46300	67600	114000
1962	56400	76300	92200	104000
1963	31600	41400	51400	72000
1964	33400	57600	65700	75600
1965	171000	228000	268000	276000
1966	49400	74800	105000	112000
1967	52200	87800	166000	170000
1968	27300	40200	75000	97900
1969	156000	199000	218000	215000
1970	35800	54900	64400	72100
1971	49800	83000	133000	138000
1972	51600	95500	98700	116000
1973	51800	78300	136000	151000
1974	39500	65200	81600	104000
1975	78300	112000	166000	183000
1976	33400	72800	120000	125000
1977	18800	26100	44800	42000
1978	40100	65400	89000	104000
1979	75400	100400	131000	133000
1980	30200	43100	69000	87400
1981	25900	43400	69800	80700
1982	57600	86700	138000	139000
1983	64100	84200	138000	145000
1984	70800	90900	106000	117000
1985	55600	73400	101000	110000
1986	83300	116000	167000	168000
1987	30300	29400	40900	158000
1988	16400	28200	46800	57200
1989	29200	49000	79400	103000
1990	35500	42900	74700	98800
1991	52000	74300	92900	104000
1992	48500	69400	92000	106000
1993	104000	130000	168000	189000
1994	59100	72900	107000	115000
1995	53900	65000	84100	99600
1996	50800	82600	144000	143000
1997	134000	161000	194000	201000
1998	54400	70400	118000	126000

Their investigation and conclusions are summarized in a report titled “Flood Hydroclimatology in the Upper Mississippi and Missouri Rivers Basin”, (J. Rolf Olsen and Eugene Z. Stakhiv, June 1999).

The analysis by IWR found statistically significant upward trends in some of the gage records along the Upper Mississippi and Missouri Rivers, and the most likely cause of the trends being natural climate variability. The conclusions from their analysis of these trends were: “Trends in the Upper Mississippi basin challenge the traditional assumption that flood series are independent and identically distributed random variables and suggest that flood risk may be changing over time. As a result, it is not clear how to accommodate this shift within traditional flood frequency analysis. In absence of viable alternatives the use of Bulletin 17-B procedures are warranted until better methods are developed. Research is needed in how to incorporate interdecadal variation in flood risk into flood frequency analysis so that state and federal water agencies can move to adopt procedures that appropriately reflect such variation.”

The ability of General Circulation Models (GCM’s) to predict future climate remains uncertain. At this time there is little evidence that flood frequencies are increasing or will increase as a result of global warming. The IWR climate research also found evidence of increasing temperature and precipitation in the Upper Midwest. The increase in precipitation and temperature may offset each other due to increased evapotranspiration (ET) as the precipitation increases are due to a slight increase in heavy rainfall events that fall during periods of increased potential ET. This is born out by an analysis of streamflow gages, which show an equal number of uptrends and downtrends in annual minimum and median flows.

At this time, there appears to be no compelling evidence that would indicate that the Upper Midwest is experiencing a climate trend that should be accounted for in this flood probability update. State and Federal water resource projects typically have project lives of 50 plus years. Frequency curves for large mainstem studies such as this study are typically updated on a 10-20 year cycle. Until a method of incorporating interdecadal variation into flood probability analysis is developed and adopted by the scientific community and water resource agencies, the recommendation by the TAG and the IAG (see HEC, 1999 and 2000) is to continue using current Bulletin 17B guidelines for this frequency analysis without climate adjustments.

Land Use Impacts

Man has had a significant impact on the hydrology of the Upper Mississippi River basin. Settlers began clearing forests for lumber and fuel in the early 1800s. This continued throughout the 1800s and by the end of the 19^{th} century the harvesting of forests was on the decline. It was during this same period that the prairies were converted to agriculture. This prairie conversion radically changed the vegetation on the landscape and led to drainage of wetlands and ditching to improve drainage from the flat prairie landscape. Drainage districts became very popular and in the first half of the 20^{th} century. Through these drainage districts, public funding was used to not only increase the total extent of the ditch system in the Upper Mississippi, but also to make these systems more efficient. In addition to the ditching, tile systems are employed to further improve the drainage of the landscape and remove water at a much faster rate. Tiling of depressional areas continues to take place throughout the Upper Mississippi River Basin in response to an extended period of above average precipitation that has plagued farmers in the last half of the 20^{th} century.

Much of the landuse change experienced in the UMRB occurred prior to 1900. The hydrologic records collected since 1900 at the Mississippi River mainstem stations reflects the effects of deforestation and prairie conversion. The change in landuse since 1900 has also had some effect on these hydrologic records. These changes occurred gradually and are distributed through various regions of the watershed. It would be very difficult to adjust the hydrologic records since 1900 to reflect the impact of these landuse changes without introducing additional uncertainty into the frequency curve analysis. Therefore, the period of record from 1898-1998 will be used for this study and is considered stationary with respect to land use.

Regulation Impacts

St. Paul to McGregor

The regulation of tributary dams has had an effect on streamflow throughout the UMRB. A fundamental assumption in frequency analysis is that the period of record data being used for computation of station statistics are stationary with respect to climate and is homogeneous (unaffected by land use change and other human activities). The period of record (1898-1998) is considered to be homogeneous, resulting from a stationary random process given the small influence of climate and land use change over this period. It was also necessary to remove the affects of regulation from this annual series of peak discharges at all the gages being studied to account for the addition of reservoir storage and changes in regulation plans over time. The resultant "Un-regulated" discharges provide a set of data appropriate for application of the regional shape estimation method.

The most upstream station in the UMRB frequency study is the USGS station (05331000) at St. Paul, Minnesota. This record was checked for the impacts from regulation of dams upstream of St. Paul in the Mississippi River headwaters and also from a flood control project in the headwaters of the Minnesota River basin at Lac Qui Parle. The Mississippi River Headwaters reservoirs consist of Cross Lake, Gull, Leech, Pokegema, Sandy and Winnibigoshish. The two largest of these lakes with the largest storage volumes, Winnibigoshish Lake and Leech Lake are over 400 miles upstream of St. Paul. The remaining reservoirs have limited flood control capability, which benefits the communities immediately downstream. Hydrologic studies were conducted to determine the approximate effects these reservoirs have on peak flows at the St. Paul gage. The studies were limited to a period from 1949 to 1995. This period has adequate data to define the reservoirs influence and downstream tributary or local inflows between the dams and St. Paul.

The HEC-1 Flood Hydrograph Package (HEC-1, Sept. 1990) was used for the hydrologic routings. The natural "Un-Regulated" flows from the lakes were determined by routing the reservoir inflow hydrographs through the lakes with a natural outflow condition (i.e. without the dams). The natural outflow rating curves were obtained from previous studies of the Headwaters lakes and of Lac Qui Parle reservoir. These Un-regulated hydrographs were routed downstream and combined with local and tributary inflows to derive the Un-regulated peak flows for each flood year. The results of these routings are tabulated in **Table B-2.** The table lists various gages in the tributaries above the mainstem gaging station at St. Paul to demonstrate how far downstream of the reservoir the regulation affects extend. The results of these routings and the impacts at St. Paul are displayed in **Figure B-1.**

Table B-2. Upper Mississippi River Regulated -Vs- Unregulated Annual Peak Discharges

	Headwaters Of Mississippi				Minnesota River					
Year	Aitkin		Anoka		Montevideo		Jordan		Saint Paul	
	Regulated	Unregulate	Regulated	Unregulate	Regulated	Unregulate	Regulated	Unregulate	Regulated	Unregulate
1949	4770	4421	17100	17843	1800	3325	31600	32047	42800	44388
1950	19900	23460	50300	50538	2860	5239	12500	12637	53700	53953
1951	8600	10808	41600	41626	12100	16901	62900	63464	92700	95382
1952	10000	11955	74600	74239	24200	32872	59100	66795	124000	127574
1953	10700	12410	33900	34188	9630	12028	22900	22136	46600	48360
1954	9440	12086	35600	38069	2360	3569	10200	10475	43400	45819
1955	7850	7840	21700	21779	2090	2764	7600	7545	25300	24662
1956	9750	10273	29100	29454	2030	2475	12000	12009	34700	35408
1957	9320	8146	44200	42407	5130	7330	40200	41597	78400	77954
1958	3080	3084	11000	11290	3040	3787	7620	8155	17900	18407
1959	7080	7631	20400	20843	1020	1038	3860	3969	22000	22434
1960	8630	9145	21900	21475	5980	6897	35100	35106	43200	44830
1961	5970	5404	15100	15272	1170	1111	15600	15796	22300	22635
1962	9300	9334	39400	38597	5790	7388	39400	39684	56200	56924
1963	6710	5265	22100	22378	2330	2597	14400	14473	31300	31600
1964	8990	9891	23700	23855	2370	2682	12900	12931	33200	32891
1965	13300	12535	90300	89901	12600	19526	112000	112295	171000	171798
1966	12600	14333	42200	43081	8070	10843	16000	14740	49000	50623
1967	8520	9861	40600	39681	3980	5460	19300	20710	52100	52173
1968	5970	6615	24700	24615	824	1183	37200	37436	58200	58228
1969	14400	14137	72300	70548	34400	48832	84500	85993	154000	152912
1970	9110	10208	25500	25888	2800	3095	11800	11958	34100	34370
1971	12200	13505	34800	33844	3400	4368	24100	33182	49500	48247
1972	10500	11729	44500	45144	8990	10120	16800	17745	51400	52044
1973	8940	8871	34900	35308	5330	6601	21500	23074	51600	53270
1974	11000	10456	28800	28600	1120	1483	13800	13676	39400	38719
1975	14500	14783	58800	59159	2910	5041	22900	24702	78100	80398
1976	7150	6904	28700	28235	2250	3175	5470	6632	33200	33685
1977	5290	4498	13800	12949	1760	4279	6580	7597	15700	15149
1978	8840	8669	28000	28783	8810	9834	13800	15642	39800	42532
1979	13300	15515	49400	51622	12000	15095	32000	38380	75400	80735
1980	4290	4885	19400	20094	1910	2597	14200	14691	30200	31163
1981	6100	5669	14700	14128	2060	3166	12400	12533	25900	26469
1982	12200	12305	44200	44185	4260	5400	17200	17480	57400	57588
1983	5810	5263	30800	30745	2160	2796	33300	33730	64100	64027
1984	9020	8904	45600	45293	8340	10309	44800	47157	70800	73428
1985	9370	10347	38100	38499	11000	15594	31900	31244	55400	55338
1986	10700	10817	50100	50444	13800	14581	36600	39311	83000	82633
1987	6100	5199	15300	14634	2120	3574	9220	9703	23700	24708
1988	4980	4866	11400	11813	1430	1366	5530	5610	16400	16607
1989	8810	9519	22300	21366	3640	6386	14000	13831	29200	30751
1990	6660	7326	19800	19946	1640	2876	16800	16865	35500	35917
1991	7430	7903	28900	29039	6290	6609	33000	34561	52000	52486
1992	5810	6302	21600	22047	8810	13773	26100	26205	48500	49095
1993	9780	9760	34400	34091	11100	11785	90900	91375	104000	104944
1994	7950	8370	35100	35820	11300	14493	22200	22411	58900	59404
1995	7930	7561	30200	29839	10100	16440	29600	31509	53700	55168
1996					9340	10746	22700	21808		

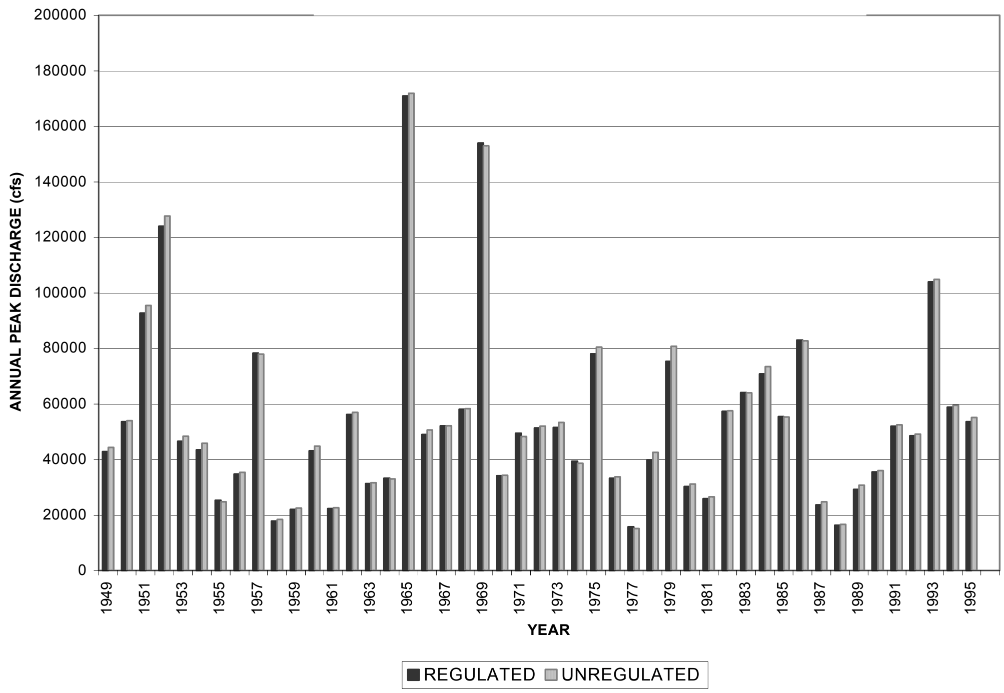


Figure B-1. St. Paul Gage, Regulated-vs-Un-regulated Discharge Comparison

This bar graph in **Figure B-1** indicates the magnitude for the regulated and un-regulated flood peak for each year from 1949 to 1995. The graph demonstrates that there is very little difference between the regulated and un-regulated flows at St. Paul. Since regulation of the headwaters reservoirs has little effect on peak flows at St. Paul, it can be assumed to have no effect on stations further downstream. In addition to the headwaters reservoirs, there are many small impoundments on the tributaries between the gage at St. Paul and the gage at McGregor, Iowa. These impoundments typically have very little flood storage and individually will have some impacts on flows immediately downstream, but have little effect on Mississippi River mainstem flows. It would be difficult to assess their impacts due to lack of adequate flow records at most of these sites. Therefore, the observed peak flow records at Prescott, Winona and McGregor will also be treated as un-impaired by regulation and the observed records will be used without adjustments for regulation influence for subsequent flood probability estimates. The observed peak discharges were used for regionalization studies and were also used to compute the final flood probabilities at the gaging stations within the St. Paul District.

Below McGregor

In the early phase of the overall study, the study team was required to provide HEC with Un-regulated flow data for all the mainstem gages. This data was to be used in the sensitivity analysis for the selection of study methodology and also for regionalization of statistics. The study team members from Rock Island and St. Paul believed that the observed record at Clinton was relatively unaffected by upstream regulation and could be used without doing the further analysis to confirm this assumption. The value added to the study by determining the minor regulation affects from the

Wisconsin River did not justify the cost of performing this complex analysis. A brief analysis of Wisconsin River data was performed to support these assumptions.

The Wisconsin River confluence with the Mississippi River at river mile 631 is downstream of the USGS gage at McGregor and therefore, has no effect on stream gages within the St. Paul District. It is a highly regulated river system and does have an effect on Mississippi River discharges below the confluence. These effects are primarily in the spring due to drawdown of Wisconsin River reservoirs. Most of the reservoirs are run-of-river hydropower operations and during the remainder of the year and have minimal impact on discharges at the mouth of the river. The effects of regulation for the period from 1915-1976 were determined by the USGS in Water Resource Investigations Open File Report 80-1103, "Streamflow Model of the Wisconsin River for Estimating Flood Frequency and Volume". The results of this study are tabulated in **Table B-3.**

This data was reviewed for the period from 1915-1976 to determine the number of floods that may have affected flood peaks downstream. The two largest reservoirs in the system, Pentenwell Flowage and Castle Rock Flowage were not put into operation until 1950. Prior to that year the effects of regulation on flood peaks was negligible. A review of flood peaks after 1950 for timing with downstream peaks and measurable regulation effects found a number of regulated flood peaks on the Wisconsin River that could have affected peak discharges at downstream gages in the 1950-1976 period. The difference between the regulated and un-regulated peaks at Muscoda for this period is tabulated in **Table B-3**. This would also be the maximum increase in peak discharge at Clinton for these respective years if the discharges were transferred without attenuation or lag. Attenuation and timing of this regulated peak would significantly reduce the increases in peak discharge at Dubuque and Clinton, which are 85 and 150 river miles downstream of Muscoda.

A UNET analysis of historic floods near the Wisconsin River confluence indicates that floodplain storage between Muscoda and Lock and Dam 10 has a significant attenuating affect on Wisconsin River peaks as they enter the Mississippi River floodplain. It is doubtful that the un-regulated peaks off the Wisconsin River since 1950 have a measurable affect on the Dubuque or Clinton peaks during the latter half of these records. A review of the Dubuque and Clinton records for the entire period indicates randomness between the respective peaks for given years. Some years Dubuque is higher than the Clinton flood peak and this is true throughout the period of record and not just prior to 1950 when the larger reservoirs were introduced on the Wisconsin River.

A sensitivity analysis was performed at the Clinton gage to determine the affects on the station statistics with and without regulation of the Wisconsin River. It was assumed that attenuation between Muscoda and Clinton would reduce the increase in the unregulated peak at Muscoda by a conservative 50 percent for the analysis. Therefore, 50 percent of the increase between the Muscoda regulated and un-regulated peak was added to the Clinton observed peak flows for the years in which regulation effects were determined. On average, this yielded about a 5 percent increase in the Clinton peak discharge for the years in question. The analysis indicated that the Clinton mean and standard deviation are unaffected by regulation and the skew is less negative when regulation affects are removed. Since the Wisconsin River regulation has a minimal impact on Clinton flood statistics, the Clinton observed flood peaks for pre and post Wisconsin River regulation will be considered homogeneous and shall be used without adjustments for regulation in computation of the frequency curves at this Mississippi River gage.

Table B-3. Wisconsin River at Muscoda - USGS Gage 05407000 Regulated -vs- Un-Regulated Flow Comparison

Year	Date	Muscoda Regulated Peak Flow (1)	Muscoda Un-Regulated Peak Flow (2)	Muscoda Regulation Effects (2-1)	Date	Clinton Peak Flow	Date	Dubuque Peak Flow
1914	1914.06.13	45700			1914.07.14	111000	1914.7.12	121000
1915	1915.04.17	24200	25000		1915.04.23	92000	1915.4.21	95000
1916	1916.04.29	54300	57000		1916.05.05	195000	1916.5.3	188000
1917	1917.04.11	33200	33600		1917.04.21	142000	1917.4.18	133000
1918	1918.06.05	40800	43200		1918.06.13	123000	1918.6.11	112000
1919	1919.04.16	42500	43800		1919.04.25	166000	1919.4.22	147000
1920	1920.04.02	63300	65700		1920.04.09	222000	1920.4.7	204000
1921	1921.05.06	39500	40400		1921.05.12	85300	1921.5.10	77000
1922	1922.04.16	72100	75400		1922.04.23	212000	1922.4.21	199000
1923	1923.04.27	52500	56400		1923.04.07	106000	1923.5.3	94000
1924	1924.04.24	42500	44200		1924.08.23	106000	1924.5.8	87000
1925	1925.06.22	25100	26500		1925.06.19	93900	1925.6.25	81000
1926	1926.08.29	43800	45300		1926.09.26	83600	1926.10.5	82000
1927	1927.03.20	43000	44800		1927.03.31	133000	1927.2.8	130000
1928	1928.09.22	52600	56600		1928.04.09	116000	1928.4.7	104000
1929	1929.04.14	51800	56700		1929.04.02	146000	1929.4.17	140000
1930	1930.	38400	41800		1930.06.28	83600	1930.6.26	73000
1931	1931.06.29	11300	13500		1931.07.06	40700	1931.12.3	47000
1932	1932.04.14	40800	44100		1932.04.22	97500	1932.4.20	94000
1933	1933.04.07	30000	32200		1933.04.08	92100	1933.4.11	81000
1934	1934.04.12	36800	38200		1934.04.19	81400	1934.4.17	82000
1935	1935.03.29	62200	64600		1935.04.07	123000	1935.4.3	130000
1936	1936.03.31	48100	49600		1936.04.07	133000	1936.4.5	137000
1937	1937.05.02	27900	31900		1937.03.08	95800	1937.3.8	84000
1938	1938.09.16	80800	80800		1938.09.23	167400	1938.9.21	184000
1939	1939.04.02	50700	55900		1939.04.09	144900	1939.4.6	145000
1940	1940.07.01	50700	51000		1940.06.19	74100	1940.6.18	72000
1941	1941.09.08	44300	47500		1941.04.25	128200	1941.4.23	129000
1942	1942.06.07	54600	54200		1942.06.13	169600	1942.6.12	166000
1943	1943.06.06	57900	62800		1943.06.30	158700	1943.6.29	161000
1944	1944.06.19	27200	30000		1944.06.28	168500	1944.6.27	162000
1945	1945.03.25	46300	57600		1945.03.31	164400	1945.3.29	161000
1946	1946.03.21	51300	59200		1946.03.28	144800	1946.3.27	146000
1947	1947.04.12	30700	37300		1947.06.15	125500	1947.6.14	118000
1948	1948.03.28	27900	35600		1948.03.21	108300	1948.3.31	104000
1949	1949.04.07	13200	16900		1949.04.07	85300	1949.4.4	83000
1950	1950.04.24	30700	36100		1950.05.22	129900	1950.5.20	136000
1951	1951.04.14	64800	79100	(14300)	1951.04.26	221500	1951.4.22	223000
1952	1952.04.16	31500	54500	(13000)	1952.04.27	225400	1952.4.25	223000
1953	1953.04.15	24600	49300		1953.04.05	104100	1953.4.1	103000

Table B - 3 (Continued)

Year	Date	Muscoda Regulated Peak Flow(1)	Muscoda Un-Regulated Peak Flow (2)	Muscoda Regulation Effects (2-1)	Date	Clinton Peak Flow	Date	Dubuque Peak Flow
1954	1954.05.09	31900	40900	(9000)	1954.05.14	175900	1954.5.12	183000
1955	1955.06.16	25600	33100		1955.04.25	96900	1955.4.14	95000
1956	1956.04.15	31600	50000	(18400)	1956.04.20	127000	1956.4.19	125000
1957	1957.06.12	12000	16500		1957.07.14	103000	1957.7.13	99000
1958	1958.07.11	10700	21500		1958.04.16	64500	1958.4.16	59000
1959	1959.04.03	25300	38300		1959.04.03	112000	1959.4.2	105000
1960	1960.05.12	67200	71900		1960.05.18	151000	1960.5.17	144000
1961	1961.04.03	35800	53100		1961.04.02	143000	1961.3.31	134000
1962	1962.04.14	34800	44900	(10100)	1962.04.21	138000	1962.4.19	128000
1963	1963.05.18	22800	39400		1963.04.02	90900	1963.4.2	86000
1964	1964.05.13	18100	21900		1964.05.19	84000	1964.5.18	83000
1965	1965.04.18	48500	69800	(21300)	1965.04.28	307000	1965.4.26	307000
1966	1966.03.27	34100	40500	(6400)	1966.04.01	143000	1966.3.30	136000
1967	1967.04.07	54200	76500	(22300)	1967.04.14	207000	1967.4.11	214000
1968	1968.07.02	43600	40900		1968.07.07	131000	1968.7.5	127000
1969	1969.07.03	45700	49400		1969.04.25	231000	1969.4.23	231000
1970		19700	27200		1970.06.08	93000	1970.6.6	91000
1971	1971.04.16	39100	57200	(18100)	1971.04.23	168000	1971.4.21	167000
1972	1972.04.24	48200	62800	(14600)	1972.05.02	153000	1972.4.29	147000
1973	1973.03.20	65000	78100	(13100)	1973.03.25	207000	1973.3.23	215000
1974	1974.04.18	30100	36100		1974.06.24	158000	1974.6.22	143000
1975	1975.05.03	42800	49100		1975.05.07	214000	1975.5.6	233000
1976	1976.04.04	46700	58300		1976.04.11	154000	1976.4.9	166000
1977	1977.04.25	11400			1977.07.19	50800	1977.12.26	90000
1978	1978.07.10	31800			1978.04.21	128000	1978.4.19	130000
1979	1979.03.28	44300			1979.05.05	153000	1979.5.4	156000
1980	1980.09.27	47200			1980.09.30	108000	1980.9.30	119000
1981	1981.04.11	28800			1980.10.01	113000	1981.4.14	98000
1982	1982.04.08	43600			1982.04.29	163000	1982.4.27	175000
1983	1983.03.13	51100			1983.03.19		1983.3.17	193000
1984	1984.05.05	39300			1984.05.11	134000	1984.5.10	140000
1985	1985.04.03	31500			1985.04.08	139000	1985.4.7	141000
1986	1986.04.06	47600			1986.04.13	195000	1986.10.5	215000
1987	1986.10.03	55500			1986.10.06	201000	1987.3.15	66000
1988	1988.03.14	13200			1988.04.06	65800	1988.4.1	78000
1989	1989.06.04	24200			1989.04.06	104000	1989.4.4	115000
1990	1990	42600					1990.6.22	121000
1991	1991.04.01	36600			1991.06.11	137000	1991.6.16	137000
1992	1992.04.22	33500			1992.04.30	147000	1992.4.29	134000
1993	1993.06.26	59600			1993.07.07	239000	1993.7.1	247000
1994	1994.05.01	31200			1994.05.08	148000	1994.5.6	138000
1995	1995.09.03	24700					1995.5.10	114000

Note: The Muscoda Regulated effects column shows difference between Wisconsin River regulated and un-regulated flow at Muscoda.

REGIONAL ANALYSIS

General

The Technical and Interagency Advisory Groups (TAG and IAG) to the Corps of Engineers recommended regional shape estimation be adopted for computing the annual maximum flood distributions at a gage based on a comprehensive study of methods made by HEC (1999). The regional estimation employs the Log-Pearson III distribution estimated from the method of moments as is recommended in the federal guidelines (see Bulletin 17B, IACWD, 1982). The regional shape estimation differs from the guideline method in that regional skew is used instead of a weighted skew. The regional skew is taken as the average skew for the stations within a homogenous flood region. The TAG and IAG also recommended linearly interpolating the mean and standard deviation between gages with drainage area based on regional investigations performed by HEC and the Corps Districts (see HEC, 2000).

Regional Smoothing

The at-site statistics at St. Paul, Prescott, Winona, and Clinton are based upon the observed period of record annual instantaneous peak discharges for period from 1898-1998. The discharge records at Keokuk were adjusted to account for regulation affects in upstream tributaries. This resultant "Un-regulated" discharge record was used to determine the at-site mean and standard deviation for this gage location. The at-site or station mean and standard deviations for these gaging stations are listed in **Table B-4**. The McGregor at-site mean and standard deviation are for the period of record from 1937-1998. These statistics are reflective of shorter period of above average runoff and do not follow the trend of the other stations in the Upper Mississippi River above Keokuk, Iowa. A sensitivity analysis of the statistics at St. Paul and Winona for the same period of record from 1937-1998 found these stations also exhibited the same higher mean and lower standard deviation for this shorter period. Therefore, it is assumed that the McGregor station statistics for the longer period would also follow the trend of the statistics for the longer record lengths at the gages listed in **Table B-4**.

Table B-4. At-Site (Un-Regulated) Statistics for St. Paul District Gages Period of Record (1898-1998)

River Mile	Station	Drainage Area	Mean	Standard Deviation
839.3	St Paul	36800	4.581	0.261
811.4	Prescott	44800	4.756	0.234
725.7	Winona	59200	4.944	0.193
633.4	McGregor (1937-1998)	67500	5.038	0.161
518.2	Clinton[1]	85600	5.114	0.146
364.0	Keokuk[1]	119000	5.248	0.142

1. Clinton and Keokuk gages are located in Rock Island District, but are listed since they are included in St. Paul District smoothing analysis. The McGregor statistics are for a shorter record from 1937-1998.

The frequency curve for the McGregor, Iowa gaging station will be based on regionalized relationships developed from the at-site statistics listed in the preceding table. The estimates of mean and standard deviation for the annual peak flows between gages will be obtained by linear interpolation of the gage estimates with drainage area, but excludes the McGregor at-site statistics. The final McGregor mean and standard deviation will be interpolated from the linear relationship between Winona and Dubuque. Other regression methods were considered to define a 'best fit' relationship between the observed data listed in **Table B-4**, but the TAG and IAG recommended linear interpolation. The plots displayed in **Figure B-2** display the linear variation estimated for the mean and standard deviation between gages that will be used to determine regionalized statistics for McGregor and other points of interest between the gaging stations. The data at Clinton and Keokuk are used to ensure consistency with the relationships in the Rock Island District. The final means and standard deviations to be used in the development of flood probabilities within the St. Paul District are listed in **Table B-5**.

Table B-5. Final Regionalized Statistics for St. Paul District Gages
Period of Record (1898-1998)

River Mile	Station	Drainage Area	Mean	Standard Deviation
839.3	St Paul	36800	4.581	0.261
811.4	Prescott	44800	4.756	0.234
725.7	Winona	59200	4.944	0.193
633.4	McGregor	67500	5.000	0.178

Skew Coefficients

The skew shape parameter of the Log Pearson III (LPIII) distribution can have a significant impact on flood quantiles and particularly those on the extreme ends of the frequency curve. Since the LPIII distribution is so sensitive to this parameter, it is usually recommended that the station skew be weighted with a regional skew coefficient. Bulletin 17B has a regional skew map which is typically used for this weighting. This map is a composite or regionalization of computed skews from many gaging stations, most with less than 3000 square miles of contributing area and records much shorter than the records being studied herein. [This map is not applicable to the gages on the mainstem Mississippi River which have significantly larger drainage areas.] Consequently, an investigation of the variation of skew for these larger drainage areas was performed (see HEC, 2000). Based on this investigation, the TAG and IAG recommended and the Corps adopted average skew estimates for reaches of the Mississippi River mainstem affected by similar climate and with similar flood response characteristics. This average skew is used with the at-site estimates of the mean and standard deviation of the flow logarithms to estimate the Log-Pearson III distribution.

Table B - 6 lists the station skews for the Mississippi River above Clinton, Iowa based on the period of record from 1898-1998. The station skews for the upper portion of this reach of the river tend to be slightly lower than the remainder of the Mississippi River system. This may be in part due to the predominantly snowmelt and rain on snowmelt regime characteristic of this region. A study for regionalization of skew was conducted by the Hydrologic Engineering Center (HEC, May, 2000) to provide guidance for the adoption of skew values for the upper reach of the Mississippi River system above Winona, Mn. This study looked at additional stations in the upper portion of the basin. The average skew for a set of eight stations with drainage areas greater than 1000 square miles was –0.05. The average for these stations agrees with the skew values for

Winona, McGregor and Clinton gages, which are all in the –0.1 range. The St. Paul and Prescott skew values do not fit into this range.

The computed skew at St. Paul is very sensitive to the lower flood peaks in the record. A sensitivity analysis was performed on the St. Paul record to determine how censoring the low peaks in the record would impact skew. Censoring of data is permissible under the Bulletin 17B guidelines if there is reason to suspect that the data is not homogeneous with the remainder of the record. The USGS indicated that the estimation of these very low flood peaks are more difficult to measure than is typical for flow estimates at these large mainstem stations. Censoring the two lowest flood peaks from the St. Paul record yields a skew of about –0.05, which is more typical of the average skews for the region. The skew at St. Paul for the last 50-year period is in the +0.4 range, indicative of the wet period over the last half of the century. This demonstrates how sensitive skew can be to record lengths and anomalies in the record. The regionalization of skew tends to remove some of the bias that may be introduced through use of the individual station skews that may be sensitive to a number of variables as previously discussed.

The gages immediately upstream of St. Paul were also analyzed to compare station skews at the Anoka gage on the Mississippi River headwaters and the Jordan gage on the Minnesota River with St. Paul. The Anoka gage has a station skew of –0.374. The Jordan gage on the Minnesota River has a station skew of 0.089 for the period of record of 1935-2000, indicative of the shorter, wetter record in the last half of the century. The Minnesota River confluence is immediately upstream of the St. Paul gaging station and this large tributary has a significant influence on floods at the St. Paul gage. There is a high correlation between the timing of flood peaks at Jordan and St. Paul. More weight should be put on the influence of this skew value than on Anoka when looking at concerns of timing and tributary impacts.

An analysis of regional skews by HEC for the Mississippi River mainstem indicates that a value of –0.1 seems appropriate for the gages up to Winona. There was concern that the St. Paul and Prescott stations did not fit into this group due to their location in the head of the system and station skews reflective of this region where flooding is primarily the result of spring snowmelt. Therefore, HEC performed an additional analysis of gages in this region to assist in selection of skews for these stations. The results of the regional analysis by HEC and the trend in the gage analysis for the remainder of the Mississippi River system all suggest that a skew value of –0.1 is appropriate for the Upper Mississippi River mainstem gages.

The use of –0.1 as the skew for the St. Paul and Prescott stations as opposed to a more negative skew or the station skews that are in the –0.25 range will yield slightly higher flood quantiles at the upper end of the frequency curves. These higher flood quantiles will be in better agreement with the gages downstream that are also using a skew of –0.1. Therefore, a skew value of (–0.1) will be adopted as the final skew for all Mississippi River gages in the St. Paul District study area.

Table B-6. Skew Coefficients for Upper Mississippi River Gages

River Mile	Station	Drainage Area	Station Skew	Adopted Skew
839.3	St Paul	36800	-0.269	-0.1
811.4	Prescott	44800	-0.240	-0.1
725.7	Winona	59200	-0.100	-0.1
633.4	McGregor	67500	-0.087	-0.1
518.2	Clinton	85600	-0.165	-0.1

Period of Record (1898-1998) for all gages except McGregor, which is (1937-1998)

Final Computed Frequency Curves

The final frequency curves for the mainstem gages, except at McGregor, within the St. Paul District will be based on the recommended LPIII distribution with at site mean and standard deviations and a regional skew value of –0.1. The mean and standard deviation at McGregor, and other mainstem locations between gages are obtained by linear interpolation with drainage area between gage values. The final regionalized means and standard deviations used in the frequency curve computations are those listed in **Table B-5**. The final frequency curves for St. Paul, Prescott, Winona and McGregor are displayed in **Figures B-3 to B-6**. The final adopted discharges for various return periods are tabulated in **Table B-7**. The "computed" frequency curves are reflective of the period of record from 1898-1998. The McGregor frequency curve is based on the regionalized, smoothed statistics and has an effective record length of 101 years based on the record lengths of the other gages in the study. **Table B-8** lists the previously published discharges from the 1979 Mississippi frequency analysis for reference.

The flood of 2001 occurred late in this frequency curve update and was not used in computing final statistics for this study. However, the station statistics at St. Paul were computed using the additional 3 years of record through 2001 to check the sensitivity of including this data in the analysis. A comparison of the 1% quantile flood using the station statistics and station skews for the POR through 1998 versus using POR through 2001 indicates an increase in the 1% flood quantile from 143,000 cfs to 145,000 cfs. The POR through 2001 with a regional skew of -0.1 yields a 1% flood value of 153,000 cfs at St. Paul. The adopted statistics for this study using the 1898-1998 POR and –0.1 regional skew yield a 1% flood of 148,000 cfs. This value falls between the 145,000 and 153,000 cfs range described above for the 1% flood derived from the POR through 2001.

The regional skew of -0.1 is indicative of the average for many gages throughout the region. The statistics for the 101-year period of record from 1898-1998 using a regional skew of -0.1 are good representations of flood probability for the mainstem stations within the St. Paul District. It is not justified at this time to redo the analysis including the flood of 2001 as demonstrated by the analysis above for the St. Paul gage.

Attachment B-1 includes the summary output from the FFA computer program for each of the stations. Included in this summary are the final statistics for each station with the computed frequency curve, the curve with expected probability adjustment and confidence limits, which will be used in subsequent Risk and Uncertainty analysis.

Attachment B-2 includes an additional analysis for the reach of the Mississippi River from Lock and Dam No. 10 to McGregor, Iowa. Further effort was accomplished for the refinement of the contribution of flow from the Wisconsin River. UNET statistics are used for the determination of flow between the major gaging stations in this reach.

Table B-7. Adopted Final Discharges, St. Paul District USGS Stream Gages

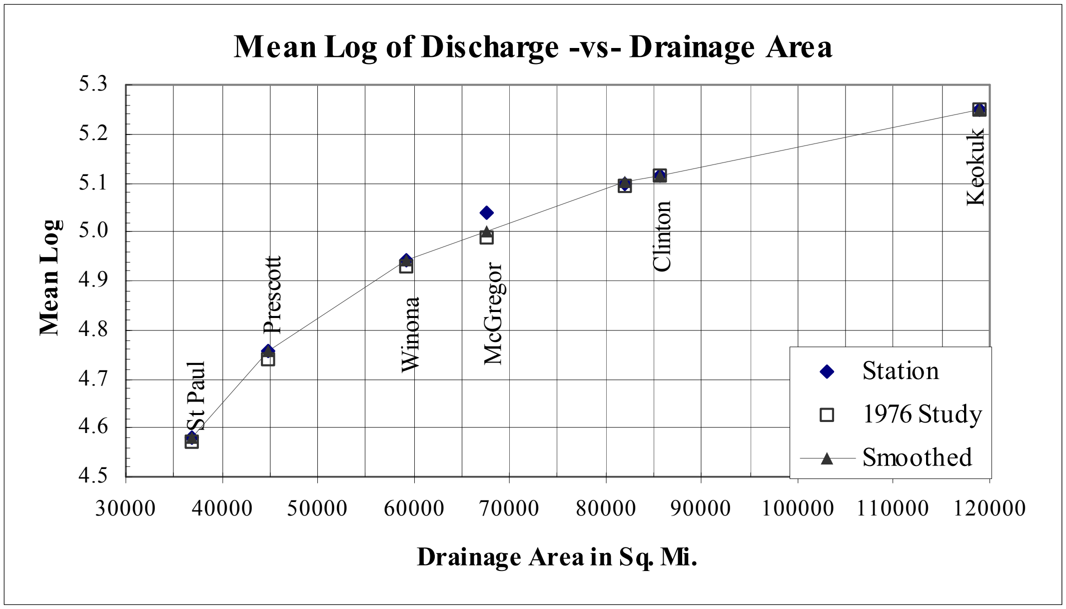
Frequency	St. Paul Gage	Prescott Gage	Winona Gage	McGregor Gage
	Regulated	Regulated	Regulated	Regulated
	Flow (CFS)	Flow (CFS)	Flow (CFS)	Flow (CFS)
2-YEAR	38,500	57,600	88,500	101,000
5-YEAR	63,400	90,000	128,000	141,000
10-YEAR	81,000	113,000	154,000	168,000
20-YEAR	101,000	136,000	180,000	194,000
25-YEAR	107,000	144,000	188,000	202,000
50-YEAR	127,000	167,000	214,000	227,000
100-YEAR	148,000	192,000	239,000	251,000
200-YEAR	169,000	217,000	265,000	276,000
500-YEAR	200,000	252,000	299,000	309,000

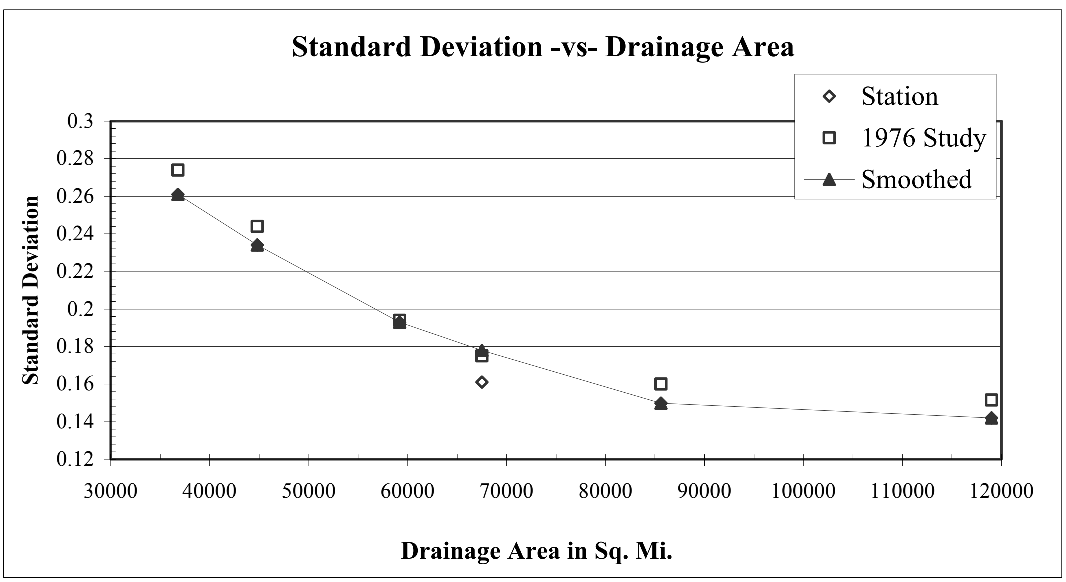
Table B-8. 1979 Published Discharges, St. Paul District USGS Stream Gages

Frequency	St. Paul Gage	Prescott Gage	Winona Gage	McGregor Gage
	Regulated	Regulated	Regulated	Regulated
	Flow (CFS)	Flow (CFS)	Flow (CFS)	Flow (CFS)
2-YEAR	37900	55500	85100	97700
5-YEAR	63500	88400	124000	137200
10-YEAR	82200	112200	150900	163800
20-YEAR	101100	136300	177500	189600
25-YEAR	107200	144100	186100	197900
50-YEAR	126700	169000	213000	223600
100-YEAR	146900	194800	240600	249500
200-YEAR	167600	221600	269000	275900
500-YEAR	196100	258700	307900	311700

Note: Discharges in Tables B-7 and B-8 are computed values without Expected probability adjustment.

Figure B-2. Smoothing at Site Statistics with Drainage Area





NOTE: Station statistics are based on period of record (POR) from 1898-1998, with exception of McGregor station where POR is from 1937-1998. The 1976 study statistics at St Paul is based on a POR of 1862-1976. The 1976 statistics for Clinton are based on POR from 1874-1975. All other 1976 study statistics are adjusted based on correlation with longer-term stations. Smoothed relationship is a linear fit between the station statistics at St Paul, Prescott, Winona, Clinton and Keokuk.

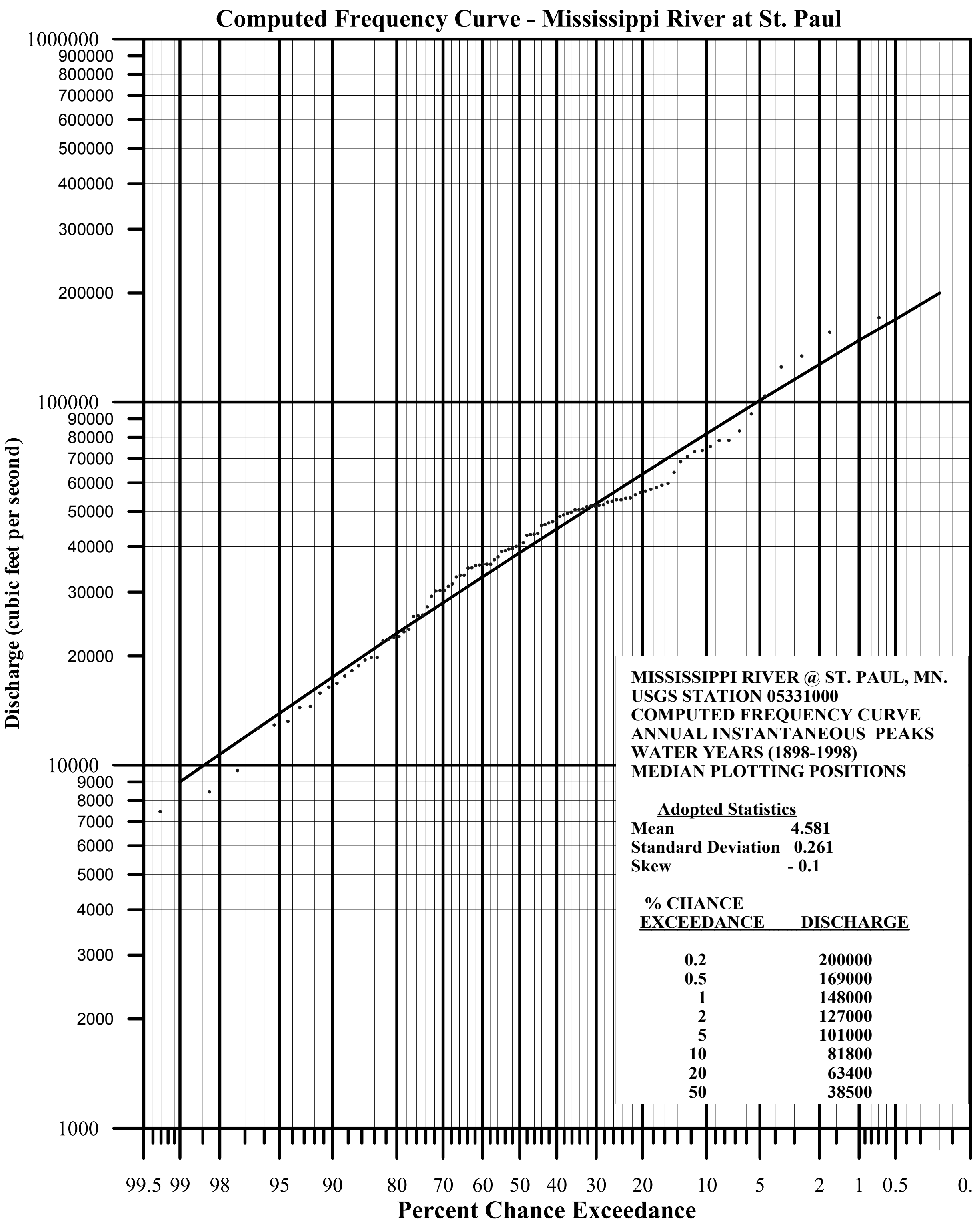


Figure B-3. Frequency Curve – St. Paul, Mn USGS Gage

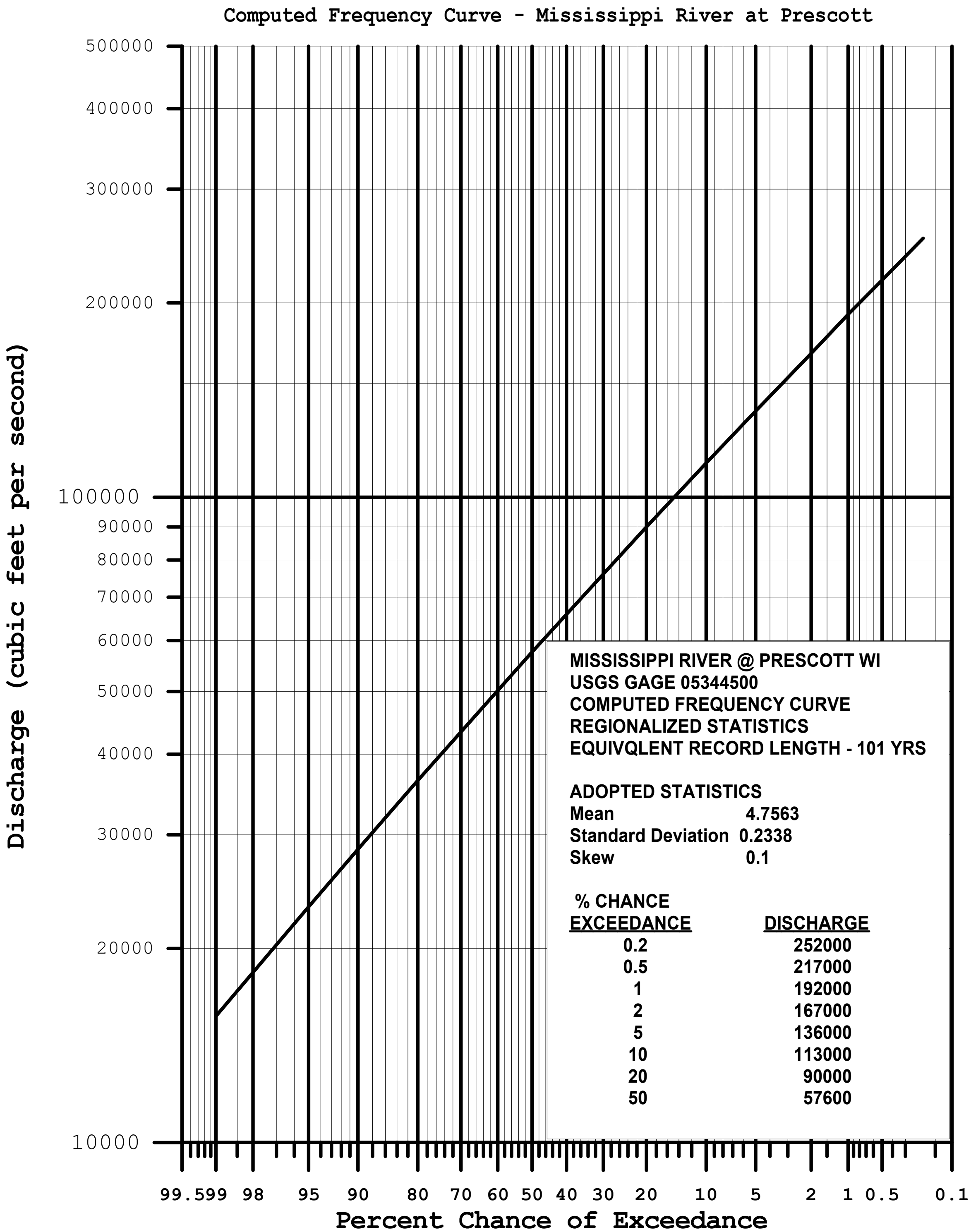


Figure B-4. Frequency Curve –Prescott, Wisc. USGS Gage

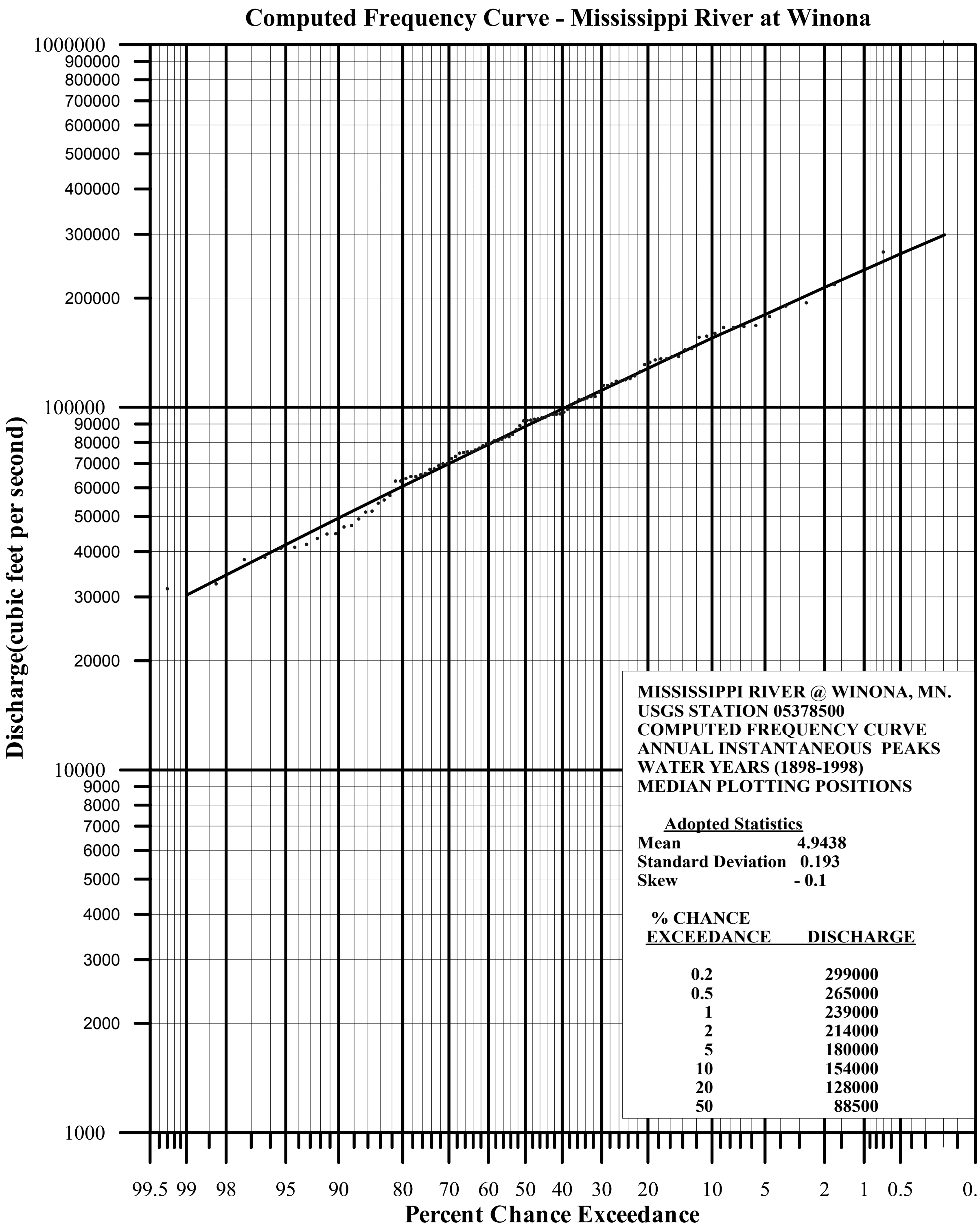


Figure B-5. Frequency Curve –Winona, Mn. USGS Gage

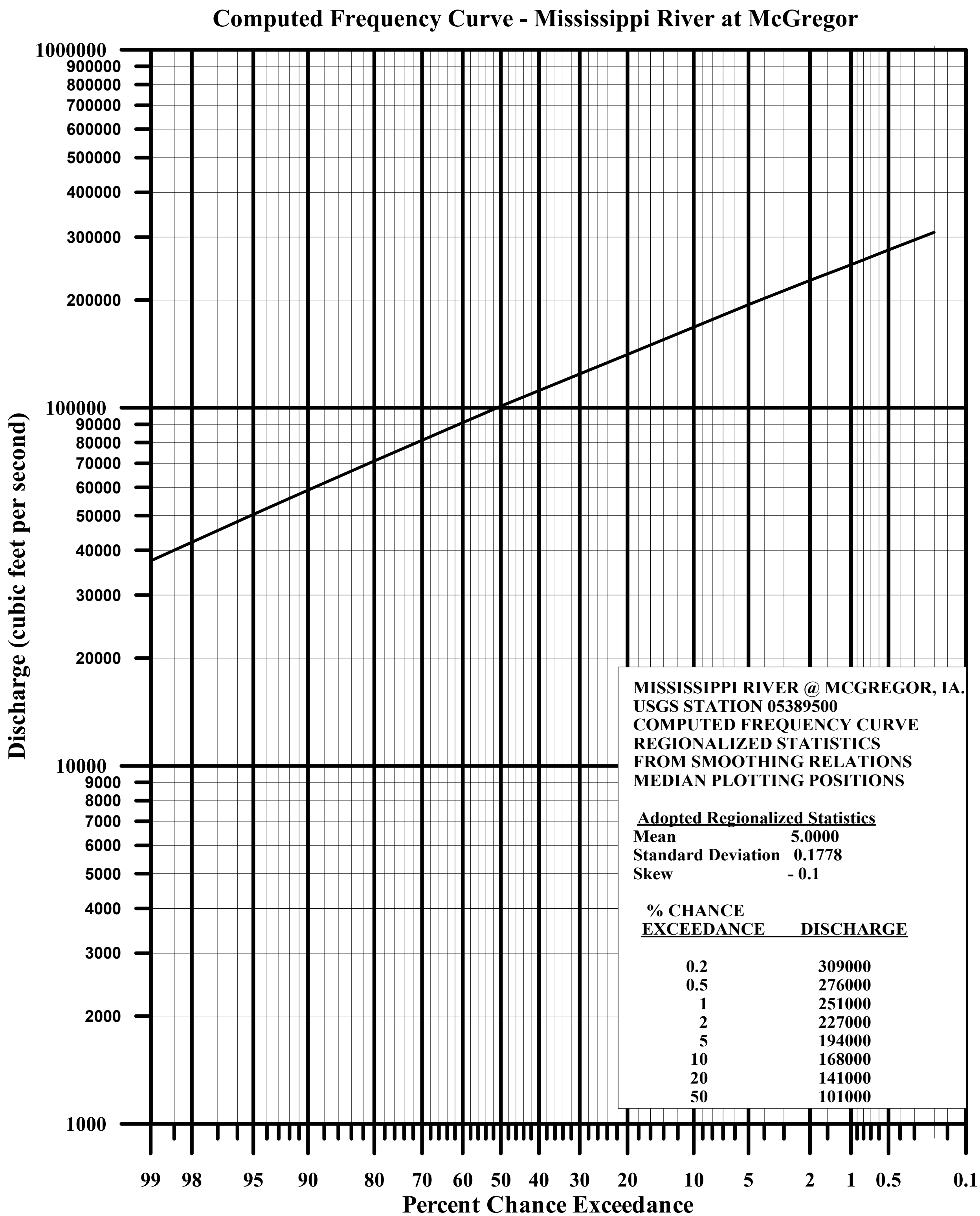


Figure B-6. Frequency Curve –McGregor, Ia. USGS Gage

HYDRAULIC ANALYSIS

The St. Paul District performed hydraulic modeling along the Mississippi River using Dr. Robert Barkau's UNET software for a period of record analysis. Additional information regarding the UNET modeling software is presented in Appendix A. Stage frequency results were determined using the output from UNET and stage-frequency software developed by Dr. David Goldman.

Geographic Coverage

The modeling effort for the Flow Frequency Study developed water surface profiles for the reach from the mouth of the St. Croix River near Hastings, Minnesota (River Mile 811.4) to the headwater of Lock and Dam 10 at Guttenberg, Iowa (River Mile 615.2). A geographic map showing significant features within the study reach is shown on Plate B-2. Navigation charts showing the plan view of the Mississippi River and river mileage are available on the St. Paul District's Water Control WEB site: http://www.mvp-wc.usace.army.mil/ftp/pub/navcharts/ . The downstream limit of the St. Paul District is at River Mile 614 which is shown on Navigation Chart 39.

Basin Description

Plate B-1 shows the Mississippi River Basin within the St. Paul District. The headwaters of the Mississippi River are in north central Minnesota in a region of dense forests, great swamps and thousands of lakes. The river begins at the outlet of Lake Itasca at an elevation of 1463 feet above sea level, and flows north, east and then southwest through timbered landscape to Brainerd, Minnesota. It flows south from Brainerd and then to the southeast through a broad, shallow glacial outwash valley to Minneapolis-St. Paul, Minnesota, and the confluence of the Minnesota River. At this point, it leaves the northern woodlands and lakes and meanders southward past fertile prairies and numerous towns and cities. High bluffs often bank the river. The St. Croix River flows into the Mississippi River at Prescott, Wisconsin. The Mississippi River forms the boundary between Minnesota and Wisconsin below this junction. Farther south, the river forms the boundary between Iowa and Wisconsin. Sixteen river miles above Lock and Dam 10 at Guttenberg, Iowa, the Wisconsin River joins the Mississippi River. The Mississippi River drops about 850 feet (almost 60 percent) of its total fall within the St. Paul District. The Mississippi River and its tributaries in the St. Paul District drain an area of almost 80,000 square miles, of which 45,000 square miles are in Minnesota, 32,000 square miles are in Wisconsin and the remainder are in South Dakota and Iowa. Between Anoka, Minnesota, and Guttenberg, Iowa, the Mississippi River drainage area increases from 19,000 square miles to 80,000 square miles.

Tributary System

The major tributaries to the Mississippi River from Anoka, Minnesota, to Dubuque, Iowa, are described in the following paragraphs.

a. Minnesota River - RM 844.0. The source of the Minnesota River is the Little Minnesota River, which flows into Big Stone Lake, located on the Minnesota-South Dakota border. There is a low divide between it and the Red River basin to the north. During the glacial epoch, the present-day Red River and Minnesota River valleys provided drainage for glacial Lake Agassiz.

Lake Agassiz was a huge body of water about 110,000 square miles in area that occupied what is now the Red River basin in Minnesota and North Dakota and parts of Ontario and Manitoba, Canada. When the glacial ice that blocked the northern drainage of this lake melted, a tremendous volume of water passed down the present Minnesota River valley. As a result, the valley is characterized by wide floodplains, which have been developed for agriculture and agricultural communities. The Minnesota River passes through a rich agricultural area, and the valley bottomlands, which can be a mile or two in width, are very productive. The low, wide floodplains and the flat slope of the basin, however, make it especially susceptible to flooding. From Big Stone Lake, the Minnesota River flows in a southeasterly direction for about 225 miles to Mankato, Minnesota. At Mankato, the river turns abruptly to the northeast and flows another 106 miles to its mouth at St. Paul, Minnesota, on the Mississippi River. The basin consists generally of an undulating prairie region with the topography characterized by gently rolling hills separated by level outwash plains. The economy and occupations of the area are related chiefly to agriculture and agricultural-based industries. A large portion of the population is rural. The major cities are located along the main stem. The Minnesota River drains an area of about 16,900 square miles, of which nearly 90 percent is in south central Minnesota. The Minnesota River also drains 1,640 square miles in South Dakota and 370 square miles in Iowa. The basin is approximately 230 miles long and varies between 60 and 100 miles in width.

b. St. Croix River - RM 811.4. The St. Croix River is a left bank tributary located on the Minnesota-Wisconsin border. The St. Croix River is deeply entrenched, with rugged terrain. Approximately 38 miles upstream of Taylors Falls, Minnesota, it has its steepest gradient, about 100 feet per mile. The maximum depths and width of the St. Croix River occur on Lake St. Croix with a width of 7,500 feet and depths of 80 to 100 feet. Because of the ruggedness of the river and the lack of development along the upper reaches, the St. Croix River is designated as a Wild and Scenic River.

c. Cannon River - RM 794.67. The Cannon River basin covers 1480 square miles in southeastern Minnesota. The river flows in an easterly direction, passing through the towns of Northfield, Cannon Falls, and Welch and eventually dumping into the Mississippi River at mile 794.67. The land use is largely agriculture on the western half of the basin. The east end of the basin has large bedrock gorges.

d. Chippewa River - RM 763.08. The Chippewa River basin covers 9544 square miles through its entire length, 6,630 square miles of which is upstream of Eau Claire, Wisconsin. The basin includes all or part of 19 counties in Wisconsin and Upper Michigan. The Chippewa River rises in the northern Wisconsin lake region, which includes a small part of Upper Michigan. It flows generally to the southwest across northwestern Wisconsin to its confluence with the Mississippi River at the lower end of Lake Pepin, near Mississippi River Mile 763. The largest tributary to the Chippewa River is the Eau Claire River, which joins the Chippewa River at Eau Claire and drains an area of about 880 square miles. Other important tributaries are the Eau Galle, Red Cedar, Yellow, Jump and Flambeau Rivers. Basin topography in the upper reaches is typified by low, gently rolling hills with numerous potholes, lakes, marshes and swamps. Runoff is very low in this area. In the lower reaches of the basin, the country is more hilly and consists of coulees and uplands, some of which rise to a height of 200 to 400 feet above the floodplain. There is rapid runoff from the upland areas. The overall slope of the Chippewa River is 4 to 5 feet per mile and is controlled by a resistant crystalline bedrock surface. The flattest slopes are in the uppermost and lowermost reaches of the basin. In the uppermost reaches, including the Flambeau-Manitowash headwater system, drainage is through a glacial outwash plain. Here, the slope is only 1.3 feet per mile. In the lower reach, below Eau Claire, the river has a uniform slope of about 1.5 feet per mile and meanders broadly over its 1- to 2-mile-wide floodplain. Over the middle reaches, the river has an average slope of about 5.8 feet per mile. This part of the river is characterized by numerous rapids and falls, which create locally steep-sloped areas. Dams and impoundments, primarily for generating electric power, are located at a number of these steep gradient reaches. Many rapids, however, remain untouched, their primary uses being recreational. About 75 percent of the land in the basin consists of deciduous and coniferous forest, and wetland. The remainder, mostly in the lower reaches, is cropland. Major land uses are recreation, forest management, and agriculture. In the north, forests provide wood harvesting and related manufacturing and, along with the lakes and streams, offer recreation opportunities. Agriculture is dominant in the south.

e. Zumbro River - RM 750.08. The drainage basin in the upper reaches of the Zumbro River is gently undulating agricultural land. East of Rochester, Minnesota, the watershed area is a plateau-like surface dissected by narrow, steep-walled gorges and by tributary coulees, hollows, or ravines. Rochester is located in a bowl-shaped valley about 2 miles in diameter surrounded by bluffs cut by the valleys of the South Fork and its tributaries at that point. Beginning in the Rochester area and extending downstream, the river valleys become sharply defined and the adjacent rock-walled bluffs rise on steep gradients to heights of 100 to 200 feet above the valley floor. At Zumbro Falls, Minnesota, about 24 miles west of the mouth of the river, the valley floor is about 160 feet below the uplands and approximately one-eighth mile wide. Between Zumbro Falls and Kellogg, Minnesota, the upland areas are as much as 500 feet above the valley floor, which in several places is a mile wide. Near Kellogg, the Zumbro River leaves a well-defined valley and crosses a wide, gently sloping area before entering the Mississippi River. Average elevations vary from about 1,300 feet in the upland areas south of Rochester to about 1,000 feet at Rochester and 680 feet near the junction of the Zumbro and Mississippi Rivers. Other than some small marsh-type impoundments, there are no natural lakes in the basin.

f. Trempealeau River - RM 717.21. The Trempealeau River basin covers an area of about 719 square miles in west central Wisconsin about midway between La Crosse and Eau Claire. Its basin characteristics are very similar to those of the Buffalo River. The main stem rises about 9 miles east of Hixton, Wisconsin, about 84 miles above the confluence with the Mississippi River. It then flows in a generally westerly direction to Independence, Wisconsin, then to the south to join the Mississippi River near RM 717. The entire drainage area of the Trempealeau River lies within the unglaciated driftless area. Surface elevations range from about 1,360 feet in the headwaters to about 650 feet in the vicinity of the Mississippi River confluence. The uplands are deeply dissected into rugged ridges and rounded hills. Covered by relatively impervious soils, the steep slopes allow for rapid runoff of surface waters. The broad valley of the Trempealeau River is the result of lateral erosion by the meandering stream. The general slope of the Trempealeau River ranges between 3 and 4 feet per mile. There are steeper slopes in the headwaters of the basin, as much as 30 feet per mile in the uppermost reaches above Hixton. These increase the average slope of the stream, based on a total fall of 555 feet in 84 miles, to about 6.5 feet per mile. The river is free flowing throughout its length. Land use in the basin is primarily agricultural, with steeper sloped areas kept mainly in woodlot.

g. Black River - RM 709.08. The Black River is one of five principal tributaries to the Mississippi River above La Crosse whose course and drainage basins are entirely within Wisconsin. It drains an area of 2,080 square miles above Galesville, Wisconsin, near its confluence with the Mississippi River, and 1,290 square miles above the Hatfield Dam near Black River Falls, Wisconsin. The river drains at least part of six Wisconsin counties: Taylor, Clark, Jackson, Monroe, Trempealeau and La Crosse. Upstream of Black River Falls, the river flows through a region of flat to gently rolling terrain in a previously glaciated area. The drainage network is young and mainly postglacial, and valleys are shallow. There are widespread swampy areas east of Black River Falls. Compared to the upper reaches of other river systems in the region, the slope of the Black River is relatively mild and uniform, at about 6 feet per mile, in this area. This is due to the presence of a crystalline bedrock substrate which has limited downcutting. After passing Black River Falls, the river enters the unglaciated "driftless area," an area characterized by deeply cut valleys, or coulees, above which are areas of relatively uniform tableland. Here, the river flows in a meandering manner through a thick alluvial fill at a slope of about 2 feet per mile to its confluence with the Mississippi River at La Crosse, near Mississippi River Mile 709. There are two impoundments on the Black River: Lake Arbutus, formed by the Hatfield Dam; and an unnamed impoundment formed by the Black River Dam in Black River Falls. Land use in the basin is predominantly agricultural, with some recreational use around Lake Arbutus and along parts of the main Black River channel.

h. South Fork of the Root River. The South Fork of the Root River is a small tributary to the Root River within the Root River basin.

i. Root River - RM 693.99. The Root River basin is located in the southeastern portion of Minnesota. The basin has a drainage area of 1660 square miles and is elliptical in shape, with a length of approximately 77 miles and a width of approximately 34 miles. The basin encompasses all or portions of Houston, Olmsted, Fillmore, and Mower Counties. The basin's major watercourse is the Root River. The Root River has steep slopes in the upper reaches of the basin and mild slopes near its confluence with the Mississippi River. The river passes through incorporated areas as well as large expanses of agricultural areas. A number of the communities in the upper reaches of the basin are flash flood prone.

j. Upper Iowa River - RM 671.08. The Upper Iowa River has its source in the southeast corner of Mower County, Minnesota. It flows in a southeasterly direction to Decorah, Iowa. It then flows in an easterly direction, entering the floodplain of the Mississippi River about 1.5 miles south of New Albin, Iowa. The total drainage area of the Upper Iowa River is about 990 square miles and includes parts of Allamakee, Winneshiek, Howard, and Mitchell Counties of northeastern Iowa, and small areas along the southern boundaries of Houston, Fillmore, and Mower Counties in southeastern Minnesota.

k. Kickapoo River. The Kickapoo River rises in Monroe County in southwestern Wisconsin and flows southwest through Vernon, Richland, and Crawford Counties. The river empties into the Wisconsin River near Wauzeka, about 16 miles upstream from the junction of the latter stream with the Mississippi River. The Kickapoo River basin includes about 776 square miles and is about 60 miles long and 10 to 15 miles wide. The largest tributaries are the West Fork, Taintor Creek, Morris Creek, and Billings Creek. The topography of the basin is comparatively rugged, consisting of narrow ridges and deep valleys. The ridge crests, which are distinctly round-topped, are 0.1 to 0.6 mile wide. The valley bottoms are 0.1 to 1.0 mile in width and are 300 to 400 feet below the upland level. The summits of the ridges generally slope southward with the dip of the rock strata.

l. Wisconsin River - RM 631.0. The Wisconsin River has an elongated drainage area of 11880 square miles. It rises in Lac Vieux Desert, on the Wisconsin-Michigan Upper Peninsula border. From this point, it flows in a generally north to south direction, winding through heavily forested lands, agricultural lands, and then the rolling hills and bluffs of southwestern Wisconsin to its confluence with the Mississippi River at Prairie du Chien, Wisconsin, near Mississippi River Mile 631. The U.S. Geological Survey (USGS) divides the Wisconsin River basin into three sections. These are the upper basin, which is between the source at Lac Vieux Desert and Merrill, Wisconsin; the central basin, which extends from Merrill to Wisconsin Dells; and the lower basin, which extends from Wisconsin Dells to the confluence with the Mississippi River.

The drainage area of the upper Wisconsin River basin is about 2,780 square miles, including parts of six counties. The terrain varies from flat glacial outwash plains to hilly ground moraines. Most of the upper basin is made up of the flat outwash with a gentle slope and many shallow depressions occupied by lakes or bogs. Vegetation is mostly deciduous or coniferous forest except in boggy areas. There is very little runoff from this area. South of the Oneida County line, the terrain becomes more varied, and runoff increases. About half of this area is forest or pastured woodlot and has many lakes and bogs. The slope of the river through the upper basin is fairly uniform at 3.5 feet per mile. Principal tributaries in this reach are the Pelican, Tomahawk, Spirit, and Prairie Rivers. There are a number of impoundments both on the main stem and on the tributaries. These are used for water supply, recreation and some hydropower.

The drainage area of the central Wisconsin River basin is about 5,050 square miles, including parts of 12 counties. Here, the river flows through extensive sand plain. Most of the terrain is flat to gently sloping, with a few isolated large hills such as Rib Mountain, near Wausau, Wisconsin. Like the upper basin, there are a number of large, flat, boggy depressions. Some of these have no surface outlets and are thus closed off from the rest of the river system in this way. Over 50 percent of the land in this area is used for agriculture. There is recreational and some hydropower use along the streams and impoundments. The slope of the river through the central basin averages 3.3 feet per mile from Merrill to Petenwell Lake, and 1.7 feet per mile from Petenwell Lake to Wisconsin Dells. Principal tributaries in this reach are the Rib, Eau Claire, Big Eau Pleine, Little Eau Pleine, Yellow, and Lemonweir Rivers. There are 14 impoundments on this reach of the Wisconsin River, the largest of which are Lake Dubay, between Stevens Point and Wausau, and Petenwell and Castle Rock Lakes, which are located, one immediately flowing into the other, between Wisconsin Rapids and Wisconsin Dells.

The remainder of the Wisconsin River basin, an area of about 4,450 square miles, comprises the lower basin. Here, the terrain is hilly; there was no glaciation in this area to level it out, as in the central and northern areas. There is high runoff in this area. Most of this portion of the basin is used for agriculture, except for the steeper slopes which have been retained mostly in wood lots, and the waterways which are used for recreation and some hydropower. The river channel meanders through its alluvium-filled valley at an average slope of about 1.5 feet per mile. The river has two major tributaries in this part of the basin, the Baraboo and Kickapoo Rivers. There is one last impoundment on the river before it flows unimpeded to its confluence with the Mississippi River. This is Lake Wisconsin, just downstream of Portage.

Connections with Other Districts

The St. Paul District UNET model is the most upstream model for the Mississippi River. Therefore, there is no connection with other Districts upstream. However, on the downstream end of the model there is an overlap from Lock and Dam No. 10 to Dubuque, Iowa. This overlapping reach is in the Rock Island District and allows for a convergence reach at the downstream end of the model for accounting for any instabilities that could results from the downstream boundary condition at Dubuque, Iowa. The stage and discharge hydrograph from the St. Paul District model at Lock and Dam No. 10 is available for boundary condition information for the upstream end of the Rock Island Districts UNET model. Water surface elevations computed in the convergence reach from Dubuque, Iowa to Lock and Dam No. 10 should be obtained from the Rock Island District's UNET model.

UNET APPLICATION

UNET Hydraulic Modeling Computer Program

UNET is the hydraulic analysis computer program selected and used for the Upper Mississippi River System Flow Frequency Study (FFS). UNET is used since the methodology used accounts for the unsteady flow. This is especially important in the other Districts where the levee analysis is an important consideration. A decision was made to use one methodology for all five Districts so that the methodology would be consistent. This decision was made after coordination with FEMA, other Districts and HEC.

UNET is a one-dimensional, unsteady open-channel flow computer model that can simulate flow in single reaches or complex networks of interconnected reaches. UNET also has the capability to simulate storage areas, which is used in this study to simulate the interaction of the river with levees. Storage areas are lake-like regions that can either divert water from, or provide water to, a channel. Primary development and application of UNET was accomplished by Dr. Robert L Barkau. The Hydrologic Engineering Center (HEC) maintains, distributes, and supports the standard version of UNET for Corps of Engineers' offices.

Attachment B-3 is an independent determination of the headloss for the Wisconsin and Mississippi River channel junction using equations from a procedure outlined in the write-up on junction loss by Danny Fread in Appendix A.

Previous Modeling

The St. Paul District developed a UNET hydraulic model for the Mississippi River in 1997 and has used the model for river forecasting. This model was built using available sounding data for channel geometry and USGS 7-minute quadrangle mapping for overbank areas geometry.

Model Geometry Development and Description

Geometry Data Acquisition above Water Surface Elevation (WSEL)

Aerial photography, airborne global positioning system (GPS) control, ground survey control, and aero triangulation were used in development of a digital terrain model (DTM) and digital elevation model (DEM) of the project area for the St. Paul District (Mississippi River from Anoka, Minnesota, to Lock and Dam 10 at Guttenberg, Iowa, RM 864.8 to 615.1). The aerial photography for the DTM was taken in April and May 1999 under the direction of the Scientific Assessment Study Team (SAST). The above Water Surface Elevation reference corresponds to the Water Surface Elevation at the time that the Aerial photography was taken, which was in the time period between April and May 1999. The DTM data is composed of mass points and break lines that adequately define elevated roads, railroads, levees (features that would impede flow) and other major topographic changes required for accurate DEM development. The aerial mapping is based on surveyed ground control points. The floodplain digital terrain models were developed from 1998 aerial photography and photogrammetry. Mississippi River floodplain ("bluff-to-bluff") digital terrain model data was designed and compiled so that spot elevations on well-defined features would be within 0.67 feet (vertical) of the true position (as determined by a higher order method of measurement) 67% of the time. The 0.67 feet (vertical) is as per ASPRS Class I Standards as stated in the USACE EM 1110-1-1000, dated 31 March 1993. It is approximately 1/6th of a contour interval (4 foot contours). The level of detail in the elevation data was kept to the minimum for this purpose. Mass points and break-lines to depict roads, railroads and levees were specified.

Geometry Data Acquisition below Water Surface Elevation (WSEL)

Data below water surface elevation for the UNET model cross-sections are from various sources including xyz data obtained from Construction-Operations. Construction-Operations Division obtains sounding data for maintenance of the Navigation Channel for the Mississippi River. In areas that soundings were not available in the Navigation Channel, data from the Brown Surveys was utilized. The Brown Surveys are surveys taken in the early 1930's across the Navigation Channel at approximately ½ mile increments. The Surveys were acquired from the St. Paul District map file archives. In the Overbank areas data was obtained from the Upper Midwest Environmental Sciences Center (UMESC formerly the EMTC). In areas that the UMESC data was not available flowage surveys were utilized. The flowage surveys were taken in the early 1930's prior to placement of the lock and dams. The Flowage Surveys were acquired from the St. Paul district map file archives. In areas that new geometry was not available previously developed geometry data was utilized from the Mississippi River UNET model.

Development of Geometry Data

Geometry data from the varying sources described above was imported into the GIS program Arcview 3.2. All geometry data was converted to horizontal UTM Coordinates, NAD 83, Zone 15, Feet and vertical NGVD 1929, US Survey Feet. Cross-sections, reach lengths, and overbank line shapefiles were created in Arcview 3.2. Each geometry data source was combined with the cross-sections shapefile and cross-sections were cut using an extension in Arcview 3.2 called Geo-RAS. By the use of Geo-RAS the cross-sections, reach lengths and overbank geometric data was imported into HEC-RAS 3.0 as a geometry file. A separate geometry file was created for each geometry data source. The geometry files were then combined in HEC-RAS 3.0 and a final geometry data file was created. The final geometry data file contains data from the DEM/DTM above WSEL and soundings data, UMESC data, Brown Surveys data, Flowage Surveys Data, and Old UNET data (listed in decreasing control) below WSEL. The channel roughness coefficients were assigned by use of UMESC supplied land use data. The land use data was imported into Arcview 3.2 and each landuse was assigned a roughness coefficient. The data was then imported into HEC-RAS 3.0 by use of the Geo-RAS extension.

Development of HEC-RAS Steady Flow Model and Conversion to UNET

The geometry data was completed in HEC-RAS with the addition of effective flow limits, bridges, control structures (locks and dams), and levees. Steady flow discharges were acquired from the hydrologic study. Calibration was then completed by the use of High Water Marks for the 1965, 1969, 1993, 1997 and 2001 floods. Rating curves were used for calibration at each Lock and Dam, at each control point between the Lock and Dams, and at the gaging stations at Anoka, St. Paul, Winona and McGregor. The geometry for the Calibrated steady flow HEC-RAS model was then imported into UNET for an unsteady flow calibration. The UNET model schematic is shown below.

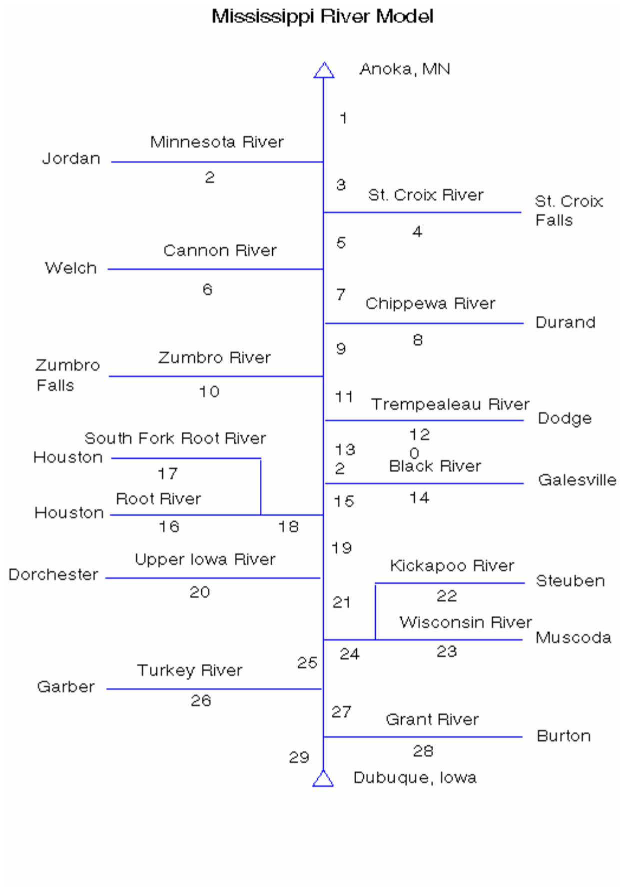


Figure B-7 - Schematic Mississippi River UNET Model for the St. Paul District

Boundary Conditions

Flow and stage data are required to provide the boundary conditions that drive the model. For historic simulations, the inflow data for the model are from the records at the USGS gaging stations and the boundary stages are from the records of the St. Paul District. The U.S. Geological Survey compiles flow data at the gaging stations listed in Tables B-9, B-10, and B-11. Flow data from these stations were collected for the period 1940 through September 2001.

Table B-9 USGS Stream Gages		
Stream	**Station**	**River Mile**
Mississippi River	Anoka	864.80
Mississippi River	St. Paul	839.34
Mississippi River	Winona	725.70
Mississippi River	McGregor	633.60
Minnesota River	Jordan	39.4
St. Croix River	St. Croix Falls	52.2
Cannon River	Welch	12.3
Chippewa River	Durand	17.6
Zumbro River	Zumbro Falls	47.5
Trempealeau River	Dodge	8.9
Black River	Galesville	13.8
South Fork Root River	Houston	3.7
Root River	Houston	18.5
Upper Iowa River	Dorchester	18.1
Kickapoo River	Steuben	20.5
Wisconsin River	Muscoda	92
Turkey River	Garber	19.9
Grant River	Burton	9.1

Table B-10 Mississippi River Gaging Stations		
Station Name	**River Mile**	**Station Code**
Anoka	864.80	ANKM5
Upper St. Anthony Falls Headwater	853.90	USAFHW
Upper St. Anthony Falls Tailwater	853.85	USAFTW
Lower St. Anthony Falls Headwater	853.34	LSAFHW
Lower St. Anthony Falls Tailwater	853.23	LSAFTW
Lock and Dam 1 Headwater	847.60	LD1HW
Lock and Dam 1 Tailwater	847.50	LD1TW
St. Paul	839.34	STPM5
South St. Paul	833.73	SSPM5
Lock and Dam 2 Headwater	815.20	LD2HW
Lock and Dam 2 Tailwater	815.05	LD2TW
Prescott	811.06	PREW3
Lock and Dam 3 Headwater	796.91	LD3HW
Lock and Dam 3 Tailwater	796.80	LD3TW
Lake City	772.56	LKCM5
Wabasha	760.50	WABM5
Lock and Dam 4 Headwater	752.95	LD4HW
Lock and Dam 4 Tailwater	752.60	LD4TW
Lock and Dam 5 Headwater	738.27	LD5HW
Lock and Dam 5 Tailwater	737.90	LD5TW
Lock and Dam 5A Headwater	728.52	LD5AHW
Lock and Dam 5A Tailwater	728.48	LD5ATW
Winona	725.70	WNAM5
Lock and Dam 6 Headwater	714.31	LD6HW
Lock and Dam 6 Tailwater	714.26	LD6TW
Dakota	707.23	DKTM5
Lock and Dam 7 Headwater	702.61	LD7HW
Lock and Dam 7 Tailwater	702.47	LD7TW
La Crosse	696.75	LACW3
Brownsville	688.95	BRWM5
Lock and Dam 8 Headwater	679.39	LD8HW
Lock and Dam 8 Tailwater	679.15	LD8TW
Lansing	663.00	LNSI4
Lock and Dam 9 Headwater	648.09	LD9HW
Lock and Dam 9 Tailwater	647.88	LD9TW
McGregor	633.60	MCGI4
Clayton	624.80	CLAI4
Lock and Dam 10 Headwater	615.20	LD10HW
Lock and Dam 10 Tailwater	614.89	
Cassville	606.30	
Waupeton	599.90	
Spechts Ferry	592.30	
Lock and Dam 11 Headwater	583.00	
Lock and Dam 11 Tailwater	582.60	
Dubuque	579.30	

Table B-11 Tributary Gages				
Stream	**Station**	**Station Code**	**River Mile**	**Datum**
Minnesota River	Jordan	JDNM5	39.4	690.00
St. Croix River	St. Croix Falls	SCFW3	52.2	689.94
Cannon River	Welch	WCHM5	12.3	699.16
Chippewa River	Durand	DURW3	17.6	694.59
Zumbro River	Zumbro Falls	ZUMM5	47.5	811.26
Trempealeau River	Dodge	DDGW3	8.9	661.42
Black River	Galesville	GALW3	13.8	658.43
South Fork Root River	Houston	HUSM5	3.7	680.41
Root River	Houston	HOUM5	18.5	667.00
Upper Iowa River	Dorchester	DCHI4	18.1	660.00
Kickapoo River	Steuben	STEW3	20.5	657.00
Wisconsin River	Muscoda	MUSW3	92.0	666.77
Turkey River	Garber	GRBI4	19.9	634.46
Grant River	Burton	BTNW3	9.1	606.43

Levees

The UNET model for the Flow Frequency Study includes only those levees which are Federal Flood Control Project levees. This includes the levees for the Winona, Minnesota and Guttenberg, Iowa flood control projects. The storage is quite small behind these levees. Public Law 99 Levees and any other emergency levees are not reflected in the UNET modeling. These levees will have little impact on the UNET and HECRAS steady flow computed water surface elevations.

Control Structures (Locks and Dams)

The St. Paul District unet model has 13 navigation dams, which are regulated to maintain navigation pools. The navigation dams are listed in Table B-12. The upper three navigation pools behind the Upper St. Anthony Falls Dam, the Lower St. Anthony Falls Dam, and Lock and Dam 1 were simulated by rating curves at the structure. The lower 10 navigation dams are simulated according to operating rules presented in the Regulation Manuals for Dams 2 through 10 (St. Paul District, 1972). Each dam is regulated according to a hinge pool procedure which attempts to maintain a control point at stages given by a rating curve. The operating rule is a rating curve of flow versus stage **at the Dam** that, through experience, has been shown to maintain the proper stage at the control point. A sample operating rule for Lock and Dam 10 is shown on Figures B-8 and B-9.

The UNET program was modified (Barkau, 1996) to simulate navigation dams according to the operating rules. The program allows the operating rules to vary according to the seasons. Figure B-9 shows the entry of the operating rule for Lock and Dam 10. The ND card defines the navigation dam. The NR cards defines the operating rule. The operating rules work for spring and summer when ice does not influence stages. In the winter**,** seasonal adjustments are needed to simulate observed stages. Seasonal adjustments for the modeling are not used in this study since a period of record analysis is required where the extent of the seasonal affects can vary greatly from one year to the next. Since the purpose of this study is the development of stage frequency results for events equal to or greater than the 2-year event, the use of one operational rule representing the spring and summer events is adequate for this study. Additional refinement of the UNET model using seasonal adjusments is needed for any low flow analysis.

Table B-12 Navigation Dams

Dam	Tailwater River Mile	Pool Elevation (Feet NGVD)
Upper St. Anthony Falls	853.85	798.7
Lower St. Anthony Falls	853.23	749.5
1	847.50	724.6
2	815.05	686.7
3	796.80	674.5
4	752.60	666.5
5	737.90	659.5
5A	728.48	650.5
6	714.26	645.0
7	702.47	638.5
8	679.15	630.5
9	647.88	619.5
10	614.89	610.5

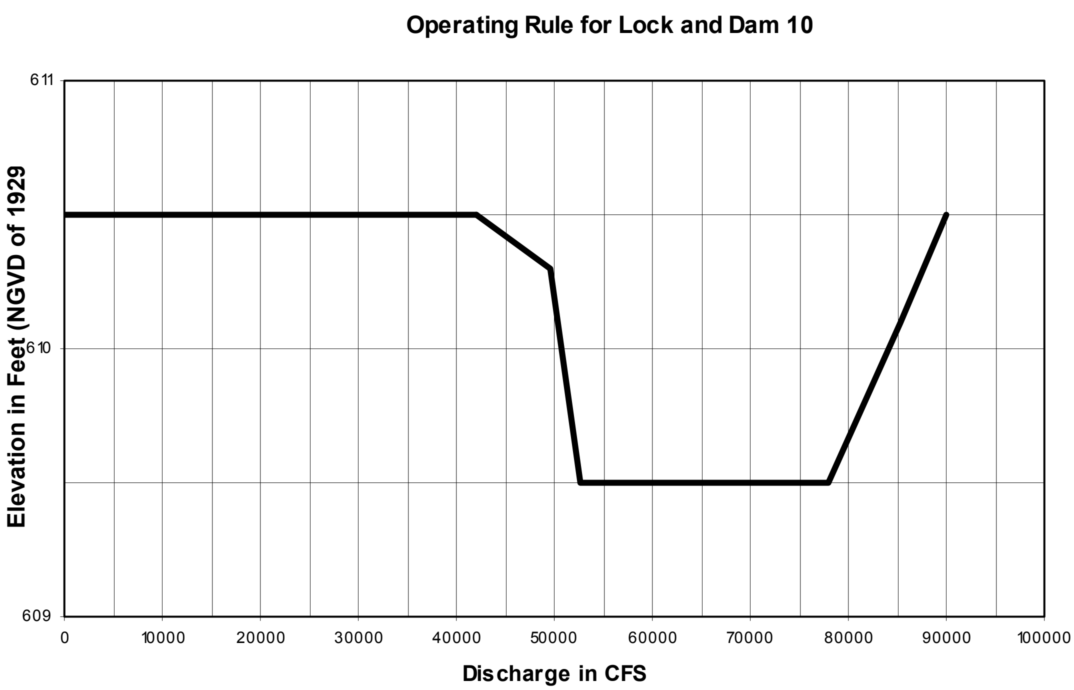


Figure B-8 – Operating Rule for Lock and Dam No. 10.

```
NH     8    .127     182    .058    1455    .127    1571    .999    5635    .028
NH  6629    .058    6913    .063    8550    .058    9096
X1615.20     303    5478    6626     186     141     232
KR NCS-MI-RATINGS.DSS:/MISSISSIPPI/LD10HW/1929ELEV-FLOW///EST/
X3     0       0       0       0       0    7298   633.6
OH MISSOLD://DAM10-POOL/ELEV//1DAY//
OH MISSOLD://DAM10/FLOW//1DAY/COMPUTED/
Z0   -.5
HY LD10HW
GR 679.8       0   643.8      58   630.0      91   624.7     103   619.8     114
GR 619.9     116   619.9     117   620.2     124   620.2     139   619.8     148
.
.
.
GR 611.9    8919   612.1    8963   612.3    8977   612.5    8998   613.6    9052
GR 613.7    9062   614.4    9092   614.4    9096
ND                 610.5                                     -.6        L&D 10
NR     7   610.5       0   610.5   42000   610.5   49565   610.3   52609   609.5
NR 78000   609.5   85360   610.1   90000   610.5
XK            40     640            2.00
KR OFF
BF                                         0.000   0.000
NH     7    .165     242    .028    1442    .075    1810    .999    5550    .165
NH  5881    .028    7161    .083    9307
X1614.89     174    5882    7075    1119    1556    1480
KR NCS-MI-RATINGS.DSS:/MISSISSIPPI/LD10TW/1929ELEV-FLOW///EST/
X3     0       0       0       0       0    7310   636.0
OH MISSOLD://DAM10-TAIL/ELEV//1DAY//
OH MISSOLD://DAM10/FLOW//1DAY/COMPUTED/
Z0   -.5
HY LD10TW
GR 728.4       0   716.8      17   711.5      23   644.6     106   642.4     110
GR 641.9     111   623.6     156   626.1     170   620.6     200   621.9     209
.
.
.
GR 610.5    9137   612.3    9192   612.3    9212   615.8    9227   616.9    9239
GR 616.9    9250   617.3    9257   617.6    9295   617.5    9307
```

Figure B-9. Entry of the Operating Rule for Lock and Dam 10 into the Cross-Section File.

All Elevations are in NGVD of 1929 in the UNET model. Normally, Water Control Data is in 1912 datum along the Mississippi River downstream of St. Paul. In general, elevations in 1912 are about 0.5 foot higher than NGVD of 1929 elevations along the Mississippi River in the St. Paul District downstream of St. Paul, Minnesota.

UNET ADJUSTMENT OF FLOW AND CONVEYANCE

Application of Null Internal Boundary Condition for Lateral Inflows.

The St. Paul District UNET Model is calibrated with the observed hydrograph data at the USGS gaging stations at Anoka, St. Paul, Winona and McGregor. Other observed stage hydrograph data from the Locks and Dams and Data Collection Platforms shown in the above table listing Mississippi River Gaging Stations is also used for optimization of the UNET model. In addition, available highwater mark data for the 1965, 1969, 1993, 1997 and 2001 flood events is used for optimization of the model between the gage locations with observed hydrograph data.

The Null Internal Boundary Condition (NIBC) is a tool for estimating ungaged lateral inflow in a river system. Use of the NIBC is an important component of calibrating the model to both flow and stage. The NIBC technique estimates ungaged inflow to reproduce either a stage hydrograph or a flow hydrograph at the NIBC station. When stage reproduction is the priority, the reproduction of flow is secondary, being dependent on the calibration of the model. Likewise, when flow reproduction is the priority, the reproduction of stage is secondary, being dependent on the calibration of the model. In either case, the ungaged inflow compensates for all the errors in the measurement of stage and flow and for systematic changes in roughness and geometry that may not be included in the model. As a result, the ungaged inflow determined using the NIBC procedure includes both flow and an error correction term. A detailed description of the NIBC is provided in the documentation for the UNET software in Appendix A.

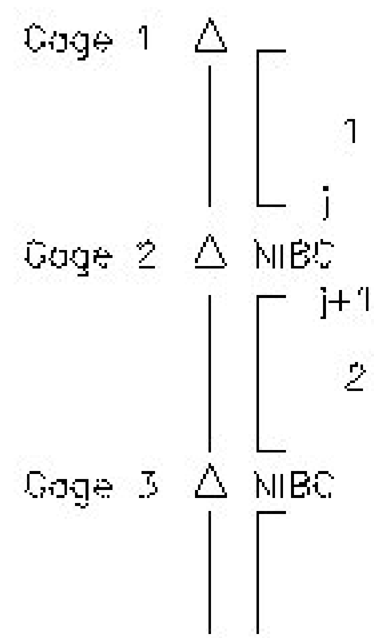
The NIBC feature is used for the St. Paul District Flow Frequency Study Unet Model for optimization to reproduce flow at the USGS gage locations at St. Paul, Winona and McGregor. The following paragraphs are excerpts from Dr. Robert Barkau's documentation for the UNET software utilized for this study.

The NIBC is inserted between two identical cross-sections that are separated by a small distance. The NIBC assumes that the stage and flow at the two cross-sections are the same; hence, if the upstream cross-section is number j, then

$$Z_j^n = Z_{j+1}^n$$
$$Q_j^n = Q_{j+1}^n \qquad (1)$$

in which Z is the stage and Q is the flow.

When optimizing flow, the flow hydrograph is applied as the upstream boundary at cross-section $j+1$ and serves as the upstream boundary of the downstream reach. The stage hydrograph is still applied at cross-section j and serves as the downstream boundary of the upstream reach. Figure B-10 shows the upstream and downstream routing reaches.



The NIBC is inserted between cross-section j and j+1.

Figure B-10 – Illustration of application of Null Interior Boundary Condition

After running the model, the flow at j is the routed flow from upstream. Since the ungaged inflow is unknown and not entered, the flow at j is missing the ungaged inflow. For the downstream reach, the flow at j+1 contains the ungaged inflow. If the flow at j+1 is computed from a stage boundary condition, the flow is generated by the hydrodynamics and the geometry of the reach downstream. The ungaged inflow is the difference between the flow hydrographs at j and the flow at j+1,

$$Q_U^1 = Q_{j+1}^n - Q_j^n \quad (2)$$

in which Q_U^1 is the ungaged inflow for iteration 1.

The ungaged inflow enters from the upstream boundary of the upstream reach to cross-section j , the downstream boundary. To use the ungaged inflow in a model, the flow is lagged backward in time (usually one day) and inserted in the model as point and uniform lateral inflow. Point inflow occurs a known ungaged tributaries and uniform inflow is the remainder. The inflow is normally distributed by drainage area. The backward lag is adjusted by distance. For example, if a one day lag is assumed, the upper one-half of the reach has a lag of one day and the lower one-half of the reach has no lag.

The NIBC is inserted at the principal gage locations where the stage or flow records are the most accurate. Generally, these locations are the USGS (U. S. Geological Survey) gaging stations. If a reach includes k interior gages, inserting NIBC at each of the gages creates k routing reaches.

Ungaged inflow is optimized by successively applying ungaged inflow to the upstream reach. The initial estimate of ungaged inflow is computed using equation 2 and ungaged inflow is successively corrected using:

$$Q_U^k = Q_U^{k-1} + \left(Q_{j+1}^n - Q_j^n\right) \tag{3}$$

This iterative procedure usually requires three to five iterations to converge. For a free flowing river, the ungaged inflow can be optimized for the routing reaches simultaneously, since, the flow computation at j+1 is not impacted by the ungaged inflow downstream. This procedure is called simultaneous calibration.

For flat streams, when a stage hydrograph is applied, backwater from downstream of the NIBC will impact the convergence of the ungaged inflow for the upstream reach. The flow at cross-section j+1 is computed from the stage hydrograph. If cross-section j+1 is impacted by backwater, the flow changes with the degree of backwater. Hence, the flow at j+1 changes as ungaged inflow is applied downstream and the optimization of ungaged inflow begins to oscillate. The computed flow at cross-section j+1 is dependent on the ungaged inflow downstream. Generally, this problem occurs on streams with a gradient less than 0.2 feet per mile. Optimizing the reaches one reach at a time can eliminate this problem. This procedure is called sequential calibration.

After ungaged inflow is optimized simultaneously, an error still exists in the routed flow hydrograph at cross-section j. Simultaneous calibration preserves this error, which can be significant after the stage hydrographs at the NIBC's are released. However, sequential calibration corrects these errors as the optimization moves downstream. Therefore, after simultaneous calibration, the model should be optimized sequentially to correct the residual errors.

The steps in simultaneous calibration follows:

1) Observed stage hydrographs and flow hydrographs (if optimizing to flow) are applied at the NIBC stations.

2) The model is run.

3) Ungaged inflow is computed upstream of the NIBC stations, using equation 2.

4) The ungaged inflow is distributed as point and uniform lateral inflow and lagged backward in time.

5) The model is rerun.

6) The ungaged inflow is corrected using equation 3.

7) Computed flow is compared at the NIBC stations at cross-section j and j+1. If convergence is satisfactory, the simultaneous iteration is concluded. Go to step 9.

8) Iteration continues with step 4.

9) One pass of sequential iteration should be performed to correct errors.

The steps in sequential calibration follows:

1) An observed stage hydrograph and a flow hydrographs (if optimizing to flow) are applied at the first NIBC station. No observed hydrographs are applied at downstream stations.

2) The model is run.

3) Ungaged inflow is calculated for the first reach using equation 2.

4) The model is rerun and ungaged inflow for the first reach is corrected using equation 3.

5) If the flow hydrographs at cross-sections j and j+1 have converged go to step 7.

6) Go to step 4.

7) Move to the next downstream NIBC station. Remove observed hydrographs at all upstream NIBC stations. Apply a stage hydrograph and a flow hydrograph (if optimizing to flow) to the NIBC station. No observed hydrographs are applied to downstream stations.

8) The model is run.

9) Ungaged inflow is calculated for the first reach using equation 2.

10) The model is rerun and ungaged inflow for the first reach is corrected using equation 3.

11) If the flow hydrographs at cross-sections j and j+1 have converged go to step 13.

12) Go to step 10.

13) If the last NIBC, the iteration is complete. Otherwise go to step 7.

The NIBC is inserted into the UNET cross-section file using the NI card between cross-section j and j+1. Cross-section j is a repeat of cross-section j+1 and the reach length between the cross-sections is very small, usually one foot. The only parameter on the NI card is a eight character name which uniquely defines the name of the NIBC when attaching an observed stage or flow hydrograph in the boundary condition file. HY cards must be inserted at cross-sections j and j+1 to define output hydrographs. The OH cards upstream and downstream attach the USGS hydrograph to the plot macro.

Attachment B-4 presents plots of ungaged, observed and computed flow hydrographs.

Application of Automatic Conveyance Adjustment

A detailed discussion on the write-up for the Automatic Conveyance Adjustment is provided in the UNET documentation in Appendix A. The automatic calibration adjustment reduces the effort for the adjustment of conveyance substantially in comparison to manual procedures. The following paragraphs are excerpts from Dr. Robert Barkau's documentation for the UNET software utilized for this study.

A rating curve reflects the stage-conveyance structure of the cross-section. At elevation z the conveyance is computed from Manning's Equation,

$$K = \frac{1.49}{n} R^{2/3} A \qquad (1)$$

where: K = conveyance.
n = Manning's roughness factor.
$R = \frac{A}{W_p}$, the hydraulic radius.
W_p = the wetted perimeter.
A = cross-sectional area.

In equation 1 the area and the wetted perimeter are cross-section properties, but the roughness is unknown. If the friction slope, S_f, is known, the conveyance can be computed from

$$S_f = \left(\frac{Q}{K}\right)^2 \qquad (2)$$

When the stream gradient is steep (greater than ten feet per mile), the water surface slope approximately equals the friction slope and conveyance can be computed from the rating curve. But, when the gradient is shallow, the friction slope is controlled by backwater and conveyance cannot be calculated from a single rating curve.

If a second rating curve is known at a downstream cross-section, the stage at the upstream cross-section can be computed using steady state backwater. A constant flow is assumed between the first and second rating curve and many cross-sections can be defined between the rating curves. Most likely the upstream stage will not match the stage at the upstream rating curve for the constant flow. Adjusting Manning's "n" to match the stage at the upstream rating curve, calibrates the reach to reproduce the upstream rating curve. Note that the entire reach is being calibrated. The stages at the intermediate cross-sections may not be correct, but no information is available to further refine the calibration.

The Manning's "n" can be different from cross-section to cross-section. Generally, one assumes a constant "n" value for the wetted channel area along a reach, but "n" values for exposed areas such as islands in the channel and overbank areas can vary from cross-section to cross-section. The density and type of the vegetation is variable.

When calibrating a model, the special variation of Manning's "n" from cross-section to cross-section poses a problem. How does one distribute changes in roughness throughout the reach? The calibration reach has stage information at the upstream and downstream ends and nothing in between. Therefore, changing roughness uniformly is a solution to this problem.

River stage is inversely related to conveyance: Increasing conveyance causes water levels to fall and decreasing conveyance causes water levels to rise. When calibrating river conveyance, multiplying a single conveyance factor times the conveyance properties at all the cross-section can adjust the reach to reproduce an upstream stage. Hence, optimizing a single reach calibration factor calibrates a reach for a single flow.

The conveyance factor is optimized through iteration. During each iteration, the upstream stage is computed by backwater and the factor is improved by the following formulas:

For the first iteration, the factor, F, is improved by

$$F_1 = \begin{cases} F_0 + 0.05 & \text{if } z_0 > z_{Obs} \\ F_0 - 0.05 & \text{if } z_0 < z_{Obs} \end{cases} \quad (3)$$

where: $z_0 =$ the upstream stage computed by backwater during the initial iteration.
$z_{Obs} =$ the upstream stage from the rating curve.

For subsequent iterations, the factor is improved by the secant method,

$$F_k = F_{k-1} - \frac{E_{k-1}}{\left(\frac{E_{k-1} - E_{k-2}}{F_{k-1} - F_{k-2}}\right)} \quad (4)$$

in which the error at iteration k-1 is $E_{k-1} = z_{k-1} - z_{Obs}$.

For each cross-section, the improved conveyance at iteration k is

$$K_j^k = F_k \; K_j^{k-1} \quad (5)$$

where: $K_j^k =$ Conveyance for iteration k at cross-section j.
$F_k =$ Conveyance adjustment factor for iteration k.

The steps in the calibration is as follows:

1) For a constant flow, read the downstream stage from the rating curve.

2) Initially assume that the conveyance factor, F_0, is 1.0.

3) Using standard step backwater, compute the upstream stage.

4) Improve the conveyance factor using equation 3.

5) Using standard step backwater, compute the upstream stage.

6) If the Abs(E_k) is less than 0.1', end iteration.

7) Improve the conveyance factor using equation 4.

The reach must be calibrated to a range of flow. In the UNET program, the upstream rating curve is divided into 21 flow ordinates and the conveyance factor is optimized for each flow. Figure B-11 shows the optimized conveyance factors and the computed stages at the Lock and Dam No. 8 Tailwater Gage.

The conveyance factors must be applied to each cross-section in the reach. At each cross-section, stage is saved for the optimized conveyance factor, creating a stage-conveyance factor curve as shown in Figure B-12. The conveyance property table at a cross-section consists of 21 stage-conveyance pairs. The property table for the Lock and Dam No. 8 Tailwater Gage. is shown in Figure B-13. At each stage ordinate, the conveyance factor is interpolated from the stage-conveyance relationship and the channel and overbank conveyances are multiplied by the factor. No extrapolation is allowed in the stage-conveyance relationship. The adjustment process is demonstrated in Figure B-14. The adjusted cross-sections are checked by reproducing the rating curve. This process is demonstrated in Figure B-15.

A calibration reach is defined between two rating curves. Rating curves are entered into the cross-section file after the cross-section section header, the **X1** card, using **KR** and **kr** cards. The interface program, DERIVE_RC maintains the **KR** card. The **kr** card is permanent and not maintained by the interface. The **KR** and **kr** cards are described in Appendix A.

Occasionally it is necessary to turn off rating curve calibration at a downstream rating curve. An example is at a navigation dam. The rating curve at the pool cross-section serves as a downstream boundary for a calibration reach upstream through the pool. But calibration is not required through the navigation dam from the pool to the tailwater; thus, the calibration is turned off after the pool cross-section with the **KR OFF** card.

Optimized Conveyance Factors at RM 679.15

I	Flow	Z D/S	Z U/S	Z U/S C	Fact	Err	Iter
**	****	*****	*****	*******	****	***	****
1	12981	619.23	620.45	620.49	0.6800	-0.0370	4
2	23902	618.87	621.40	621.43	0.8345	-0.0309	3
3	32969	618.50	622.35	622.38	0.8800	-0.0297	2
4	42036	618.50	623.30	623.26	0.9302	0.0409	2
5	51103	618.50	624.25	624.27	0.9267	-0.0219	2
6	60377	618.50	625.20	625.21	0.9217	-0.0145	2
7	70428	618.91	626.15	626.17	0.9179	-0.0220	2
8	80478	619.49	627.10	627.13	0.9051	-0.0267	2
9	90719	620.44	628.05	628.09	0.8873	-0.0399	2
10	104381	621.78	629.00	629.02	0.9004	-0.0200	2
11	119896	623.06	629.95	629.97	0.9085	-0.0152	2
12	136265	624.34	630.90	630.95	0.9019	-0.0483	2
13	152632	625.57	631.85	631.83	0.9042	0.0188	2
14	170711	626.78	632.80	632.87	0.8923	-0.0675	2
15	189111	627.97	633.75	633.76	0.9013	-0.0076	2
16	207510	629.02	634.70	634.68	0.8971	0.0153	2
17	226122	630.07	635.65	635.72	0.8800	-0.0668	2
18	245095	631.26	636.60	636.67	0.8800	-0.0681	2
19	264069	632.45	637.55	637.62	0.8800	-0.0743	2
20	283044	633.59	638.50	638.55	0.8800	-0.0473	2

Figure B-11. Optimized conveyance factors at the Lock and Dam No. 8 Tailwater Gage, river mile 679.15

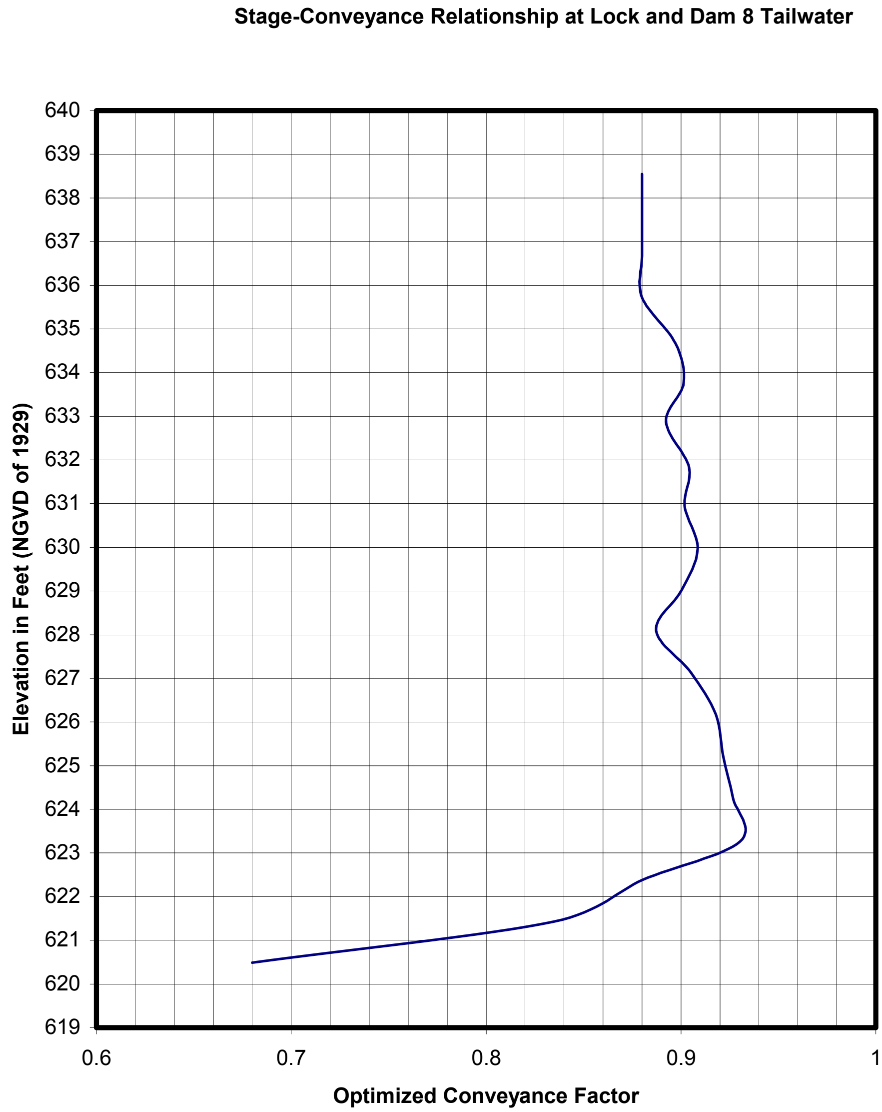


Figure B-12. The optimized conveyance factor function at the Lock and Dam No. 8 Tailwater Gage, river mile 679.15.

Ics No.1063, Cross Section Properties at R.M. 679.15

Elev	ALob	Ach	ARob	Area	CLob	Cch	CRob	Conv	Barea	TW	SLob	SRob	S	Aol	Aor
(Ft)	<---------	(Ft^2)		--------->	<-------	x1000 CFS		-------->	(Ft^2)	(Ft)	<-----	(Ft^2)	----->	<-- (Ft^2)	-->
****	******	******	******	******	******	******	******	******	******	****	******	******	******	******	******
615.00	0.	15866.	0.	15866.	0.	5009.	0.	5009.	0.	1084.	0.	0.	0.	0.	0.
616.50	0.	17495.	0.	17495.	0.	5878.	0.	5878.	0.	1088.	0.	0.	0.	0.	0.
618.00	0.	19129.	0.	19129.	0.	6801.	0.	6801.	0.	1091.	0.	0.	0.	0.	0.
619.50	0.	20769.	0.	20769.	0.	7778.	0.	7778.	0.	1095.	0.	0.	0.	0.	0.
621.00	0.	22413.	0.	22413.	0.	8806.	0.	8806.	0.	1098.	0.	351.	351.	0.	0.
622.50	0.	24064.	0.	24064.	0.	9885.	0.	9885.	0.	1102.	0.	2746.	2746.	0.	0.
624.00	0.	25719.	0.	25719.	0.	11012.	0.	11012.	0.	1105.	30.	8795.	8825.	0.	0.
625.50	0.	27380.	0.	27380.	0.	12184.	0.	12184.	0.	1110.	180.	21615.	21795.	0.	0.
627.00	0.	29049.	0.	29049.	0.	13398.	0.	13398.	0.	1115.	332.	37647.	37979.	0.	0.
628.50	0.	30721.	13.	30734.	0.	14693.	0.	14693.	0.	1152.	486.	54335.	54821.	0.	0.
630.00	0.	32395.	13873.	46268.	0.	16042.	1239.	17281.	0.	12760.	641.	57749.	58390.	0.	0.
631.50	1.	34069.	31380.	65450.	0.	17448.	3040.	20488.	0.	12794.	799.	57749.	58548.	0.	0.
633.00	2.	35743.	48903.	84648.	0.	18900.	5099.	23999.	0.	12803.	958.	57749.	58707.	0.	0.
634.50	4.	37417.	66439.	103860.	0.	20398.	7398.	27796.	0.	12813.	1120.	57749.	58869.	0.	0.
636.00	7.	39091.	83987.	123085.	0.	21941.	9925.	31867.	0.	12822.	1283.	57749.	59032.	0.	0.
637.50	11.	40765.	101566.	142341.	0.	23530.	12663.	36193.	0.	12844.	1448.	57749.	59198.	0.	0.
639.00	167.	42439.	119158.	161764.	-33.	25162.	15620.	40749.	0.	13069.	1504.	57749.	59253.	0.	0.
640.50	538.	44113.	136758.	181409.	0.	26838.	18779.	45617.	0.	13124.	1504.	57749.	59253.	0.	0.
642.00	1001.	45787.	154366.	201154.	36.	28557.	22135.	50728.	0.	13208.	1504.	57749.	59253.	0.	0.
643.50	1531.	47461.	171981.	220973.	123.	30318.	25682.	56122.	0.	13218.	1504.	57749.	59253.	0.	0.
645.00	2068.	49135.	189603.	240806.	221.	32121.	29414.	61756.	0.	13226.	1504.	57749.	59253.	0.	0.

Zmin = 592.00; XS Zmin = 592.00; Channel length = 950.; Valley length = 1178.; INVB = 0

Figure B-13. Cross-section property table at Lock and Dam No. 8 Tailwater prior to optimiation of conveyance factors.

Figure B-13. Cross-section property table at Lock and Dam No. 8 Tailwater prior to optimiation of conveyance factors.

Adjusted Conveyance at Lock and Dam No. 8 Tailwater
RM 679.15

NGVD	Channel Conveyance CFS X 0.001	Elevation Feet Overbank Conveyance CFS X 0.001	Optimized Conveyance Change Factor	Adjusted Channel Conveyance CFS X 0.001	Adjusted Overbank Conveyance CFS X 0.001
615.00	5009	0	0.68	3406	0
616.50	5878	0	0.68	3997	0
618.00	6801	0	0.68	4625	0
619.50	7778	0	0.68	5289	0
621.00	8806	0	0.77	6781	0
622.50	9885	0	0.89	8798	0
624.00	11012	0	0.93	10241	0
625.50	12184	0	0.92	11209	0
627.00	13398	0	0.91	12192	0
628.50	14693	0	0.89	13077	0
630.00	16042	1239	0.91	14598	1127
631.50	17448	3040	0.90	15703	2736
633.00	18900	5099	0.89	16821	4538
634.50	20398	7398	0.90	18358	6658
636.00	21941	9925	0.88	19308	8734
637.50	23530	12663	0.88	20706	11143
639.00	25162	15587	0.88	22143	13717
640.50	26838	18779	0.88	23617	16526
642.00	28557	22171	0.88	25130	19510
643.50	30318	25805	0.88	26680	22708
645.00	32121	29635	0.88	28266	26079

Figure B-14. Example of the adjustment of conveyance factors at Lock and Dam No. 8 Tailwater (RM 679.15) using optimized conveyance factors. The factors were interpolated from Figure B-11.

.

Conveyance Factors at RM 679.15

I	Flow	Z D/S	Z U/S	Z U/S C	Err
**	****	*****	*****	*******	***
2	12981	619.23	620.45	620.29	0.1627
3	23902	618.87	621.40	621.52	-0.1198
4	32969	618.50	622.35	622.49	-0.1368
5	42036	618.50	623.30	623.45	-0.1519
6	51103	618.50	624.25	624.38	-0.1260
7	60377	618.50	625.20	625.29	-0.0871
8	70428	618.91	626.15	626.24	-0.0944
9	80478	619.49	627.10	627.16	-0.0552
10	90719	620.44	628.05	628.02	0.0278
11	104381	621.78	629.00	629.02	-0.0229
12	119896	623.06	629.95	629.99	-0.0414
13	136265	624.34	630.90	630.93	-0.0342
14	152632	625.57	631.85	631.85	-0.0019
15	170711	626.78	632.80	632.83	-0.0253
16	189111	627.97	633.75	633.78	-0.0317
17	207510	629.02	634.70	634.71	-0.0110
18	226122	630.07	635.65	635.68	-0.0314
19	245095	631.26	636.60	636.66	-0.0637
20	264069	632.45	637.55	637.62	-0.0708
21	283044	633.59	638.50	638.55	-0.0486

Figure B-15. Reproduction of stage at RM 679.15 with distributed optimized conveyance for the calibration

Figure B-16 shows the automatic calibration conveyance adjustment reaches between Guttenberg, Iowa (L&D 10) and L&D 2 (Hastings, Minnesota). Calibration reaches are defined between:

- L&D 2 TW and L&D 3 Pool
- L&D 3 TW and L&D 4 Pool
- L&D 4 TW and L&D 5 Pool
- L&D 5 TW and L&D 5A Pool
- L&D 5A TW and Winona-USGS GAGE
- L&D Winona-USGS GAGE and L&D 6 Pool
- L&D 6 TW and L&D 7 Pool
- L&D 7 TW and L&D 8 Pool
- L&D 8 TW and L&D 9 Pool
- L&D 9 TW and McGregor-USGS GAGE
- L&D McGregor-USGS GAGE and L&D 10 Pool

Breaks in the calibration occur between the L&D Pool and Tailwater Gages where calibration is not needed.

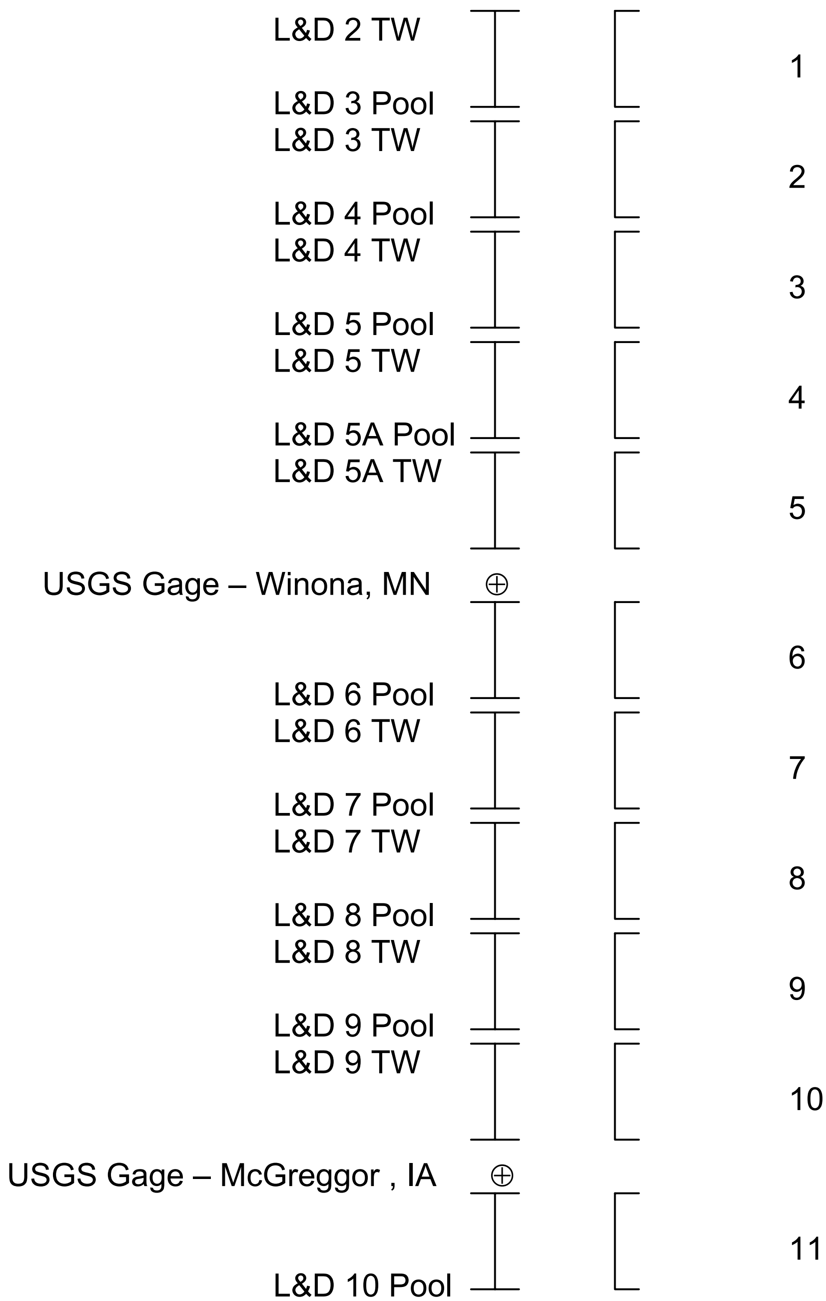


Figure B-16. Automatic calibration conveyance adjustment reaches.

Fine Tuning for Flow/Stage Effects

As discussed in the aforementioned paragraph on the application of automatic calibration conveyance adjustment, the cross-sectional conveyance of the model is optimized to reproduce rating curves that were derived from observations of stage and flow over a long period. Thus, the base calibration represents an average flow-conveyance structure that is representative of the entire observation period, not a specific event. The calibration is static; whereas, the roughness of the river is dynamic. Thus, to simulate a particular event, the average calibration must be fine-tuned to reproduce the observed stage (and flow).

Figure B-17 shows the reproduction of the calendar year 2001 for the Mississippi River at the Lock and Dam No. 8 Tailwater Gage. The station was calibrated to reproduce the rating curve shown in Figure B-18. This rating curve was fitted to the scatter of observed stage and flow from water years 1940 through 2001.

For the Mississippi River within the Flow Frequency Study reach from Prescott, Wisconsin to Guttenberg, Iowa, shifts in the stage ratings are relatively small. At the Winona, Minnesota United Stage Geological Survey gage the shifts in the ratings were quantified by 10 year periods. The results of this analysis show that the total shift from 1950 to 2002 is less than 0.5 foot. As a result of this minor shift the modifications and natural changes along the river were not included in the study. Further information regarding stage variation is available in the Risk and Uncertainity Analysis Appendix for this study. The historyof construction changes for the Upper Mississippi River is discussed further in the June 1995 *Floodplain Management Asessment of the Upper Mississippi River and Lower Missouri Rivers and Tributaries* report prepared by the US Army Corps of Engineers.

Discussion with Water Control indicates that the ice out condition on the Upper Mississippi from Prescott, Wisconsin to Guttenberg, Iowa occurs prior to a free flow condition (gates are completely raised). The free flow condition occurs approximately at the 2-year frequency, therefore ice effects were assumed to be insignificant to the frequency profiles.

The UNET program has three tools for fine-tuning the calibration of the model:

1. **Conveyance Change Factors.** These factors, one for the channel and one for the overbank, adjust the conveyance at multiple cross-sections for all stages. The factors simulate a systematic change in roughness – one that is apparent for all stages over the entire length of the simulation.

2. **Discharge-Conveyance Change Factors.** This relationship adjusts conveyance with discharge over multiple cross-sections along the same river, a calibration reach. This relationship is the primary tool for adjusting systematic errors in stage at the same discharge.

3. **Seasonal Conveyance Change Factors.** This relationship changes an overall conveyance multiplier with time, simulating seasonal shifts in roughness. The seasonal factor is applied to all the cross-sections in a calibration reach at all stages. For the Flow Frequency Study, the seasonal conveyance change factors were not used. Changing seasonal time periods from one year to the next for the period of record analysis created problems using this feature. Since the modeling effort at this time is for the purpose of developing flood

profiles for larger flows, the error introduced for low stages is not significant . If the model is used for low flows in the future, additional work is required for that application.

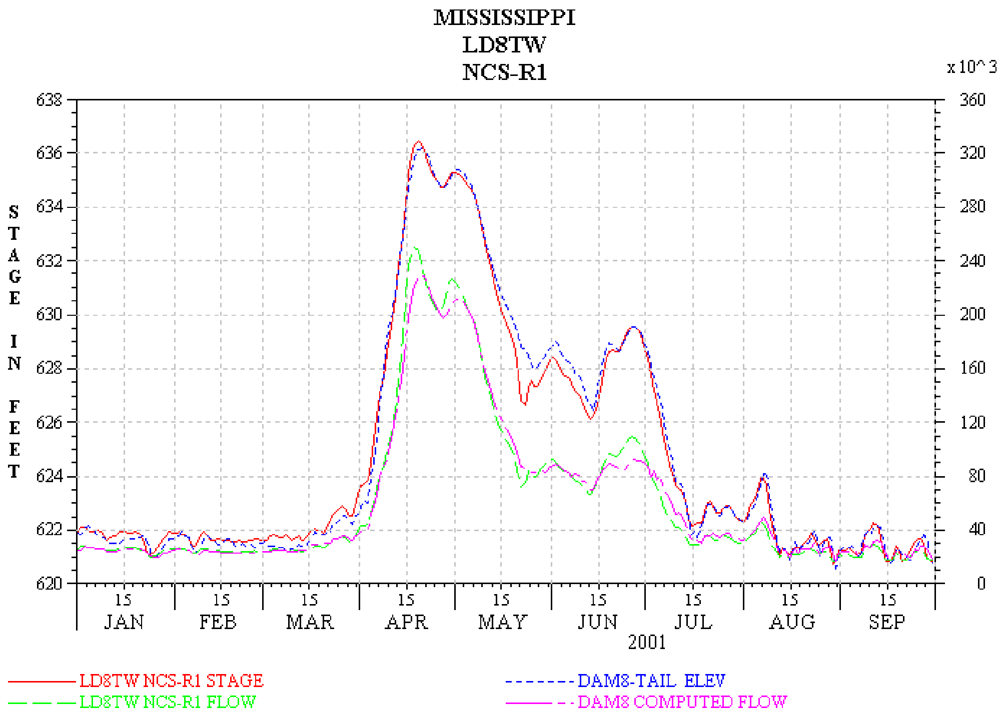


Figure B-17. The reproduction of stage and flow at the Lock and Dam No. 8 Tailwater Gage for the calendar year 2001. The model was calibrated to the rating curve shown in Figure B-17. The reproduction shows seasonal and systematic changes in roughness.

A conveyance change factor is the new conveyance divided by the old conveyance; hence,

$$F = \frac{K_{new}}{K_{old}} \qquad (1)$$

where: F= the conveyance change factor.
K_{new} = the new conveyance
K_{old} = the old conveyance.

In terms of roughness, Equation 1 is equivalent to

$$F = \frac{n_{old}}{n_{new}} \qquad (2)$$

where: n_{old} = the old roughness as measured by measured by Manning's "n."
n_{new} = the new roughness as measured by measured by Manning's "n."

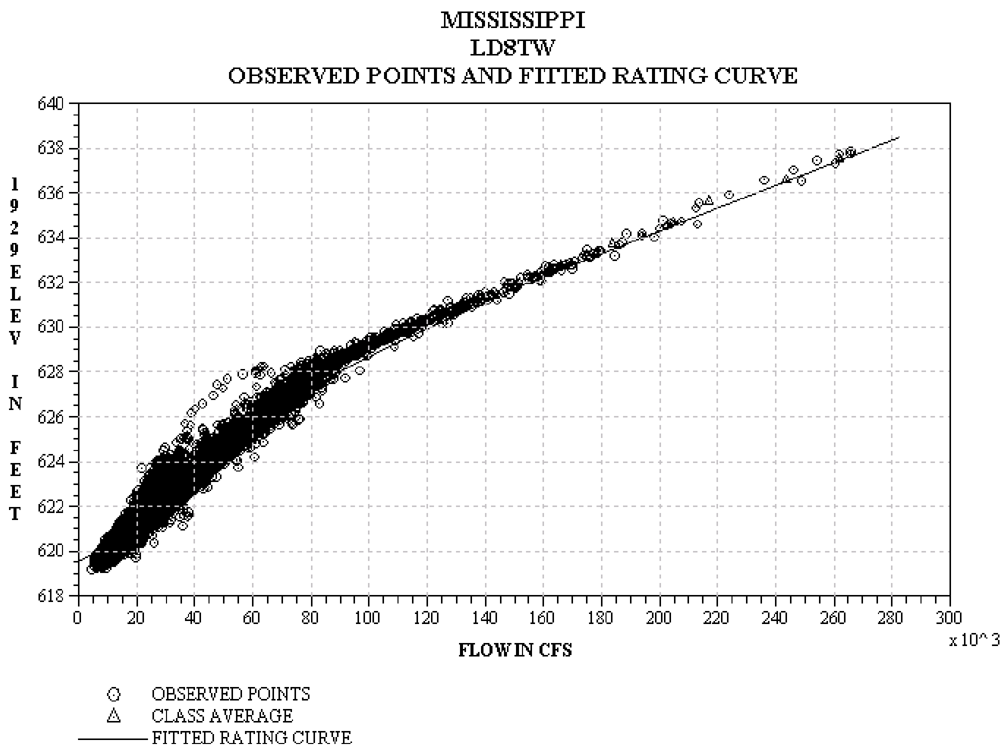


Figure B-18. Observed points and fitted rating curve for water years 1940 through 2001.

Increasing a conveyance change factor causes the computed stage to fall and decreasing the conveyance change factor causes the computed stage to rise.

For type 1, conveyance change factors, the channel and overbank factors are multiplied times the 21 channel and overbank conveyance entries in the cross-section property table for all the cross-sections in the calibration reach.

For type 2, discharge-conveyance change factors, a table of flow and conveyance change factors is defined manually. The table used to fine-tune the model in Figure B-17 is shown in Figure B-19. The table values are always at an equal interval of flow, in this case 20,000 cfs. The flow range, 0 to 380,000 cfs, is the expected range of flow. At each time step, conveyance change factors are interpolated from the flow at each cross-section in the calibration reach. Therefore, each cross-section has a different factor, since the routed flow is different at each cross-section. For example, if cross-section j has a flow of 190,000 cfs and cross-section k has a flow of 200,000 cfs, the factors would be 1.050 and 1.100, respectively. Twenty-seven discharge-conveyance change factor reaches were defined with the factors ranging between 0.80 and 1.20.

The seasonal conveyance change factors adjust the conveyance for all stages according to a time series of factors. Larger rivers such as the Mississippi and the Missouri have a cold season roughness regime and a warm season roughness regime. During the cold season, the more viscous water reduces the period and height of the dunes, reducing the roughness. The cold season starts from October to December, depending on the year. The warm season starts in late April or early May with a transition period from one to two weeks.

Figure B-19 shows where seasonal factors are entered using the Graphical User Interface for UNET. The seasonal factors are entered from January through December; hence, the factors start and end in the winter.

At cross-section i, the adjusted conveyance is

$$K_i = F_{cc} \cdot F_{QF}(Q_i) \cdot F_S(T) \cdot K_{xs\,i} \tag{3}$$

where: K_i = adjusted conveyance at cross-section i.
F_{CC} = conveyance change factor, a constant value.
$F_{QF}(Q_i)$ = discharge conveyance change factor, interpolated from the flow, Q_i, at cross-section i.
$F_S(T)$ = seasonal conveyance change factor at day T.
$K_{XS\,i}$ = conveyance from the cross-section property table at cross-section i.

The three types of conveyance change factors are inserted in the boundary condition file.
Figure B-18 shows the input of the conveyance change factors for the calibration reach downstream of the Lock and Dam No. 8 Tailwater Gage.

Attachment B-5 includes plots with computed and observed discharge and stage hydrographs at key locations.

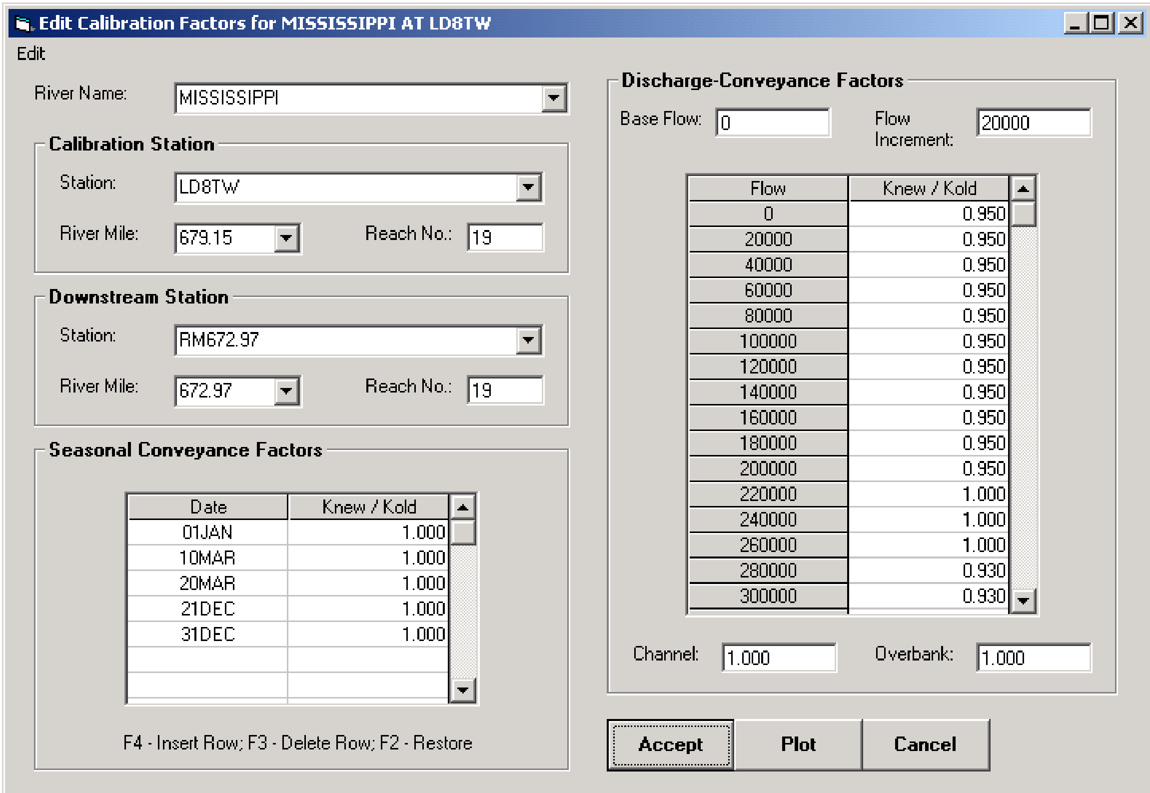


Figure B-19. Discharge conveyance change factors used to fine-tune the stages at L&D 8 Tailwater in Figure B-17.

Adjustments for seasonal effects are not included in the Period-of-record Analysis for the Flow Frequency Study since the duration of the winter season can vary considerably from year to year and since the purpose of this study is to develop profiles for high flow flood events rather than for low flow conditions when ice would be more of a concern.

Operational Policy

For the St. Paul District, the only operational considerations take into account for the Flow Frequency Study are the rule curves as illustrated for Lock and Dam No. 10 on Figures B-8 and B-9. The rule curves are based on the past experience and operational considerations in the St. Paul District Water Control Manuals.

STAGE-FREQUENCY FROM UNET RESULTS

The methodology adopted for the Flow Frequency Study requires a period of record simulation using UNET for determining annual peak stage and discharge simulated values. Once the simulated values are determined, additional stage frequency software developed by Dr. David Goldman is utilized for determining stage frequency results at each cross-section.

Regulation impacts are insignificant for the study reach of the Mississippi River within the St. Paul District. Further discussion on this topic is in the paragraph on Regulation Impacts on page B-9 of this appendix. Therefore, separate sets of data for unregulated and regulated conditions are not required. One set of data from the UNET results is utilized for the stage-frequency analysis. This same data is input as regulated and unregulated data in the regvsunreg.exe software described in the following paragraphs. In reaches of the Mississippi River outside of the St. Paul District, both regulated and unregulated data is utilized where regulation does have an impact.

PERIOD-OF-RECORD SIMULATION

Two period of record simulations are needed for the stage-frequency analysis. One is required for the determination of UNET statistics and the other is required for the development of extended rating curves for the factored events.

a. **UNET Statistics.** The period of record for the UNET statistics are for the period from 1940-1998. The UNET simulation is not extended prior to 1940 since data is lacking at the McGregor gage prior to 1937 and for many of the tributaries prior to 1940. UNET can generate an output file with Weibull results relating annual peak stage and discharge to frequency in a Data Storage System(DSS) format labeled "ANNMAX.DSS." The ANNMAX.DSS file generated from this period of record UNET simulation is used for input to the unet.dss software for generating the rireg.out output file. At the bottom, it contains the UNET-generated statistics needed for interpolation. These statistics are copied into interp.dat. The program interpolate_stats.exe then produces the series of statistics needed for the input to stage_freq.exe for the reach from RM631.0 located just downstream of the Wisconsin River to RM612.7 which is at the downstream end of the St. Paul District modeling for the stage-frequency determination.

b. **Simulation for Extended Rating Curves.** In the St. Paul District, the curves relating annual peak stage and discharge at most cross-sections don't extend far enough for even the 0.5 percent chance flood event. The Flow Frequency Study required the determination of stage frequency profiles for events up to and including the 0.2 percent chance flood event.

For the simulation needed to extend the curves, flow hydrographs for the years 1965, 1969 and 2001 were factored using a factor of 1.25. The factored events were simulated in the model as the 1937-1939 events for a total period of record from 1937-2001. This simulation produces ANNMAX.DSS files with the needed results for generating the peak annual stage versus discharge ratings. The ANNMAX.DSS file is input for the unetdss.exe software which generates rating output in the rirating.dss format. The rirating.dss file is the input to the rating_curve.exe software which generates the rcurve.dss output with the rating curve data needed for the final process using the stage_freq.out software. The Weibull frequencies generated for this simulation are not correct. However, the Weibull statistics for this simulation do not impact the extended rating curves.

Stage Frequency Software

The software programs used for the stage frequency analysis for the Flow Frequency Study are described below:

1. **unetdss.exe** The unetdss.exe program is used for generating paired dss data from the UNET ANNMAX.DSS results file and also for generating the UNET statistics. As stated in the previous paragraphs this effort is accomplished once to determine the UNET statistics for the period of record from 1940-1998 and a second time for the period from 1937-2001.

2. **rating_curve.exe** The rating_curve.exe program is used for generating the rating curves for the 1937-2001 data so that the rating curves are extended using the factored events.

3. **regvsunreg.exe** After extending the rating curves with the 1937-2001 simulation, the regvsunreg.exe program is used for generating the relationship between the regulated and unregulated discharge statistics. This program uses the output from the unetdss.exe and rating_curve.exe software. In the St. Paul District the effect of regulation is negligible, but the regvsunreg.exe program is executed so that the stage_freq.exe program can be run successfully.

4. **area_vs_stats.exe** The area_vs_stats.exe program is run to compute the discharge statistics at every UNET cross-section based on a drainage area interpolation between the gages with computed discharge statistics (St. Paul, Prescott, Winona, McGregor, and Dubuque).

5. **interpolate_stats.exe** The first file needed for the interpolate_stats.exe software is the rireg.out which is the output from unetdss.exe for the simulation for 1940-1998. At the bottom, it contains the UNET-generated statistics needed for interpolation. These statistics are copied into interp.dat. interpolate_stats.exe then produces the series of statistics needed for the input to stage_freq.exe.

6. **stage_freq.exe** For the St. Paul Districts stage frequency determination the drainage area method is used upstream of the Wisconsin River at River Mile 631.0. The UNET statistics are used downstream of the Wisconsin River. The drainage area statistics are copied into the stage_freq.dat file for the reach upstream of the Wisconsin river. The UNET statistics are copied into the reach from River Mile 631.0 to River Mile 612.7.

Finally, the stage_freq.exe program, using the output from the rating_curve.exe, regvsunreg.exe, interpolate.exe and area_vs_stats.exe programs, is run to compute the discharge and stage information at every UNET cross-section, thus generating a discharge and stage profile along the river. A sample of the discharge profile output table from the stage_freq.exe program is shown in Figure B-20. A sample of the stage profile output table, also from the stage_freq.exe program, is shown in Figure B-21.

Water surface profiles developed for the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, 200-yr, and 500-year flood events are shown on **Plates B-7 to B-10** (NGVD of 1929) and **Plates B-11 to B-14** (1912 Datum). Tabulated values are also included in **Attachments B-6 and B-7.** The water surface profiles are generated from the output of the stage_freq.exe program.

	exceedance probability vs flow							
csec	0.500	0.200	0.100	0.040	0.020	0.010	0.005	0.002
636.2	100453.	141209.	168077.	201802.	226752.	251556.	276387.	309445.
635.9	100476.	141214.	168066.	201769.	226700.	251484.	276293.	309320.
635.6	100499.	141246.	168105.	201816.	226752.	251541.	276356.	309391.
635.3	100522.	141279.	168144.	201862.	226805.	251599.	276420.	309463.
635.0	100545.	141284.	168133.	201829.	226752.	251527.	276326.	309338.
634.7	100591.	141349.	168210.	201922.	226857.	251643.	276453.	309480.
634.6	100591.	141349.	168210.	201922.	226857.	251643.	276453.	309480.
634.4	100614.	141381.	168249.	201968.	226909.	251701.	276516.	309551.
634.2	100638.	141414.	168288.	202015.	226961.	251759.	276580.	309623.
633.9	100660.	141419.	168278.	201982.	226909.	251686.	276486.	309497.
633.6	100684.	141452.	168316.	202028.	226961.	251744.	276550.	309569.
633.3	100684.	141452.	168316.	202028.	226961.	251744.	276550.	309569.
633.1	100684.	141452.	168316.	202028.	226961.	251744.	276550.	309569.
632.9	100684.	141452.	168316.	202028.	226961.	251744.	276550.	309569.
632.4	100684.	141452.	168316.	202028.	226961.	251744.	276550.	309569.
631.9	100684.	141452.	168316.	202028.	226961.	251744.	276550.	309569.
631.4	100684.	141452.	168316.	202028.	226961.	251744.	276550.	309569.
631.2	100684.	141452.	168316.	202028.	226961.	251744.	276550.	309569.
631.0	100684.	141452.	168316.	202028.	226961.	251744.	276550.	309569.
631.0	119900.	167711.	199115.	238433.	267456.	296264.	325061.	363342.
630.8	119900.	167678.	199057.	238338.	267333.	296110.	324875.	363112.
630.6	119900.	167678.	199057.	238338.	267333.	296110.	324875.	363112.

Figure B-20. Discharge profile output table from the stage_freq.exe program

	exceedance probability vs stage							
csec	0.500	0.200	0.100	0.040	0.020	0.010	0.005	0.002
636.2	619.9	623.7	625.6	627.1	628.1	629.2	630.5	632.4
635.9	619.8	623.6	625.5	627.0	628.0	629.1	630.4	632.3
635.6	619.8	623.5	625.5	627.0	627.9	629.1	630.4	632.3
635.3	619.7	623.5	625.4	626.9	627.9	629.0	630.3	632.2
635.0	619.7	623.4	625.4	626.8	627.8	628.9	630.2	632.1
634.7	619.6	623.4	625.3	626.8	627.8	628.9	630.2	632.1
634.6	619.6	623.4	625.3	626.8	627.8	628.9	630.2	632.1
634.4	619.6	623.4	625.3	626.8	627.7	628.9	630.2	632.1
634.2	619.5	623.4	625.3	626.7	627.7	628.9	630.1	632.0
633.9	619.5	623.3	625.3	626.7	627.7	628.8	630.1	632.0
633.6	619.4	623.3	625.2	626.6	627.6	628.7	630.0	631.9
633.3	619.4	623.3	625.2	626.6	627.6	628.7	630.0	631.9
633.1	619.4	623.2	625.1	626.6	627.5	628.7	630.0	631.9
632.9	619.3	623.2	625.1	626.5	627.5	628.6	629.9	631.8
632.4	619.2	623.1	625.0	626.4	627.4	628.5	629.8	631.7
631.9	619.1	623.0	624.9	626.3	627.3	628.4	629.7	631.7
631.4	619.0	622.9	624.8	626.2	627.2	628.3	629.6	631.5
631.2	619.0	622.9	624.7	626.2	627.1	628.3	629.6	631.5
631.0	618.9	622.8	624.7	626.1	627.0	628.2	629.5	631.4
631.0	618.6	622.2	624.0	625.9	627.2	628.5	629.8	631.4
630.8	618.5	622.1	623.8	625.8	627.1	628.3	629.6	631.2
630.6	618.5	622.0	623.8	625.7	627.0	628.2	629.4	631.1

Figure B-21. Stage profile output table from the stage_freq.exe program

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Goldman, Dr. David(2001). Memorandum for Record 5 October 2001, *Software for computing stage frequency curves, Upper Mississippi Basin Flow Frequency Study*.

Upper Mississippi River
Flow Frequency Study

Attachment B1
St. Paul District
FFA Model Output

```
*          FFA            FLOOD FREQUENCY ANALYSIS
  *    PROGRAM DATE:  FEB 1995    THE HYDROLOGIC ENGINEERING CENTER *
 *       VERSION:  3.1        *    *      609 SECOND STREET      *
 *    RUN  DATE  AND  TIME:    *    *    DAVIS, CALIFORNIA 95616    *
 *      26 OCT 00   11:28:54    *    *       (916) 756-1104        *

  INPUT FILE NAME: MISS\STP98M.IN
 OUTPUT FILE NAME: MISS\STP98M.OUT

 **TITLE RECORD(S)**
 TT    MISSISSIPPI RIVER AT ST. PAUL
 **JOB RECORD(S)**
    IPPC  ISKFX  IPROUT   IFMT   IWYR  IUNIT  ISMRY  IPNCH   IREG
 J1    2     3     0     0     0     0     0     3     0
 **STATION IDENTIFICATION**
 ID  USGS STATION 05331000
**GENERALIZED SKEW**
    ISTN  GGMSE   SKEW
 GS  05331   .000   -.10

 HPDISCHARGE-FREQUENCY CURVE
 HPMISSISSIPPI @ ST. PAUL, MN
 HPUSGS GAGE 05331000
 HPANNUAL INSTANTANEOUS PEAKS
 HPWATER YRS(1898-1998)
 HPBULLETIN 17-B GUIDELINES

-OUTLIER TESTS  -

 BASED ON 101 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 3.021
      0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF  6209.5

 BASED ON 101 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 3.021
     0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF  233935.

  COMPUTED  EXPECTED    PERCENT   CONFIDENCE LIMITS
   CURVE    PROBABILITY    CHANCE    .05       .95
      FLOW IN CFS       EXCEEDANCE    FLOW IN CFS

   200000.   209000.         .2      254000.   164000.
   169000.   175000.         .5      211000.   141000.
   148000.   152000.        1.0     181000.   125000.
   127000.   129000.        2.0     153000.   108000.
   101000.   102000.        5.0     119000.    87600.
     81800.    82400.      10.0      94400.    72300.
    63400.    63600.       20.0      71600.    56800.
    38500.    38500.       50.0      42500.    34900.
    23100.    23000.       80.0      25700.    20400.
    17500.    17400.       90.0      19900.    15200.
    14000.    13700.       95.0      16100.    11800.
      9020.     8730.      99.0      10800.     7260.
                    SYSTEMATIC STATISTICS
  LOG TRANSFORM: FLOW, CFS          NUMBER OF EVENTS
  MEAN                  4.5811   HISTORIC EVENTS      0
  STANDARD DEV         .2608   HIGH OUTLIERS      0
  COMPUTED SKEW      -.2687   LOW OUTLIERS      0
  REGIONAL SKEW      -.1000   ZERO OR MISSING    0
  ADOPTED SKEW       -.1000   SYSTEMATIC EVENTS    101
```

-PLOTTING POSITIONS- USGS STATION 05331000 - MISSISSIPPI RIVER @ ST. PAUL, MN.																
EVENTS ANALYZED				ORDERED EVENTS					EVENTS ANALYZED				ORDERED EVENTS			
			FLOW		WATER	FLOW	MEDIAN					FLOW		WATER	FLOW	MEDIAN
MON	DAY	YEAR	CFS	RANK	YEAR	CFS	PLOT POS		MON	DAY	YEAR	CFS	RANK	YEAR	CFS	PLOT POS
0	0	1898	35800.	1	1965	171000.	.69		0	0	1949	43200.	52	1978	40100.	50.99
0	0	1899	36800.	2	1969	156000.	1.68		0	0	1950	53900.	53	1974	39500.	51.97
0	0	1900	25800.	3	1997	134000.	2.66		0	0	1951	92800.	54	1941	39400.	52.96
0	0	1901	19800.	4	1952	125000.	3.65		0	0	1952	125000.	55	1912	39000.	53.94
0	0	1902	19800.	5	1993	104000.	4.64		0	0	1953	47000.	56	1938	38800.	54.93
0	0	1903	43000.	6	1951	92800.	5.62		0	0	1954	43500.	57	1936	37500.	55.92
0	0	1904	51800.	7	1986	83300.	6.61		0	0	1955	25700.	58	1899	36800.	56.90
0	0	1905	59800.	8	1957	78400.	7.59		0	0	1956	34900.	59	1898	35800.	57.89
0	0	1906	50600.	9	1975	78300.	8.58		0	0	1957	78400.	60	1970	35800.	58.88
0	0	1907	50600.	10	1979	75400.	9.57		0	0	1958	18200.	61	1910	35800.	59.86
0	0	1908	73000.	11	1916	73500.	10.55		0	0	1959	22200.	62	1939	35600.	60.85
0	0	1909	48900.	12	1908	73000.	11.54		0	0	1960	43300.	63	1990	35500.	61.83
0	0	1910	35800.	13	1984	70800.	12.52		0	0	1961	22600.	64	1927	35000.	62.82
0	0	1911	8450.	14	1917	68600.	13.51		0	0	1962	56400.	65	1956	34900.	63.81
0	0	1912	39000.	15	1983	64100.	14.50		0	0	1963	31600.	66	1964	33400.	64.79
0	0	1913	15800.	16	1905	59800.	15.48		0	0	1964	33400.	67	1976	33400.	65.78
0	0	1914	40500.	17	1994	59100.	16.47		0	0	1965	171000.	68	1928	33000.	66.77
0	0	1915	31100.	18	1943	58200.	17.46		0	0	1966	49400.	69	1963	31600.	67.75
0	0	1916	73500.	19	1982	57600.	18.44		0	0	1967	52200.	70	1915	31100.	68.74
0	0	1917	68600.	20	1944	56900.	19.43		0	0	1968	27300.	71	1942	30300.	69.72
0	0	1918	22500.	21	1962	56400.	20.41		0	0	1969	156000.	72	1987	30300.	70.71
0	0	1919	54500.	22	1985	55600.	21.40		0	0	1970	35800.	73	1980	30200.	71.70
0	0	1920	53100.	23	1919	54500.	22.39		0	0	1971	49800.	74	1989	29200.	72.68
0	0	1921	19500.	24	1998	54400.	23.37		0	0	1972	51600.	75	1968	27300.	73.67
0	0	1922	46000.	25	1950	53900.	24.36		0	0	1973	51800.	76	1981	25900.	74.65
0	0	1923	13200.	26	1995	53900.	25.35		0	0	1974	39500.	77	1900	25800.	75.64
0	0	1924	12900.	27	1945	53400.	26.33		0	0	1975	78300.	78	1955	25700.	76.63
0	0	1925	16800.	28	1920	53100.	27.32		0	0	1976	33400.	79	1940	23700.	77.61
0	0	1926	14500.	29	1967	52200.	28.30		0	0	1977	18800.	80	1937	23300.	78.60
0	0	1927	35000.	30	1991	52000.	29.29		0	0	1978	40100.	81	1961	22600.	79.59
0	0	1928	33000.	31	1973	51800.	30.28		0	0	1979	75400.	82	1918	22500.	80.57
0	0	1929	45800.	32	1904	51800.	31.26		0	0	1980	30200.	83	1959	22200.	81.56
0	0	1930	22000.	33	1972	51600.	32.25		0	0	1981	25900.	84	1930	22000.	82.54
0	0	1931	9670.	34	1996	50800.	33.23		0	0	1982	57600.	85	1901	19800.	83.53
0	0	1932	17600.	35	1906	50600.	34.22		0	0	1983	64100.	86	1902	19800.	84.52
0	0	1933	14400.	36	1907	50600.	35.21		0	0	1984	70800.	87	1921	19500.	85.50
0	0	1934	7460.	37	1971	49800.	36.19		0	0	1985	55600.	88	1977	18800.	86.49
0	0	1935	12600.	38	1966	49400.	37.18		0	0	1986	83300.	89	1958	18200.	87.48
0	0	1936	37500.	39	1909	48900.	38.17		0	0	1987	30300.	90	1932	17600.	88.46
0	0	1937	23300.	40	1992	48500.	39.15		0	0	1988	16400.	91	1925	16800.	89.45
0	0	1938	38800.	41	1953	47000.	40.14		0	0	1989	29200.	92	1988	16400.	90.43
0	0	1939	35600.	42	1948	46900.	41.12		0	0	1990	35500.	93	1913	15800.	91.42
0	0	1940	23700.	43	1947	46500.	42.11		0	0	1991	52000.	94	1926	14500.	92.41
0	0	1941	39400.	44	1922	46000.	43.10		0	0	1992	48500.	95	1933	14400.	93.39
0	0	1942	30300.	45	1929	45800.	44.08		0	0	1993	104000.	96	1923	13200.	94.38
0	0	1943	58200.	46	1954	43500.	45.07		0	0	1994	59100.	97	1924	12900.	95.36
0	0	1944	56900.	47	1960	43300.	46.06		0	0	1995	53900.	98	1935	12600.	96.35
0	0	1945	53400.	48	1949	43200.	47.04		0	0	1996	50800.	99	1931	9670.	97.34
0	0	1946	41000.	49	1903	43000.	48.03		0	0	1997	134000.	100	1911	8450.	98.32
0	0	1947	46500.	50	1946	41000.	49.01		0	0	1998	54400.	101	1934	7460.	99.31
0	0	1948	46900.	51	1914	40500.	50.00									

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*    FFA             FLOOD FREQUENCY ANALYSIS       U.S. ARMY CORPS OF ENGINEERS   *
*    PROGRAM DATE:  FEB 1995    *    * THE HYDROLOGIC ENGINEERING CENTER *
*       VERSION:  3.1         *    *      609 SECOND STREET      *
*    RUN  DATE  AND  TIME:    *    *    DAVIS, CALIFORNIA 95616    *
*      26 OCT 00   15:30:09    *    *       (916) 756-1104        *

 INPUT FILE NAME: MISS\PRSCTPK.IN
OUTPUT FILE NAME: MISS\PRSCTPK.OUT

**TITLE RECORD(S)**
TT    MISSISSIPPI RIVER AT PRESCOTT, WI
**JOB RECORD(S)**
   IPPC  ISKFX  IPROUT   IFMT   IWYR  IUNIT  ISMRY  IPNCH   IREG
J1    2     3     0     0     0     0     0     3     0
**STATION IDENTIFICATION**
ID  USGS STATION 05344500
**GENERALIZED SKEW**
   ISTN  GGMSE   SKEW
GS 05331    .000   -.10

HPDISCHARGE-FREQUENCY CURVE
HPMISSISSIPPI @ PRESCOTT WI
HPUSGS GAGE 53445
HPANNUAL INSTANTANEOUS PEAKS
HPWATER YRS(1898-1998)
HPBULLETIN 17-B GUIDELINES
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COMPUTED CURVE	EXPECTED PROBABILITY	PERCENT CHANCE	CONFIDENCE LIMITS .05	.95
FLOW IN CFS		EXCEEDANCE	FLOW IN CFS	
252000.	262000.	.2	313000.	211000.
217000.	224000.	.5	265000.	185000.
192000.	197000.	1.0	231000.	165000.
167000.	171000.	2.0	198000.	146000.
136000.	138000.	5.0	158000.	120000.
113000.	114000.	10.0	129000.	101000.
90000.	90300.	20.0	100000.	81600.
57600.	57600.	50.0	62900.	52700.
36400.	36200.	80.0	40100.	32600.
28500.	28200.	90.0	31800.	25000.
23200.	22900.	95.0	26300.	19900.
15700.	15200.	99.0	18400.	12900.

SYSTEMATIC STATISTICS

LOG TRANSFORM: FLOW, CFS		NUMBER OF EVENTS	
MEAN	4.7563	HISTORIC EVENTS	0
STANDARD DEV	.2338	HIGH OUTLIERS	0
COMPUTED SKEW	-.2397	LOW OUTLIERS	0
REGIONAL SKEW	-.1000	ZERO OR MISSING	0
ADOPTED SKEW	-.1000	SYSTEMATIC EVENTS	101

PLOTTING POSITIONS- USGS STATION 05344500 - MISSISSIPPI RIVER @ PRESCOTT, WI

EVENTS ANALYZED				ORDERED		
			FLOW		WATER	FLOW
MON	DAY	YEAR	CFS	RANK	YEAR	CFS
0	0	1898	82700.	1	1965	
0	0	1899	51600.	2	1969	
0	0	1900	33500.	3	1997	
0	0	1901	39600.	4	1952	
0	0	1902	36700.	5	1993	
0	0	1903	68700.	6	1951	
0	0	1904	50600.	7	1986	
0	0	1905	82400.	8	1975	
0	0	1906	74000.	9	1950	
0	0	1907	75200.	10	1979	
0	0	1908	93900.	11	1916	
0	0	1909	53100.	12	1972	
0	0	1910	45500.	13	1957	
0	0	1911	16900.	14	1908	
0	0	1912	65100.	15	1984	
0	0	1913	29000.	16	1920	
0	0	1914	67800.	17	1922	
0	0	1915	40000.	18	1967	
0	0	1916	96800.	19	1945	
0	0	1917	85500.	20	1982	
0	0	1918	31300.	21	1917	
0	0	1919	68700.	22	1944	
0	0	1920	88800.	23	1983	
0	0	1921	29300.	24	1971	
0	0	1922	88800.	25	1954	
0	0	1923	22500.	26	1898	
0	0	1924	17800.	27	1996	
0	0	1925	19800.	28	1905	
0	0	1926	23400.	29	1943	
0	0	1927	51600.	30	1973	
0	0	1928	54000.	31	1962	
0	0	1929	49600.	32	1907	
0	0	1930	33700.	33	1966	
0	0	1931	22400.	34	1991	
0	0	1932	30300.	35	1906	
0	0	1933	19800.	36	1985	
0	0	1934	15000.	37	1994	
0	0	1935	36200.	38	1976	
0	0	1936	52500.	39	1998	
0	0	1937	31000.	40	1992	
0	0	1938	60700.	41	1919	
0	0	1939	65000.	42	1903	
0	0	1940	33800.	43	1914	
0	0	1941	67600.	44	1953	
0	0	1942	42400.	45	1941	
0	0	1943	80200.	46	1946	
0	0	1944	84700.	47	1978	
0	0	1945	87500.	48	1974	
0	0	1946	65500.	49	1912	
0	0	1947	63100.	50	1939	
0	0	1948	63100.	51	1995	
0	0	1949	53800.	52	1947	
0	0	1950	101000.	53	1948	
0	0	1951	128000.	54	1956	
0	0	1952	155000.	55	1938	
0	0	1953	67700.	56	1964	
0	0	1954	82800.	57	1970	
0	0	1955	45200.	58	1960	
0	0	1956	62700.	59	1928	
0	0	1957	94000.	60	1949	
0	0	1958	28400.	61	1909	
0	0	1959	35300.	62	1936	
0	0	1960	54000.	63	1899	
0	0	1961	46300.	64	1927	
0	0	1962	76300.	65	1904	
0	0	1963	41400.	66	1929	
0	0	1964	57600.	67	1989	
0	0	1965	228000.	68	1961	
0	0	1966	74800.	69	1910	
0	0	1967	87800.	70	1955	
0	0	1968	40200.	71	1981	
0	0	1969	199000.	72	1980	
0	0	1970	54900.	73	1990	
0	0	1971	83000.	74	1942	
0	0	1972	95500.	75	1963	
0	0	1973	78300.	76	1968	
0	0	1974	65200.	77	1915	
0	0	1975	112000.	78	1901	
0	0	1976	72800.	79	1902	
0	0	1977	26100.	80	1935	
0	0	1978	65400.	81	1959	
0	0	1979	100400.	82	1940	
0	0	1980	43100.	83	1930	
0	0	1981	43400.	84	1900	
0	0	1982	86700.	85	1918	
0	0	1983	84200.	86	1937	
0	0	1984	90900.	87	1932	
0	0	1985	73400.	88	1987	
0	0	1986	116000.	89	1921	
0	0	1987	29400.	90	1913	
0	0	1988	28200.	91	1958	
0	0	1989	49000.	92	1988	
0	0	1990	42900.	93	1977	
0	0	1991	74300.	94	1926	
0	0	1992	69400.	95	1923	
0	0	1993	130000.	96	1931	
0	0	1994	72900.	97	1933	
0	0	1995	65000.	98	1925	
0	0	1996	82600.	99	1924	
0	0	1997	161000.	100	1911	
0	0	1998	70400.	101	1934	

```
*              FFA                 *      *                                    *
 *     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS    *
 *     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
 *          VERSION:  3.1           *      *         609 SECOND STREET         *
 *     RUN  DATE   AND   TIME:      *      *      DAVIS, CALIFORNIA 95616      *
 *        26 OCT 00    15:30:37     *      *          (916) 756-1104           *

  INPUT FILE NAME: MISS\WIN1898.IN
 OUTPUT FILE NAME: MISS\WIN1898.OUT

 **TITLE RECORD(S)**
 TT      MISSISSIPPI RIVER AT WINONA MN
 **JOB RECORD(S)**
      IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
 J1     2       3       0       0       0       0       0       3       0
 **STATION IDENTIFICATION**
 ID   USGS STATION 05378500
 **GENERALIZED SKEW**
      ISTN   GGMSE    SKEW
 GS 05331     .000    -.10

 HPDISCHARGE-FREQUENCY CURVE
 HPMISSISSIPPI @ WINONA MN
 HPUSGS GAGE 05378500
 HPANNUAL INSTANTANEOUS PEAKS
 HPWATER YEARS 1898-1998
 HPBULLETIN 17-B GUIDELINES


-FREQUENCY CURVE- USGS STATION 05378500

   COMPUTED   EXPECTED      PERCENT       CONFIDENCE LIMITS
    CURVE   PROBABILITY      CHANCE          .05        .95
       FLOW IN CFS         EXCEEDANCE       FLOW IN CFS

    299000.    309000.          .2       358000.    258000.
    265000.    271000.          .5       312000.    231000.
    239000.    244000.         1.0       279000.    211000.
    214000.    217000.         2.0       246000.    190000.
    180000.    182000.         5.0       204000.    163000.
    154000.    155000.        10.0       172000.    141000.
    128000.    128000.        20.0       140000.    118000.
     88500.     88500.        50.0        95300.     82300.
     60600.     60400.        80.0        65700.     55300.
     49500.     49200.        90.0        54300.     44400.
     41800.     41300.        95.0        46400.     36900.
     30300.     29500.        99.0        34500.     25800.
                          SYSTEMATIC STATISTICS
  LOG TRANSFORM: FLOW, CFS               NUMBER OF EVENTS

   MEAN                     4.9438    HISTORIC EVENTS         0
   STANDARD DEV              .1929    HIGH OUTLIERS         0
   COMPUTED SKEW          -.0996    LOW OUTLIERS         0
   REGIONAL SKEW           -.1000    ZERO OR MISSING     0
   ADOPTED SKEW            -.1000    SYSTEMATIC EVENTS     100
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-PLOTTING POSITIONS- USGS STATION 05378500 - MISSISSIPPI RIVER @ WINONA, MINN

EVENTS ANALYZED				ORDERED EVENTS				EVENTS ANALYZED				ORDERED EVENTS			
			FLOW		WATER	FLOW	MEDIAN				FLOW		WATER	FLOW	MEDIAN
MON	DAY	YEAR	CFS	RANK	YEAR	CFS	PLOT POS	MON	DAY	YEAR	CFS	RANK	YEAR	CFS	PLOT POS
0	0	1898	83000.	1	1965	268000.	.70	0	0	1949	65200.	51	1956	91700.	50.50
0	0	1899	95600.	2	1969	218000.	1.69	0	0	1950	122000.	52	1978	89000.	51.49
0	0	1900	72200.	3	1997	194000.	2.69	0	0	1951	178000.	53	1941	86700.	52.49
0	0	1901	96900.	4	1952	190000.	3.69	0	0	1952	190000.	54	1995	84100.	53.49
0	0	1902	47200.	5	1951	178000.	4.68	0	0	1953	82800.	55	1898	83000.	54.48
0	0	1903	136000.	6	1993	168000.	5.68	0	0	1954	156000.	56	1953	82800.	55.48
0	0	1904	75300.	7	1986	167000.	6.67	0	0	1955	64400.	57	1974	81600.	56.47
0	0	1905	125000.	8	1967	166000.	7.67	0	0	1956	91700.	58	1918	80800.	57.47
0	0	1906	118000.	9	1975	166000.	8.67	0	0	1957	95800.	59	1928	80800.	58.47
0	0	1907	115000.	10	1916	160000.	9.66	0	0	1958	43500.	60	1947	79400.	59.46
0	0	1908	119000.	11	1920	157000.	10.66	0	0	1959	41900.	61	1989	79400.	60.46
0	0	1909	75300.	12	1954	156000.	11.65	0	0	1960	70000.	62	1929	78300.	61.45
0	0	1910	63600.	13	1922	145000.	12.65	0	0	1961	67600.	63	1948	77100.	62.45
0	0	1911	32600.	14	1996	144000.	13.65	0	0	1962	92200.	64	1935	76200.	63.45
0	0	1912	95600.	15	1982	138000.	14.64	0	0	1963	51400.	65	1909	75300.	64.44
0	0	1913	67400.	16	1983	138000.	15.64	0	0	1964	65700.	66	1904	75300.	65.44
0	0	1914	107000.	17	1973	136000.	16.63	0	0	1965	268000.	67	1968	75000.	66.43
0	0	1915	73200.	18	1903	136000.	17.63	0	0	1966	105000.	68	1990	74700.	67.43
0	0	1916	160000.	19	1943	135000.	18.63	0	0	1967	166000.	69	1915	73200.	68.43
0	0	1917	116000.	20	1971	133000.	19.62	0	0	1968	75000.	70	1900	72200.	69.42
0	0	1918	80800.	21	1979	131000.	20.62	0	0	1969	218000.	71	1960	70000.	70.42
0	0	1919	110000.	22	1905	125000.	21.61	0	0	1970	64400.	72	1981	69800.	71.41
0	0	1920	157000.	23	1950	122000.	22.61	0	0	1971	133000.	73	1980	69000.	72.41
0	0	1921	44700.	24	1976	120000.	23.61	0	0	1972	98700.	74	1961	67600.	73.41
0	0	1922	145000.	25	1908	119000.	24.60	0	0	1973	136000.	75	1913	67400.	74.40
0	0	1924	54400.	26	1906	118000.	25.60	0	0	1974	81600.	76	1964	65700.	75.40
0	0	1925	38000.	27	1998	118000.	26.59	0	0	1975	166000.	77	1949	65200.	76.39
0	0	1926	57100.	28	1917	116000.	27.59	0	0	1976	120000.	78	1970	64400.	77.39
0	0	1927	62600.	29	1907	115000.	28.59	0	0	1977	44800.	79	1955	64400.	78.39
0	0	1928	80800.	30	1945	115000.	29.58	0	0	1978	89000.	80	1910	63600.	79.38
0	0	1929	78300.	31	1919	110000.	30.58	0	0	1979	131000.	81	1932	62600.	80.38
0	0	1930	41100.	32	1914	107000.	31.57	0	0	1980	69000.	82	1927	62600.	81.37
0	0	1931	31600.	33	1994	107000.	32.57	0	0	1981	69800.	83	1926	57100.	82.37
0	0	1932	62600.	34	1984	106000.	33.57	0	0	1982	138000.	84	1934	55500.	83.37
0	0	1933	38600.	35	1944	105000.	34.56	0	0	1983	138000.	85	1924	54400.	84.36
0	0	1934	55500.	36	1966	105000.	35.56	0	0	1984	106000.	86	1940	51700.	85.36
0	0	1935	76200.	37	1942	103000.	36.55	0	0	1985	101000.	87	1963	51400.	86.35
0	0	1936	94900.	38	1985	101000.	37.55	0	0	1986	167000.	88	1937	49200.	87.35
0	0	1937	49200.	39	1972	98700.	38.55	0	0	1987	40900.	89	1902	47200.	88.35
0	0	1938	93400.	40	1901	96900.	39.54	0	0	1988	46800.	90	1988	46800.	89.34
0	0	1939	93900.	41	1957	95800.	40.54	0	0	1989	79400.	91	1977	44800.	90.34
0	0	1940	51700.	42	1899	95600.	41.53	0	0	1990	74700.	92	1921	44700.	91.33
0	0	1941	86700.	43	1912	95600.	42.53	0	0	1991	92900.	93	1958	43500.	92.33
0	0	1942	103000.	44	1936	94900.	43.53	0	0	1992	92000.	94	1959	41900.	93.33
0	0	1943	135000.	45	1939	93900.	44.52	0	0	1993	168000.	95	1930	41100.	94.32
0	0	1944	105000.	46	1938	93400.	45.52	0	0	1994	107000.	96	1987	40900.	95.32
0	0	1945	115000.	47	1991	92900.	46.51	0	0	1995	84100.	97	1933	38600.	96.31
0	0	1946	92700.	48	1946	92700.	47.51	0	0	1996	144000.	98	1925	38000.	97.31
0	0	1947	79400.	49	1962	92200.	48.51	0	0	1997	194000.	99	1911	32600.	98.31
0	0	1948	77100.	50	1992	92000.	49.50	0	0	1998	118000.	100	1931	31600.	99.30

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 *            FFA                  *      *                                *
 *     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS    *
 *     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
 *          VERSION:  3.1           *      *         609 SECOND STREET         *
 *     RUN  DATE   AND   TIME:      *      *      DAVIS, CALIFORNIA 95616      *
 *        26 OCT 00    15:31:16     *      *          (916) 756-1104           *
 *                                  *      *                                   *

  INPUT FILE NAME: MISS\MAC1898.IN
 OUTPUT FILE NAME: MISS\MAC1898.OUT

 **TITLE RECORD(S)**
 TT      MISSISSIPPI RIVER AT McGREGOR IA
 **JOB RECORD(S)**
      IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
 J1     2       3       0       0       0       0       0       3       0
**STATION IDENTIFICATION**
 ID   USGS STATION 05389500
**GENERALIZED SKEW**
      ISTN   GGMSE    SKEW
 GS 05331     .000    -.10
**HP PLOT **
      HP PLOT FILE                  IHPCV  KLIMIT    IPER    BAREA
 HPMISS\PLOTMCG.PCL                     2       1       1    67500SQ. MI

BASED ON  62 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.849
        0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF  37963.6

 BASED ON  62 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.849
       0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF  313852.

 HPDISCHARGE-FREQUENCY CURVE
 HPMISSISSIPPI @ MCGREGOR, IA
 HPUSGS GAGE 05389500
 HPANNUAL INSTANTANEOUS PEAKS
 HPWATER YEARS 1937-1998
 HPBULLETIN 17-B GUIDELINES
FINAL RESULTS

 -FREQUENCY CURVE- USGS STATION 05389500

   COMPUTED   EXPECTED      PERCENT       CONFIDENCE LIMITS
    CURVE   PROBABILITY      CHANCE          .05        .95
       FLOW IN CFS         EXCEEDANCE       FLOW IN CFS

    303000.    318000.          .2       370000.    261000.
    274000.    284000.          .5       328000.    238000.
    252000.    259000.         1.0       298000.    221000.
    229000.    234000.         2.0       267000.    203000.
    199000.    201000.         5.0       227000.    179000.
    175000.    176000.        10.0       196000.    159000.
    149000.    150000.        20.0       165000.    137000.
    110000.    110000.        50.0       119000.    102000.
     80100.     79700.        80.0        87100.     72500.
     67600.     67000.        90.0        74400.     60100.
     58700.     57800.        95.0        65400.     51200.
     44800.     43400.        99.0        51400.     37600.
                      SYSTEMATIC STATISTICS
 LOG TRANSFORM: FLOW, CFS              NUMBER OF EVENTS

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   STANDARD DEV            .1610    HIGH OUTLIERS       0
   COMPUTED SKEW         -.0873    LOW OUTLIERS        0
   REGIONAL SKEW          -.1000    ZERO OR MISSING     0
   ADOPTED SKEW          -.1000    SYSTEMATIC EVENTS      62
```

-

PLOTTING POSITIONS FOR SYSTEMATIC EVENTS- USGS STATION 05389500 MISSISSIPPI RIVER @ McGREGOR, IA.

EVENTS ANALYZED ORDERED EVENTS	EVENTS ANALYZED ORDERED EVENTS
FLOW WATER FLOW MEDIAN	FLOW WATER FLOW MEDIAN
MON DAY YEAR CFS RANK YEAR CFS PLOT POS	MON DAY YEAR CFS RANK YEAR CFS PLOT POS
0 0 1937 54700. 1 1965 276000. 1.12	0 0 1968 97900. 32 1956 105000. 50.80
0 0 1938 101400. 2 1969 215000. 2.72	0 0 1969 215000. 33 1974 104000. 52.40
0 0 1939 96900. 3 1997 201000. 4.33	0 0 1970 72100. 34 1978 104000. 54.01
0 0 1940 52100. 4 1952 197500. 5.93	0 0 1971 138000. 35 1991 104000. 55.61
0 0 1941 102800. 5 1993 189000. 7.53	0 0 1972 116000. 36 1962 104000. 57.21
0 0 1942 113800. 6 1951 185700. 9.13	0 0 1973 151000. 37 1989 103000. 58.81
0 0 1943 124600. 7 1975 183000. 10.74	0 0 1974 104000. 38 1941 102800. 60.42
0 0 1944 122500. 8 1967 170000. 12.34	0 0 1975 183000. 39 1938 101400. 62.02
0 0 1945 127700. 9 1986 168000. 13.94	0 0 1976 125000. 40 1946 101200. 63.62
0 0 1946 101200. 10 1954 165500. 15.54	0 0 1977 42000. 41 1995 99600. 65.22
0 0 1947 85500. 11 1987 158000. 17.15	0 0 1978 104000. 42 1990 98800. 66.83
0 0 1948 84000. 12 1973 151000. 18.75	0 0 1979 133000. 43 1968 97900. 68.43
0 0 1949 73100. 13 1983 145000. 20.35	0 0 1980 87400. 44 1939 96900. 70.03
0 0 1950 123300. 14 1996 143000. 21.96	0 0 1981 80700. 45 1957 95800. 71.63
0 0 1951 185700. 15 1982 139000. 23.56	0 0 1982 139000. 46 1980 87400. 73.24
0 0 1952 197500. 16 1971 138000. 25.16	0 0 1983 145000. 47 1953 86200. 74.84
0 0 1953 86200. 17 1979 133000. 26.76	0 0 1984 117000. 48 1947 85500. 76.44
0 0 1954 165500. 18 1945 127700. 28.37	0 0 1985 110000. 49 1948 84000. 78.04
0 0 1955 73700. 19 1998 126000. 29.97	0 0 1986 168000. 50 1960 83100. 79.65
0 0 1956 105000. 20 1976 125000. 31.57	0 0 1987 158000. 51 1981 80700. 81.25
0 0 1957 95800. 21 1943 124600. 33.17	0 0 1988 57200. 52 1964 75600. 82.85
0 0 1958 55800. 22 1950 123300. 34.78	0 0 1989 103000. 53 1955 73700. 84.46
0 0 1959 72300. 23 1944 122500. 36.38	0 0 1990 98800. 54 1949 73100. 86.06
0 0 1960 83100. 24 1984 117000. 37.98	0 0 1991 104000. 55 1959 72300. 87.66
0 0 1961 114000. 25 1972 116000. 39.58	0 0 1992 106000. 56 1970 72100. 89.26
0 0 1962 104000. 26 1994 115000. 41.19	0 0 1993 189000. 57 1963 72000. 90.87
0 0 1963 72000. 27 1961 114000. 42.79	0 0 1994 115000. 58 1988 57200. 92.47
0 0 1964 75600. 28 1942 113800. 44.39	0 0 1995 99600. 59 1958 55800. 94.07
0 0 1965 276000. 29 1966 112000. 45.99	0 0 1996 143000. 60 1937 54700. 95.67
0 0 1966 112000. 30 1985 110000. 47.60	0 0 1997 201000. 61 1940 52100. 97.28
0 0 1967 170000. 31 1992 106000. 49.20	0 0 1998 126000. 62 1977 42000. 98.88

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 ************************************       ************************************
*             FFA                  *      *                                   *
*     FLOOD FREQUENCY ANALYSIS     *      *   U.S. ARMY CORPS OF ENGINEERS    *
*     PROGRAM DATE:  FEB 1995      *      * THE HYDROLOGIC ENGINEERING CENTER *
*          VERSION:  3.1           *      *        609 SECOND STREET          *
*     RUN  DATE   AND   TIME:      *      *      DAVIS, CALIFORNIA 95616      *
*        20 AUG 02    14:58:35     *      *          (916) 756-1104           *
*                                  *      *                                   *
************************************      ************************************


 INPUT FILE NAME: miss\macwdbq.dat
OUTPUT FILE NAME: miss\macwdbq.out


**TITLE RECORD(S)**
TT      MISSISSIPPI RIVER AT MCGREGOR    (Freqency Curve Based on Regionalized Statistics)

**STATION IDENTIFICATION**
ID   USGS STATION 05389500
**INPUT STATISTICS**
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        XM       S       G    SKEW      AG   NHIS  NOUTL   NLOW  NZMSG
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**HP PLOT **
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     SELECTED CURVES ON HPPLOT
          COMPUTED PROBABILITY CURVE

HPDISCHARGE-FREQUENCY CURVE
HPMISSISSIPPI @ MCGREGOR,IA
HPUSGS GAGE 05389500
HPFINAL MEAN AND STD.DEV
HPFROM SMOOTHING RELATIONSHIP
HPOF UPPER MISS. STATIONS

FINAL RESULTS

-FREQUENCY CURVE- USGS STATION 05389500
ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÑÍÍÍÍÍÍÍÍÍÍÍÍÍÍÑÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
º  COMPUTED   EXPECTED   ³   PERCENT   ³    CONFIDENCE LIMITS  º
º   CURVE   PROBABILITY  ³    CHANCE   ³       .05        .95   º
º      FLOW IN CFS       ³  EXCEEDANCE ³      FLOW IN CFS       º
ÇÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¶
º   309000.    319000.   ³       .2    ³  365000.    270000.  º
º   276000.    283000.   ³       .5    ³  321000.    244000.  º
º   251000.    256000.   ³      1.0    ³  289000.    224000.  º
º   227000.    230000.   ³      2.0    ³  258000.    204000.  º
º   194000.    196000.   ³      5.0    ³  217000.    176000.  º
º   168000.    169000.   ³     10.0    ³  186000.    155000.  º
º   141000.    142000.   ³     20.0    ³  154000.    131000.  º
º   101000.    101000.   ³     50.0    ³  108000.     94100.  º
º    71000.     70800.   ³     80.0    ³   76500.     65300.  º
º    58900.     58600.   ³     90.0    ³   64100.     53400.  º
º    50400.     49900.   ³     95.0    ³   55500.     45000.  º
º    37400.     36600.   ³     99.0    ³   42200.     32300.  º
ÌÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¹
º                      SYSTEMATIC STATISTICS                    º
ÇÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÂÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¶
º LOG TRANSFORM: FLOW, CFS       ³       NUMBER OF EVENTS      º
ÇÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÅÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ¶
º  MEAN                  5.0000  ³  HISTORIC EVENTS         0  º
º  STANDARD DEV           .1778  ³  HIGH OUTLIERS       0       º
º  COMPUTED SKEW          .0000  ³  LOW OUTLIERS        0       º
º  REGIONAL SKEW          .0000  ³  ZERO OR MISSING     0       º
º  ADOPTED SKEW          -.1000  ³  SYSTEMATIC EVENTS     101  º
ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÏÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
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Upper Mississippi River
Flow Frequency Study

Attachment B2
St. Paul District
Mississippi River Backwater Area and Tributaries

Mississippi River Updated Stage-Frequency Backwater Areas

Stuart V. Dobberpuhl[1], P.E. and Gregory W. Eggers[2]

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Abstract

Stage-frequency profiles for the Mississippi River were developed from Hastings, Minnesota downstream to Guttenberg, Iowa in the St. Paul District using updated flow-frequency values. Period of record inflow hydrographs were routed with a current condition unsteady flow model to determine a stage-discharge relationship at each cross section using the annual maximum values. A statistical analysis combines the flow-frequency with stage-discharge to determine stage-frequency values at each individual cross section. In backwater areas such as exists just upstream of the Wisconsin, River, the methodology produced jumps in the computed water surface profiles requiring an alternative procedure. The stage upstream of the mouth of a major tributary is a function of both the upstream flow on the main stem and the stage downstream of the tributary. The downstream stage on the tributary is a function of the total flow upstream on the main stem plus the coincidental tributary flow. The problem and alternative procedure are discussed as well as the stage frequency results.

Introduction

Congress tasked the Corps of Engineers to conduct a comprehensive, system-wide study to assess flood control and floodplain management practices in the areas that were flooded after the flood of 1993. That resulted in the Floodplain Management Assessment study (FPMA) (USACE, 1995). The study involved the following Corps of Engineer Districts: St. Paul, Rock Island, and St. Louis on the Mississippi River, and Omaha and Kansas City on the Missouri River. Each District developed independent unsteady flow UNET models. UNET is a one-dimensional unsteady open channel flow simulation model. The UNET simulation models were developed further for the Mississippi River Basin Modeling System and the Upper Mississippi Flow Frequency Study. Additional stage frequency software developed for the Flow Frequency Study is used in combination with the UNET period of record output for determining stage frequency profiles. The recommendation for the Mississippi River presented in this paper are a result of a joint effort between the Rock Island and St. Paul District Corps of Engineers and Dr. David Goldman, Consultant for the Upper Mississippi River System Flow Frequency Study.

Figure 1. Area Map of the Mississippi River Study Area within the St. Paul District

Geographic Coverage. The area modeled using UNET is extensive - from Anoka, MN to Thebes on the Mississippi River, from Gavins Point Dam on the Missouri River to St. Louis (confluence with the Mississippi) and from Lockport Lock & Dam to Grafton on the Illinois River. Portions of numerous smaller tributaries in the Basin are also modeled as unsteady flow routing reaches. The area of interest for the St. Paul District for the Mississippi River in the vicinity of the Wisconsin River is shown on **Figures 1 and 2**. Impacts from the tributary analysis influence stages on the Mississippi River downstream to Dubuque, Iowa which is at River Mile 579.3. Dubuque, Iowa is within the Rock Island District.

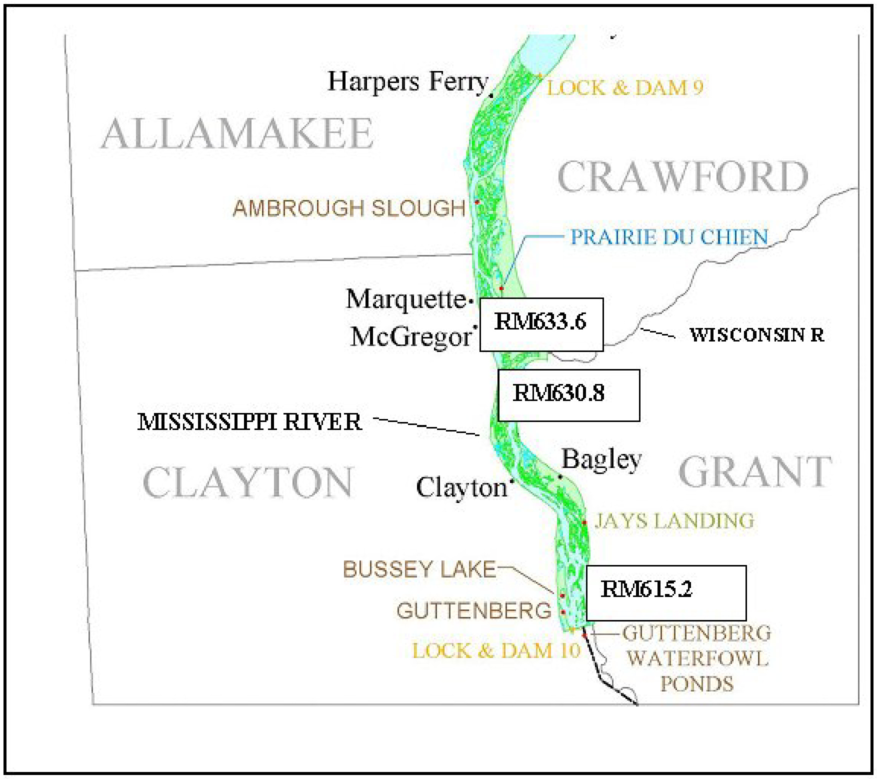


Figure 2. Area Map of the Mississippi River in the vicinity of the Wisconsin River

BASIN DESCRIPTION

Watershed Characteristics

This study encompasses the entire Mississippi River watershed area of about 714,000 square miles above the mouth of the Ohio River at Cairo, Illinois. The portion of the study area within the St. Paul District includes about 79,400 square miles above Lock and Dam 10 at river mile 615.1 miles above the mouth of the Ohio River at Cairo, Illinois. The area of the Upper Mississippi River within the St. Paul District is comprised of six major hydrologic units representing a diverse landscape and wide range of hydrologic conditions. The principal drainage units displayed in **Figure 3** include the Headwaters of the Mississippi River area above St. Paul, Minnesota River, St. Croix River, Chippewa River, the Black and Root River drainage unit and the Wisconsin River.

Watershed characteristics vary considerably from the Mississippi River's origin at Lake Itasca in the headwaters area, which is dominated by lakes and forest to the prairie pothole region of the Minnesota River basin, which has been extensively drained and is dominated by agriculture. Mean annual runoff varies from about 3.6 inches in the western portion of the Minnesota River basin to about 9.5 inches in the St. Croix River basin.

Flood Frequency Distribution Estimation Method

An investigation of flood frequency distribution estimation methods resulted in a recommendation by the Technical and Interagency Advisory Groups (TAG and IAG) to use the basic methodology described in Bulletin 17B for obtaining at-site estimates of flood distributions for the Upper Mississippi Basin Flood Frequency Study. The Bulletin recommends the log-Pearson III distribution with method of moments to estimate flood quantiles (e.g., the 1% chance annual peak flow). The TAG and IAG also recommended linear smoothing of the flood statistics to obtain consistent flood quantile estimates. Regional shape estimation also involves estimating average skew values for statistically homogenous regions and substituting this average value for the at-site value when estimating the flood-frequency distribution.

Flood regions may be defined by the confluence of major rivers (e.g., Kansas and Missouri, Illinois and Mississippi, Mississippi and Missouri), a change in climatology or some other feature that is manifested in the observed flow series. A statistical approach is proposed by the Technical Advisory Group (TAG) to obtain regional boundaries (see Hydrologic Engineering Center, 2000). The approach taken identifies boundaries based on channel characteristics, statistical variation of flood characteristics, and climate across the study area. Once regions with statistically similar flood characteristics were defined, a regional skew coefficient (a regional shape parameter) is obtained as an average of the at-site gage estimates within the region. The flood frequency distribution is computed from the at-site mean and standard deviation combined with the regional skew coefficient used as the adopted skew coefficient. Flood distributions in between gages are obtained by a linear smoothing relationship of the mean flow and the standard deviation with drainage area.

The final McGregor mean and standard deviation are interpolated from the linear relationship between Winona and Dubuque. Other regression methods were considered to define a 'best fit' relationship between the observed data listed in **Table 1**, but the TAG and IAG recommended linear interpolation. The plots displayed in **Figure 4** display the linear variation estimated for the mean and standard deviation between gages that are used to determine regionalized statistics for McGregor and other points of interest between the gauging stations. The data at Clinton and Keokuk are used to ensure consistency with the relationships in the Rock Island District. The final means and standard deviations to be used in the development of flood probabilities within the St. Paul District are listed in **Table 2**.

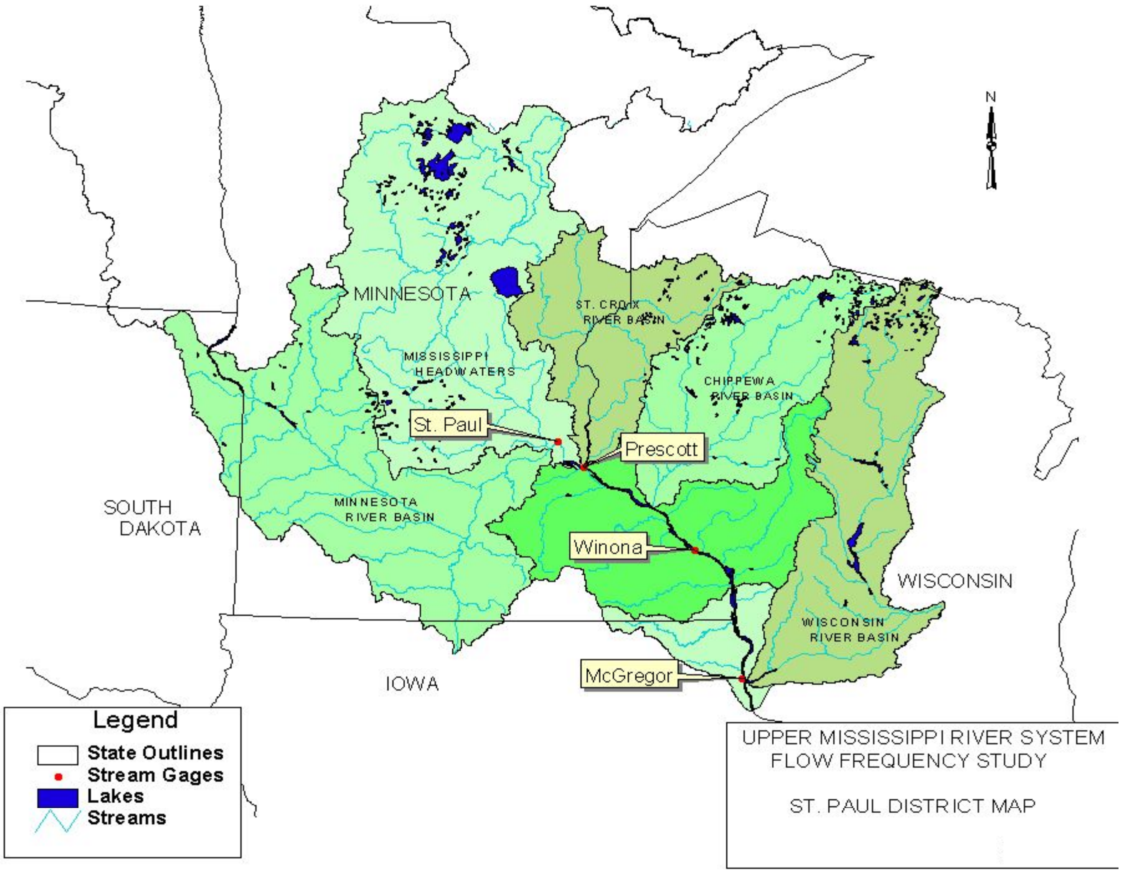


Figure 3. Principal Drainage Area Units for the Mississippi River - St. Paul District

Table 1. At-Site (Un-Regulated) Statistics for St. Paul District Gages Period of Record (1898-1998)

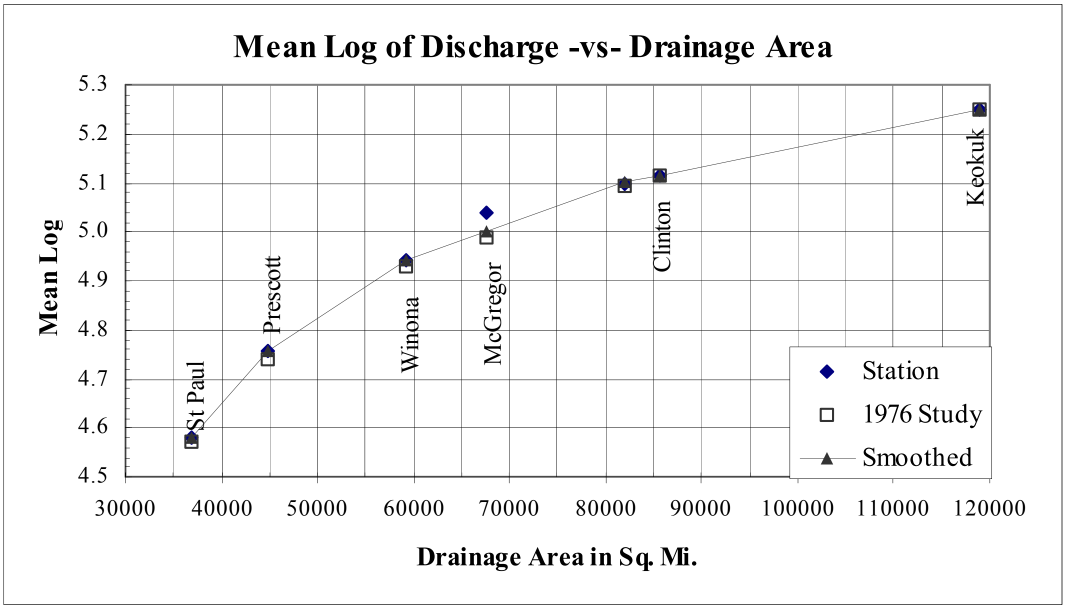
River Mile	Station	Drainage Area	Mean	Standard Deviation
839.3	St Paul	36800	4.581	0.261
811.4	Prescott	44800	4.756	0.234
725.7	Winona	59200	4.944	0.193
633.4	McGregor (1937-1998)	67500	5.038	0.161
518.2	Clinton[1]	85600	5.114	0.146
364.0	Keokuk[1]	119000	5.248	0.142

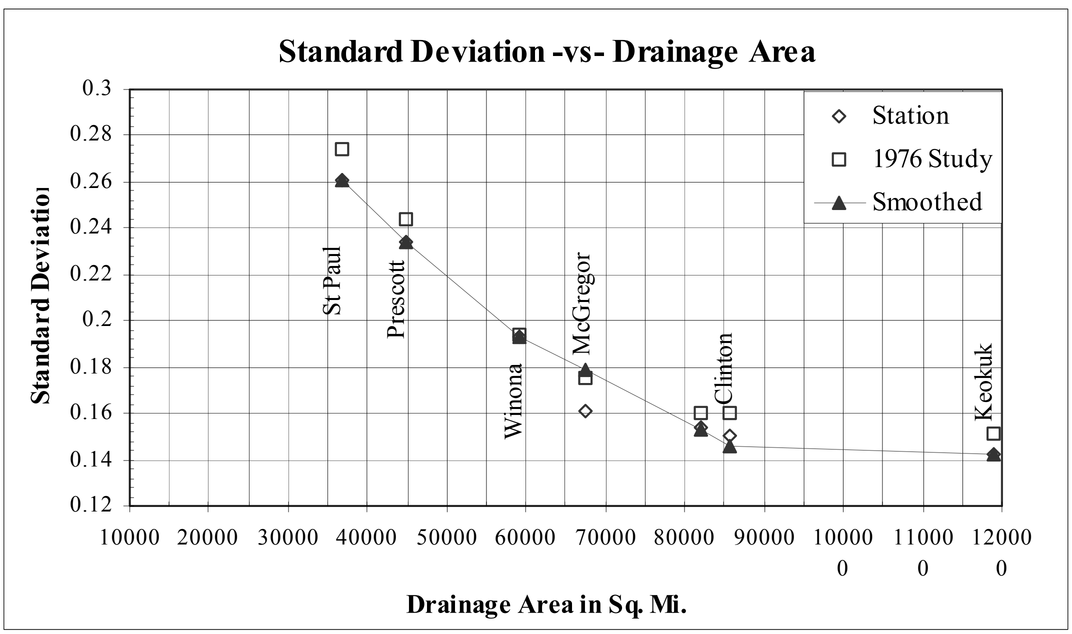
1. Clinton and Keokuk gages are located in Rock Island District, but are listed since they are included in St. Paul District smoothing analysis. The McGregor statistics are for a shorter record from 1937-1998.

Table 2. Final Regionalized Statistics for St. Paul District Gages Period of Record (1898-1998)

River Mile	Station	Drainage Area	Mean	Standard Deviation
839.3	St Paul	36800	4.581	0.261
811.4	Prescott	44800	4.756	0.234
725.7	Winona	59200	4.944	0.193
633.4	McGregor	67500	5.000	0.178

Figure 4. Smoothing at Site Statistics with Drainage Area





NOTE: Station statistics are based on period of record (POR) from 1898-1998, with exception of McGregor station where POR is from 1937-1998. The 1976 study statistics at St Paul is based on a POR of 1862-1976. The 1976 statistics for Clinton are based on POR from 1874-1975. All other 1976 study statistics are adjusted based on correlation with longer-term stations. Smoothed relationship is a linear fit between the station statistics at St Paul, Prescott, Winona, Dubuque, Clinton and Keokuk.

Stage Frequency Methodology

The methodology adopted for the Flow Frequency Study consists of a period of record analysis using UNET for determining annual peak stage and discharge simulated values. Once the simulated values are determined, additional stage frequency software developed by Dr. David Goldman is utilized for determining stage frequency results at each cross-section.

Period of Record UNET analysis

The observed period of record UNET runs are for the period from 1940-2001. In the St. Paul District, the curves at many cross-sections don't extend far enough for even the 0.5 percent chance flood event. The Flow Frequency Study required the determination of stage frequency profiles for events up to and including the 0.2 percent chance flood event. For the simulations needed to extend the curves, flow hydrographs for the years 1965, 1969 and 2001 were factored using a factor of 1.25. The results from the factored events combined with the historical period of record provide the annual peak discharge and stage data needed for the stage frequency analysis.

Stage Discharge for Cross-section just Downstream of Wisconsin River

In reaches of the river not influenced by tributary backwater effects (non-backwater reaches), a plot of the paired data has very little scatter about the spline rating curve. The absence of scatter is demonstrated in **Figure 5** , which represents cross-section 630.83, just downstream of the Wisconsin River.

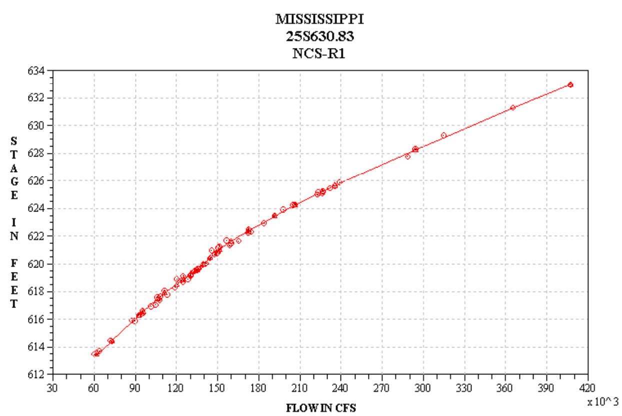


Figure 5. Comparison of paired annual maximum data and spline rating curve at cross-section 630.83 located just downstream of the Wisconsin River.

Stage Discharge for Cross-section just Upstream of Wisconsin River

In reaches influenced by tributary backwater effects (backwater reaches), a plot of the paired data shows more scatter about the spline rating curve. This is demonstrated in **Figure 6**, which represents cross-section 631.26, just upstream of the Wisconsin River. The scatter reflects the fact that the river stage in the backwater reach of a tributary is not simply a function of the upstream river discharge. Rather, it is dependent upon the river discharge upstream of the tributary and the river stage just downstream of the tributary. Since the stage in the backwater reach is a function of two variables, a family of rating curves is necessary to truly define the stage-discharge relationship. Because backwater reach rating curves generated by the rating_curve.exe program are only a function of the discharge upstream of the tributary, the stage obtained from the rating is correct only if the flow relationship between the Wisconsin River and the Mississippi River for the period of record analysis is preserved when the stage frequency analysis is accomplished. Otherwise, an unrealistic jump in the flood profile can occur across the tributary.

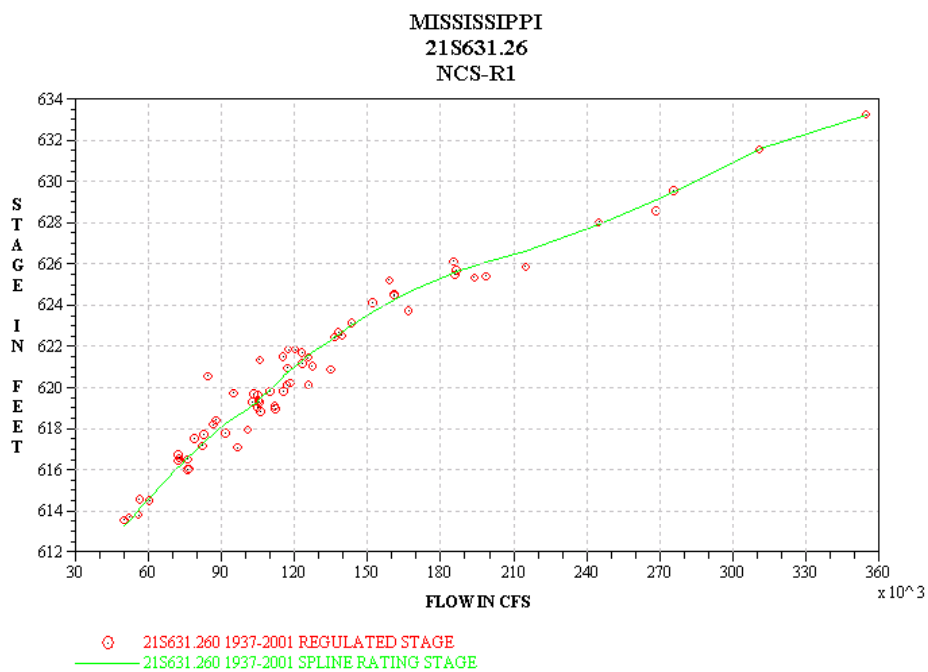


Figure 6. Comparison of paired annual maximum data and spline rating curve at cross-section 631.26, just upstream of the Wisconsin River.

Stage Frequency Software

The Flow Frequency Study stage-frequency programs [unetdss.exe, rating_curve.exe, regvsunreg.exe, area_vs_stats.exe, interpolate_stats.exe and stage_freq.exe] are used to process the UNET annual maximum data. for calculating the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year, 200-yr, and 500-year discharge and stage profiles. First, the unetdss.exe program is run to pair the annual maximum discharge and stage data. Second, the rating_curve.exe program is run to rank the annual maximum discharge and stage data and produce a best-fit spline curve of the paired, ranked data. While the spline curve is typically referred to as a rating curve, it is, in essence, a curve relating the discharge and stage. Third, the area_vs_stats.exe or interpolate_stats.exe programs are used to interpolate statistics for each cross-section in the UNET model. Last, the stage_freq.exe program is used for computing the stage frequency elevations at each cross-section using the rating curve and statistics developed for each cross-section.

Discontinuity in Stage at the Wisconsin River

A Weibull annual exceedance stage probability plot of the UNET results for the Period or Record for River Mile 631.0 upstream and downstream of the Wisconsin River is shown below in **Figure 7**. As expected, the Weibull plots for the period of record do not show any difference in elevation for the sections immediately upstream and downstream of the Wisconsin River.

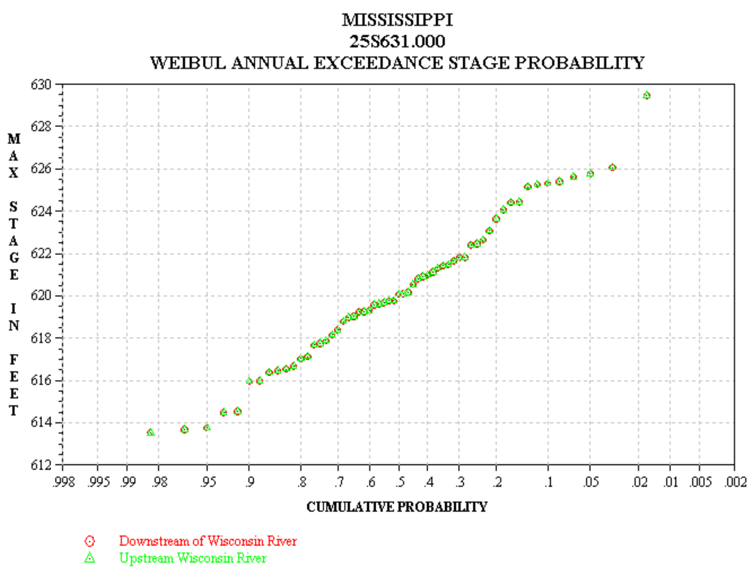


Figure 7. Wiebul Annual Exceedance Stage Probability for sections just upstream and downstream of the Wisconsin River.

Application of the stage frequency software for Mississippi River main stem discharge values across the Wisconsin River tributary using the drainage area statistics generated discontinuities in the computed water surface profiles. For the one percent chance flood event, the discontinuity or jump in the water surface profile is one foot for the Wisconsin River as shown in **Figure 8** below. Since the computed stage and discharge are one foot low at that location using the drainage area method, water surface elevations are impacted from that location to Dubuque, Iowa which is 52 miles downstream.

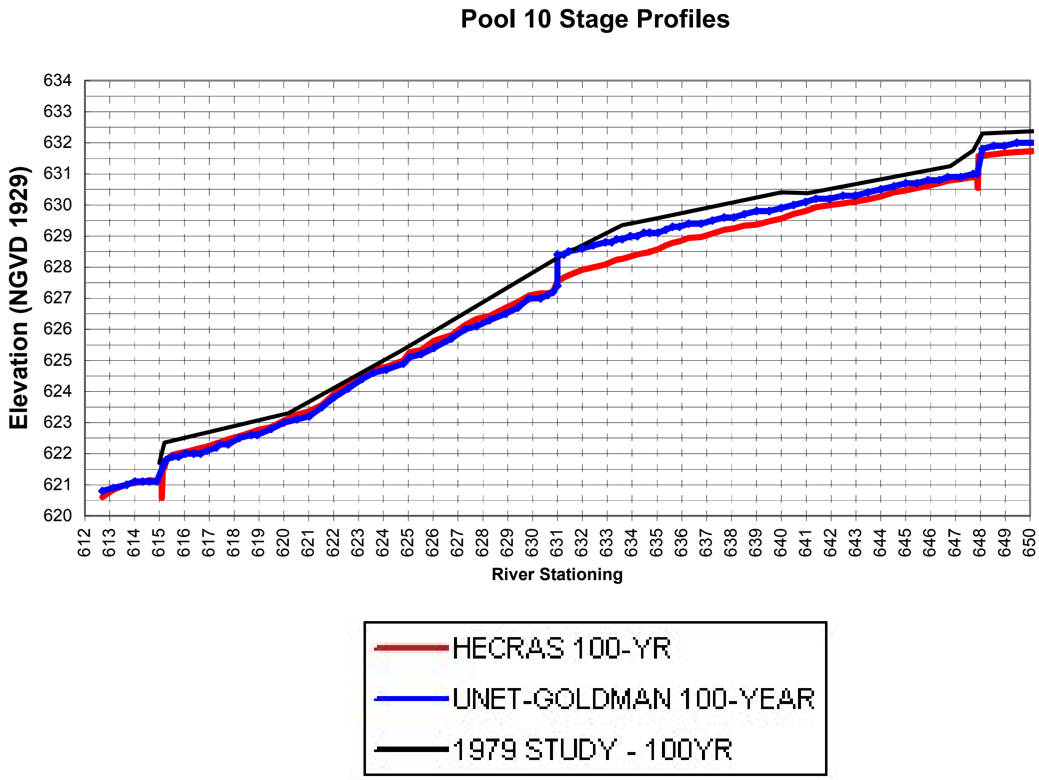


Figure 8. Illustration of the jump in the one percent chance flood profile generated at River Mile 631.0 using the Drainage Area Methodology.

[Utilizing the recommended general approach of determining flood distributions in between gages by a linear smoothing relationship of the mean flow and the standard deviation with drainage impacts the determination of stages upstream and downstream of the Wisconsin River.] Coincident flows for the Wisconsin River in the UNET period of record simulation are not captured by the drainage area statistics at the main stem gages because of the excessive distance between those gages.

The general Flow Frequency Study methodology requires the development of rating curves at each section based on the annual maximum peak stage and flow values. This procedure generates curves which are dependent on the observed coincident flows from the Wisconsin River. **Figure 9** shows the relationship between the Mississippi River flow downstream of the Wisconsin River versus the flow upstream of the Wisconsin River at McGregor. The values determined by the drainage area approach are considerably lower than the values determined based on the UNET statistics. For this study, the results from the UNET period of record runs serve as a basis for determining the statistics downstream of the Wisconsin River. **Figure 10** shows the Wisconsin River coincidental flow plotted as a function of the McGregor flow. This plot also shows that the contribution from the Wisconsin River is much less using the drainage area approach in comparison to the contribution based on the UNET statistics.

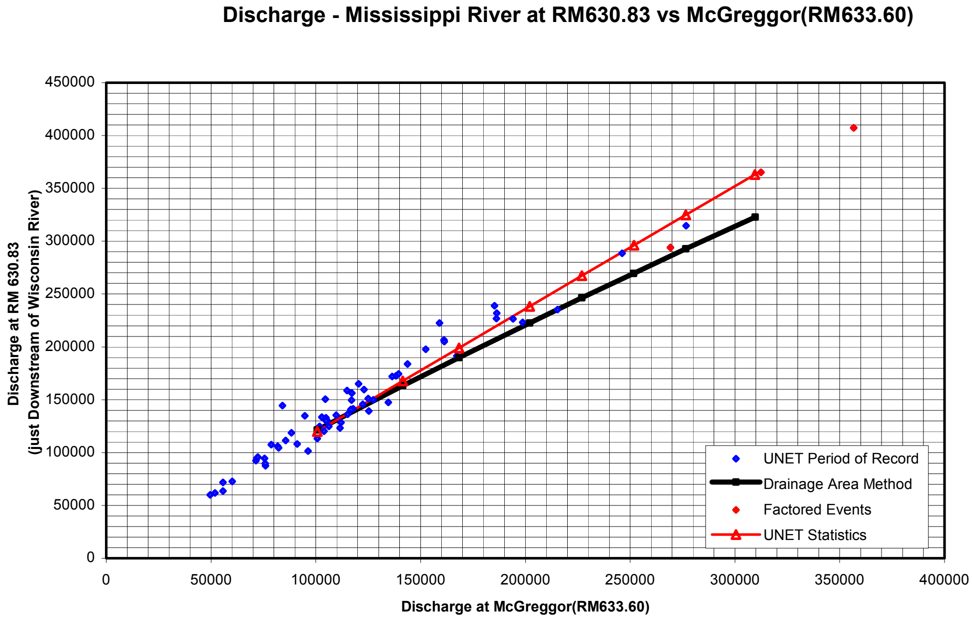


Figure 9. UNET Annual Peak Discharge at McGregor versus RM630.8 located just downstream of the Junction of the Mississippi River and Wisconsin River.

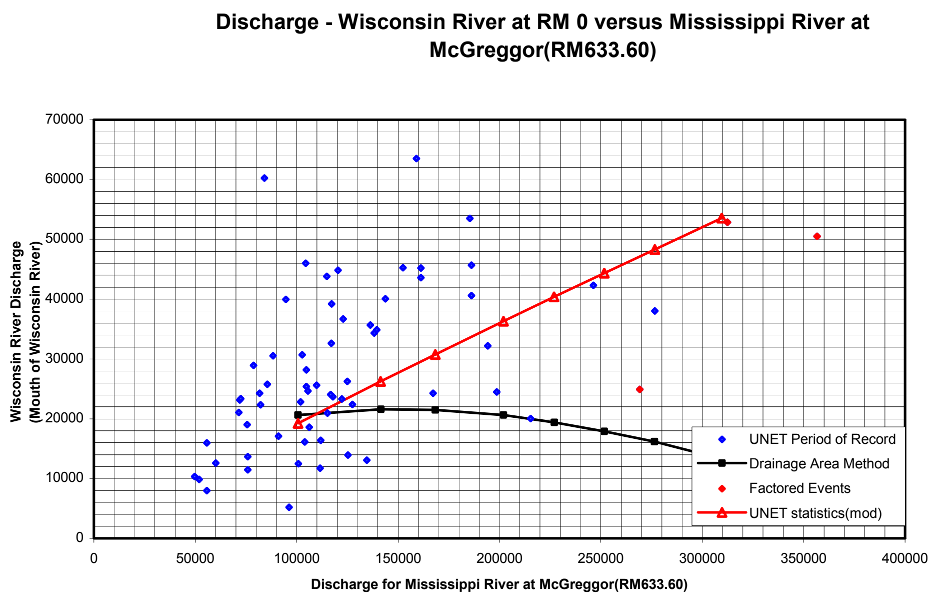


Figure 10. Discharge for Wisconsin River versus Peak Discharge for the Mississippi River at McGregor (River Mile 633.6).

Wisconsin River Confluence

The discharge profiles initially used drainage area relationships between USGS and COE gages for determining the appropriate discharges between these gages for development of the final water surface profiles. [The final interpretation of water surface profiles is for determining the water surface elevations from elevation-discharge rating curves developed at each cross section.] This procedure worked well in most reaches, but resulted in jumps in the water surface profiles at certain locations where coincident flows from larger tributaries are not appropriately described by the drainage area relationships. The Wisconsin River confluence is one of these locations. The timing of larger floods required an adjustment at the mouth of the Wisconsin River due to the greater influence it has on peak discharges in the reach below the McGregor, Iowa. gage. This influence is not captured by the next downstream main stem gage at Dubuque in the main stem frequency analysis due to attenuation in this reach. This required the adjustment of the statistics at this location using the statistics from the UNET model for the shorter concurrent records analyzed at McGregor (RM 633.6) and the cross section just downstream of the confluence of the Mississippi River and Wisconsin River (RM 630.8).

The UNET statistics are used to weight the statistics between the McGregor and Dubuque Gages. The weighting is used for determining the appropriate adjustment in the statistics at River Mile 630.8 that is necessary to reflect the higher coincident flows needed for eliminating the discontinuity in the water surface profiles resulting from the drainage area interpolation procedure at this location. The following table reflects the statistics used in this weighting procedure.

Table 3. Statistics for the Wisconsin River.

	STATION				
	(1898-1998)	(1940-1998)	(1940-1998)	(1940-1998)	(1898-1998)
	McGregor[1]	**McGregor**	**RM633.6**	**Rm630.8**	**Dubuque**
	Regionalized Skew	Instantaneous Peaks	Mean Daily Peaks	Mean Daily Peaks	Regionalized Statistics
	USGS	USGS	UNET	UNET	COE
Mean	5.000	5.0446	5.0513	5.1366	5.1000
Std. Dev	0.178	0.16	0.1545	0.1573	0.1530
Skew	-0.1	-0.1016	-0.0154	-0.2518	0.1

1. McGregor mean and std. deviation derived from smoothing relationships in **Figure 4**.

The weighting procedure yielded adjusted statistics tabulated in the following table at River Mile 630.8.

Table 4. Adjusted Statistics for River Mile 630.8.

	(1940-1998)
	Rm630.8
	Adjusted Statistics
Mean	5.0759
Std. Dev	0.1756
Skew	-0.1

Table 5. Period of Record Concurrent Analysis

PERCENT CHANCE Exceedance	Period of Record 1940-1998 Concurrent Record Analysis		
	STATION		
	McGregor	**RM633.6**	**Rm630.8**
	COMPUTED Curves		
0.2	306000	311000	341000
0.5	276000	280000	314000
1	254000	256000	294000
2	231000	233000	272000
5	201000	202000	241000
10	177000	177000	215000
20	151000	152000	187000
50	111000	113000	139000
80	81400	83400	102000
90	68800	71300	85200
95	59800	62600	73300
99	45800	49000	54500

Table 6. Instantaneous and Mean Daily Discharges for the Wisconsin River at McGregor and at River Mile 630.8 which is located just downstream of the Wisconsin River.

Year	McGregor Inst. Peaks USGS	RM633.6 McGregor Mean Daily Peaks-UNET	RM630.8 Wisc. River Mean Daily Peaks-UNET	Year	McGregor Inst. Peaks USGS	RM633.6 McGregor Mean Daily Peaks-UNET	RM630.8 Wisc. River Mean Daily Peaks-UNET
1940	52100	55757	71729	1970	72100	72364	95693
1941	102800	101858	124682	1971	138000	136406	172065
1942	113800	117176	156386	1972	116000	114844	158640
1943	124600	124951	151207	1973	151000	159060	222557
1944	122500	122349	145625	1974	104000	103940	120072
1945	127700	138198	172504	1975	183000	186122	226745
1946	101200	104535	150541	1976	125000	120357	165167
1947	85500	85598	111356	1977	42000	49632	59980
1948	84000	81771	106024	1978	104000	105517	130165
1949	73100	75969	87438	1979	133000	134549	147621
1950	123300	125251	139173	1980	87400	88303	118842
1951	185700	186266	231935	1981	80700	82241	104601
1952	197500	198728	223212	1982	139000	139542	174407
1953	86200	91050	108147	1983	145000	152486	197724
1954	165500	167248	191534	1984	117000	117861	141551
1955	73700	71443	92476	1985	110000	109794	135395
1956	105000	104839	132999	1986	168000	161320	204936
1957	95800	96308	101508	1987	158000	161000	197200
1958	55800	55777	63738	1988	57200	60131	72708
1959	72300	72020	95177	1989	103000	111944	128329
1960	83100	84115	144381	1990	98800	106158	124733
1961	114000	127470	149871	1991	104000	104805	130179
1962	104000	102788	133478	1992	106000	115262	136227
1963	72000	75588	94584	1993	189000	185342	238839
1964	75600	75833	89514	1994	115000	116687	140748
1965	276000	276673	314722	1995	99600	100750	113253
1966	112000	117024	149616	1996	143000	143785	183842
1967	170000	161224	206444	1997	201000	194170	226375
1968	97900	94722	134664	1998	126000	122942	159636
1969	215000	215353	235364				

Comparison adjusted UNET statistics versus Drainage Area Statistics
A comparison of the one percent chance flood discharge profile from Dubuque, Iowa to McGregor, Iowa is shown in Figure 10 based on the results of the Drainage Area methodology versus the UNET statistics methodology**.**

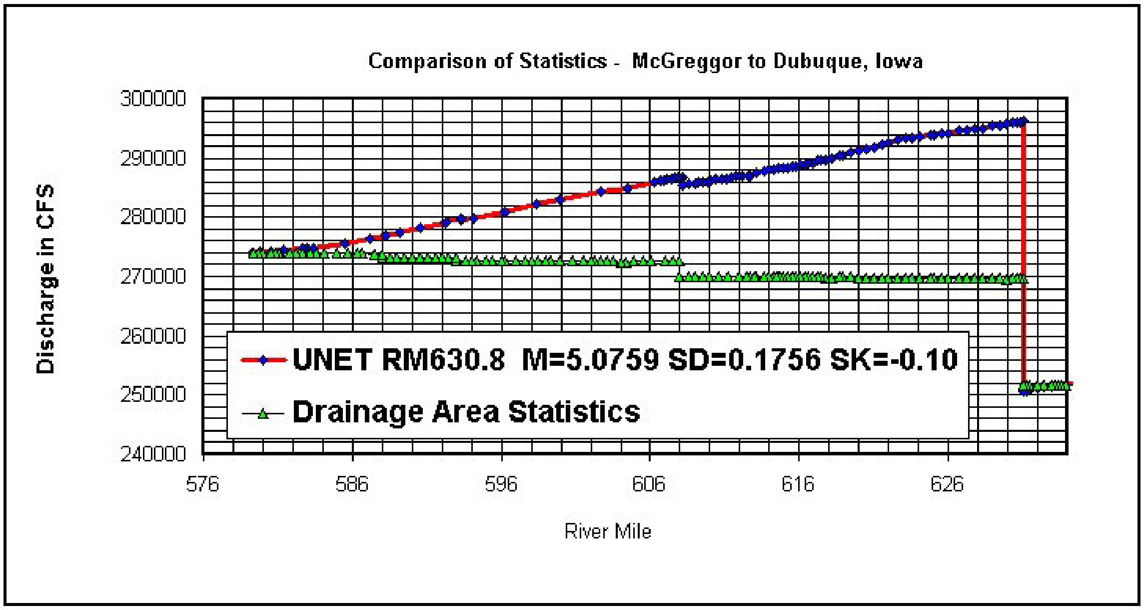


Figure 10. One percent chance discharge profiles for Drainage Area Methodology versus UNET statistics for the reach between McGregor and Dubuque, Iowa.

Annual peak floods statistics between McGregor and Dubuque, Iowa

A detailed discussion regarding the statistics for the flood profile between Dubuque and McGregor, Iowa is summarized in Dr. David Goldman's 24 April 2003 Memorandum for Record entitled, "Flood profile between McGregor and Dubuque." The following paragraphs summarizes conclusions from that memorandum.

The re-estimated statistics result in a flood profile where infrequent quantiles (e.g., the one percent chance flood peak annual discharge) decrease from McGregor to Dubuque despite the increase in drainage area. The decrease in flood quantiles seen between McGregor and Dubuque can be explained by the lack of coincidence between peaks occurring due to snowmelt upstream of River Mile 631 (the confluence with the Wisconsin River) and those for tributaries below this confluence. Note that the Turkey River, Grant and Platte Rivers, have flood peaks in March (presumably consisting of some snowmelt) and June (rainfall related floods). Peaks resulting from the Mississippi at or above the Wisconsin River confluence peak generally in April, missing these local tributary peaks. This is the most likely explanation for a decrease in flood quantiles despite the ten percent increase in drainage area from McGregor to Dubuque.

Flood peak statistics (the mean and standard deviation of the annual maximums) had been interpolated as a linear function of the drainage area. This is probably defensible upstream of McGregor and downstream of Dubuque where local inflows cause the expected increase of flood quantiles with drainage area. Note that the snowmelt floods occurring on the Minnesota, Wisconsin and Mississippi River at McGregor coincide in the month of April. Downstream of Clinton, spring floods from the Rock and Des Moines Rivers contribute significantly to the frequency of flooding on the Mississippi River at Keokuk. However, in the reach between McGregor and Dubuque, local flows are not coincident with the predominant flooding period at Dubuque in April. In this reach, interpolation using UNET period of record statistics is more appropriate because UNET captures the lack of coincidence in this reach.

Mississippi River Stage Frequency Water Surface.

From Mississippi River Mile 630.8 located just downstream of the Wisconsin River to Dubuque, Iowa, the St. Paul and Rock Island District's stage frequency analysis used the UNET statistics adjusted with anchor points at River Mile 630.8 and at Dubuque, Iowa. The resulting one percent chance flood profile is about one foot higher at Mississippi River Mile 630.8 thereby eliminating the jump in the profile at that location.

Conclusions

The annual maximum peak flow results from the UNET period of record simulations can provide a means for determining the coincidental flow from tributaries provided that the UNET model is optimized with regard to flow. The LATQ feature in the Graphical User Interface of the version of UNET used for the flow frequency study allows for the optimization of flow. In the case of the St. Paul Districts UNET model, flow is calibrated at the USGS gaging station at McGregor, Iowa upstream of the Wisconsin River and at the Dubuque, Iowa gage. For Dubuque, the stage hydrograph at the Lock and Dam No.11 Tailwater is used with the stage-discharge rating curve for that location for generating observed discharge hydrographs for the period of record. With the observed flow hydrographs for the Mississippi River at McGregor, Iowa and Dubuque, Iowa, the Wisconsin River at Muscoda, Wisconsin, the Grant River at Burton, Wisconsin and the Turkey River at Garber, Iowa, the LATQ feature of UNET optimized the ungaged local inflow allowing for the determination of flow hydrographs at locations in between the major gaging stations.

Assuring that the coincidental tributary flow is determined adequately minimizes the magnitude of discontinuities in the water surface profile when using the UNET period of record results in combination with the Flow Frequency Study stage frequency software.

References

Barkau, Dr. Robert(2000). UNET Training Course Documentation, *Modeling of Large River Systems, September 18-22, 2000*.

Goldman, Dr. David(2001). Memorandum for Record 5 October 2001, *Software for computing stage frequency curves, Upper Mississippi Basin Flow Frequency Study.*

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U.S. Army Corps of Engineers(USACE). *UNET, One-Dimensional Unsteady Flow Through a Full Network of Open Channels:Users Manual, April 2001*, CPD-66, Version 4.0.

U.S. Army Corps of Engineers(USACE)(2003). Draft Report, *Upper Mississippi River Flow Frequency Study.*

Upper Mississippi River
Flow Frequency Study

Attachment B3
St. Paul District

Junction of the Wisconsin and Mississippi Rivers for the Upper Mississippi River System Flow Frequency Study

Analysis: Junction of the Wisconsin and Mississippi Rivers for the Upper Mississippi River System Flow Frequency Study

1. Methodology. Procedure discussed in *Comments/Analyses of Upper Mississippi River System Flow Frequency Study by Danny L. Fread.*

2. HECRAS Steady Flow Geometry. The junction of the Wisconsin and Mississippi Rivers is located just downstream of Prairie Du Chien, Wisconsin at River Mile 631 as shown on **Figure 1** below.

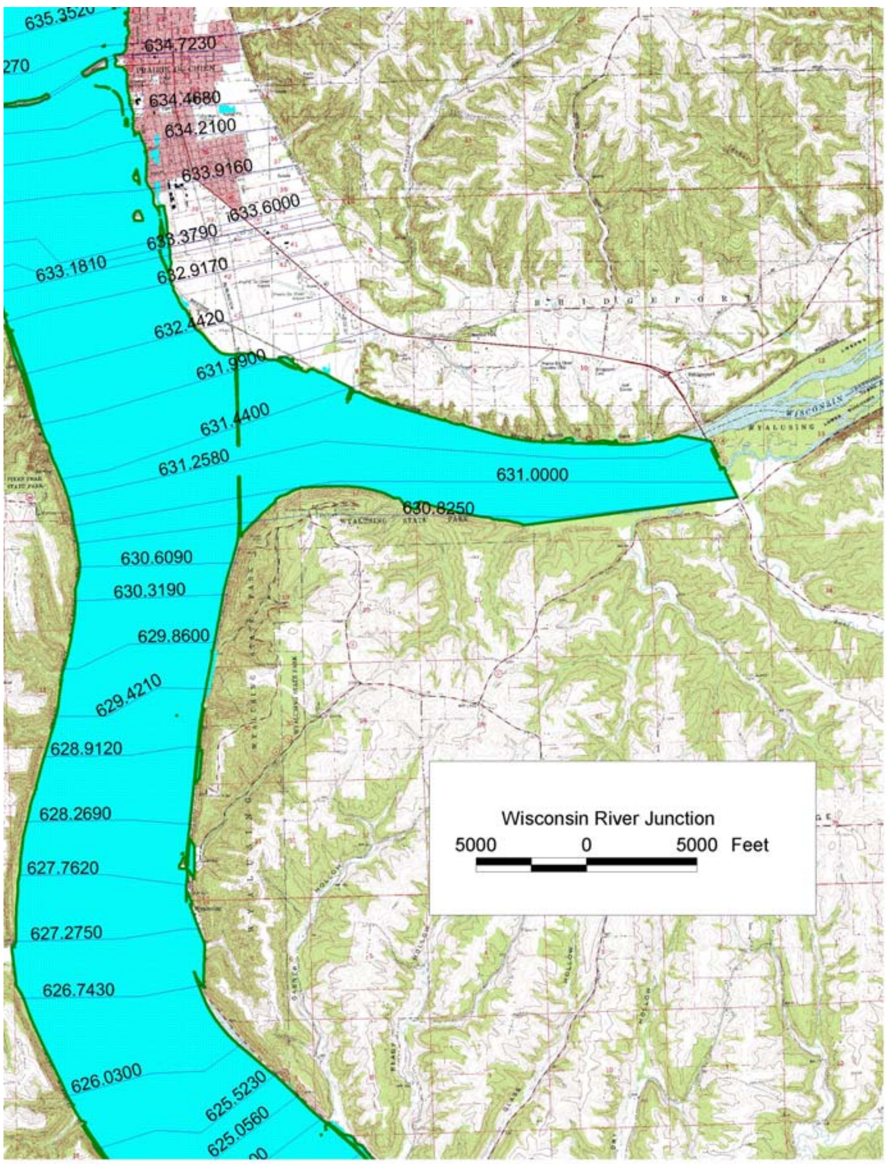


FIGURE 1

The plot on **Figure 2** below shows the cross-section for the Mississippi River at River Mile 631.0.

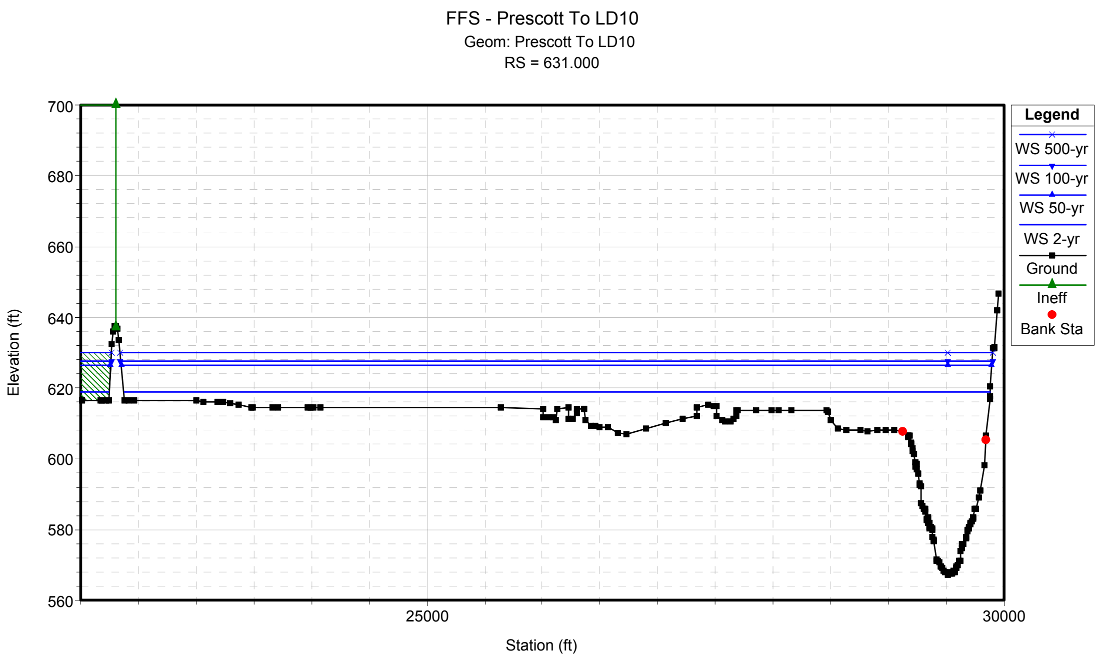
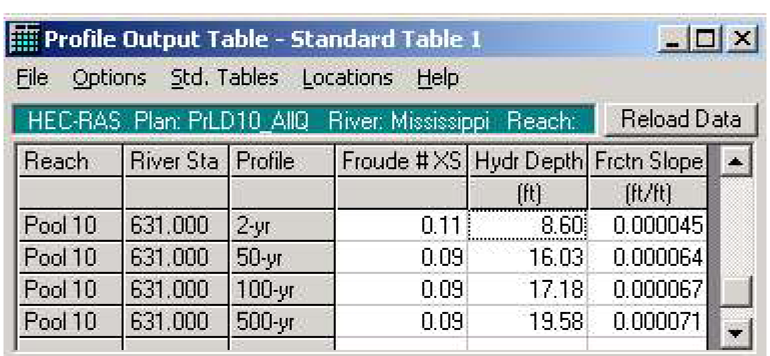


FIGURE 2

3. HECRAS Steady Flow Analysis Results. A summary of the computed results from a HECRAS steady flow is shown below in **Figures 3 and 4**.



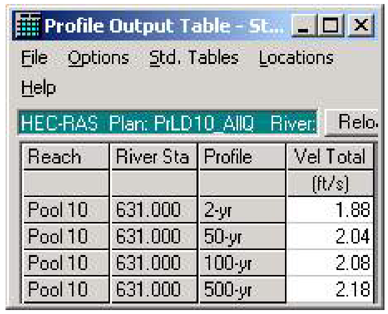
Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

HEC-RAS Plan: PrLD10_AllQ River: Mississippi Reach: | Reload Data

Reach	River Sta	Profile	Froude # XS	Hydr Depth	Frctn Slope
				(ft)	(ft/ft)
Pool 10	631.000	2-yr	0.11	8.60	0.000045
Pool 10	631.000	50-yr	0.09	16.03	0.000064
Pool 10	631.000	100-yr	0.09	17.18	0.000067
Pool 10	631.000	500-yr	0.09	19.58	0.000071

FIGURE 3


Profile Output Table - St...

File Options Std. Tables Locations Help

HEC-RAS Plan: PrLD10_AllQ River: Relo

Reach	River Sta	Profile	Vel Total (ft/s)
Pool 10	631.000	2-yr	1.88
Pool 10	631.000	50-yr	2.04
Pool 10	631.000	100-yr	2.08
Pool 10	631.000	500-yr	2.18

FIGURE 4

4. Equation 3 for Junction Loss Determination. Eq. (3) of Danny Freads paper entitled *Comments/ Analyses of Upper Mississippi River System Flow Frequency Study* is:

$$\Delta h \approx 4k(1 - k/2)\frac{V_2^2}{2g} + S_f \Delta x \qquad (3)$$

in which k = Q_L/Q_2,

Where:

Δh = the increase in stage across the junction or, $\Delta h = h_1 - h_2$ in which h_1 is the upstream stage and h_2 is the downstream stage.

Q_L = the tributary flow combining with the main river flow at the junction.

Q_2 = the downstream flow immediately below the junction

S_f = Friction slope which is computed from the Manning Equation or approximated by the water surface slope downstream of the junction.

Δx = The reach along the main river in which the tributary entered and it essentially represents the maximum width of the tributary.

The procedure outlined in Danny Freads paper for Equation 3 is utilized in the computation of the junction loss for the Mississippi and Wisconsin Rivers. The results are shown in **Figure 5** below.

Event	Discharge Q_2 CS631.44 (cfs)	Discharge Q_1 CS631.0 (cfs)	Wisconsin River Lateral Q_L Discharge (cfs)	$k = Q_L/Q_2$	Proportionality Factor $4k(1-k/2)$	Azimuth Angle Upstream Main River and Tributary (Deg)	Mississippi River Velocity V_2 (fps)	Δx (Ft)	Friction Slope (Ft/Ft)	Junction Loss other than Friction Loss $4k(1-k/2)\frac{V_2^2}{2g}$	Junction Friction Loss (Ft)	$\Delta h = 4k(1-k/2)\frac{V_2^2}{2g} + S_f \Delta x$ (Ft)
2-YR	119900	100684	19216	0.160267	0.58969660	90	1.88	1400	0.000045	0.03236372	0.06300	0.09536372
50-YR	267456	226961	40495	0.151408	0.55978351	90	2.04	1400	0.000064	0.03617384	0.08960	0.12577384
100-YR	296264	251744	44520	0.150271	0.55592254	90	2.08	1400	0.000067	0.03734695	0.09380	0.13114695
500-YR	363342	309569	53773	0.147996	0.54817684	90	2.18	1400	0.000071	0.04045273	0.09940	0.13985273

Caption: Junction Loss for the Mississippi and Wisconsin Rivers - Equation 3 from Danny Fread's Paper

Note that the topwidth of the Wisconsin River in the table is shown as 1400 feet. This is the width of railroad embankment opening. If the embankment did not constrict the flow, the topwidth would be over 8000 feet.

FIGURE 5

5. Equation 8 for Junction Loss Determination. Eq. (8) of Danny Freads paper entitled *Comments/ Analyses of Upper Mississippi River System Flow Frequency Study* is:

$$\Delta h \approx 0.005 Fr_2 D_2 + S_f \Delta x \quad \text{for} \quad Fr_2 < 0.20$$

Where:

Δh = the increase in stage across the junction or, $\Delta h = h_1 - h_2$ in which h_1 is the upstream stage and h_2 is the downstream stage

Fr_2 = Froude Number of the section just downstream of the channel junction.

D_2 = Hydraulic depth (assumed herein to be applicable for non-rectangular sections instead of depth.)

S_f = Friction slope which is computed from the Manning Equation or approximated by the water surface slope downstream of the junction.

Δx = The reach along the main river in which the tributary entered and it essentially represents the maximum width of the tributary.

The procedure outlined in Danny Freads paper for Equation 8 is utilized in the computation of the junction loss for the Mississippi and Wisconsin Rivers. The results are shown in **Figure 6** below.

Junction Loss for the Mississippi and Wisconsin Rivers - Equation 8 from Danny Fread's Paper

Event	Froude Number XS Fr CS631.0	Hydraulic Depth Dhydraulic CS631.0 (Ft)	Friction Slope Sf (Ft/Ft)	Delta X (Ft)	Junction Loss other than Friction Loss .005 Fr2 D2 (Ft)	Junction Friction Loss Sf Delta X (Ft)	Delta h=.005 Fr2 D2 + Sf Delta X (Ft)
2-YR	0.11	8.6	0.000045	1400	0.00473000	0.06	0.07
50-YR	0.09	16.03	0.000064	1400	0.00721350	0.09	0.10
100-YR	0.09	17.18	0.000067	1400	0.00773100	0.09	0.10
500-YR	0.09	19.58	0.000071	1400	0.00881100	0.10	0.11

Note that the topwidth of the Wisconsin River in the table is shown as 1400 feet. This is the width of railroad embankment opening. If the embankment did not constrict the flow, the topwidth would be over 8000 feet.

FIGURE 6

6. Conclusion. The determination of headloss at channel junctions is discussed in the *Executive Summary of Comments* by William Thomas for the Upper Mississippi River Flow Frequency Study. As stated in the summary, it is a three-dimension, hydrodynamic problem. UNET and HECRAS are one-dimensional model. The calculations in Danny Fread's paper are also one-dimensional calculations. The scope of work for this study did not include sufficient funding for a three-dimensional model for evaluation of the headloss. If the results of this analysis are an indication of the headloss that is expected, further analysis is also not warranted.

The conclusion of this analysis is that the junction loss other than the friction loss is less than 0.1 foot for the junction of the Mississippi and Wisconsin Rivers. The UNET computations for the Upper Mississippi River Flow Frequency Study accounted for the friction loss but assumed that the other losses are negligible. This analysis confirms that the assumption is valid.

References

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Shabayek, S., Steffler, P., Hicks, F., “Dynamic Model for Subcritical Combining Flows in Channel Junctions,” ASCE Journal of Hydraulic Engineering, Sept. 2002, Vol. 128, No. 9, pp. 821-828.

Thomas, William, “Executive Summary of Comments,” for “The Analysis of Stage-Uncertainity” for the Upper Mississippi Basin Flood Frequency Study, February 25, 2003.

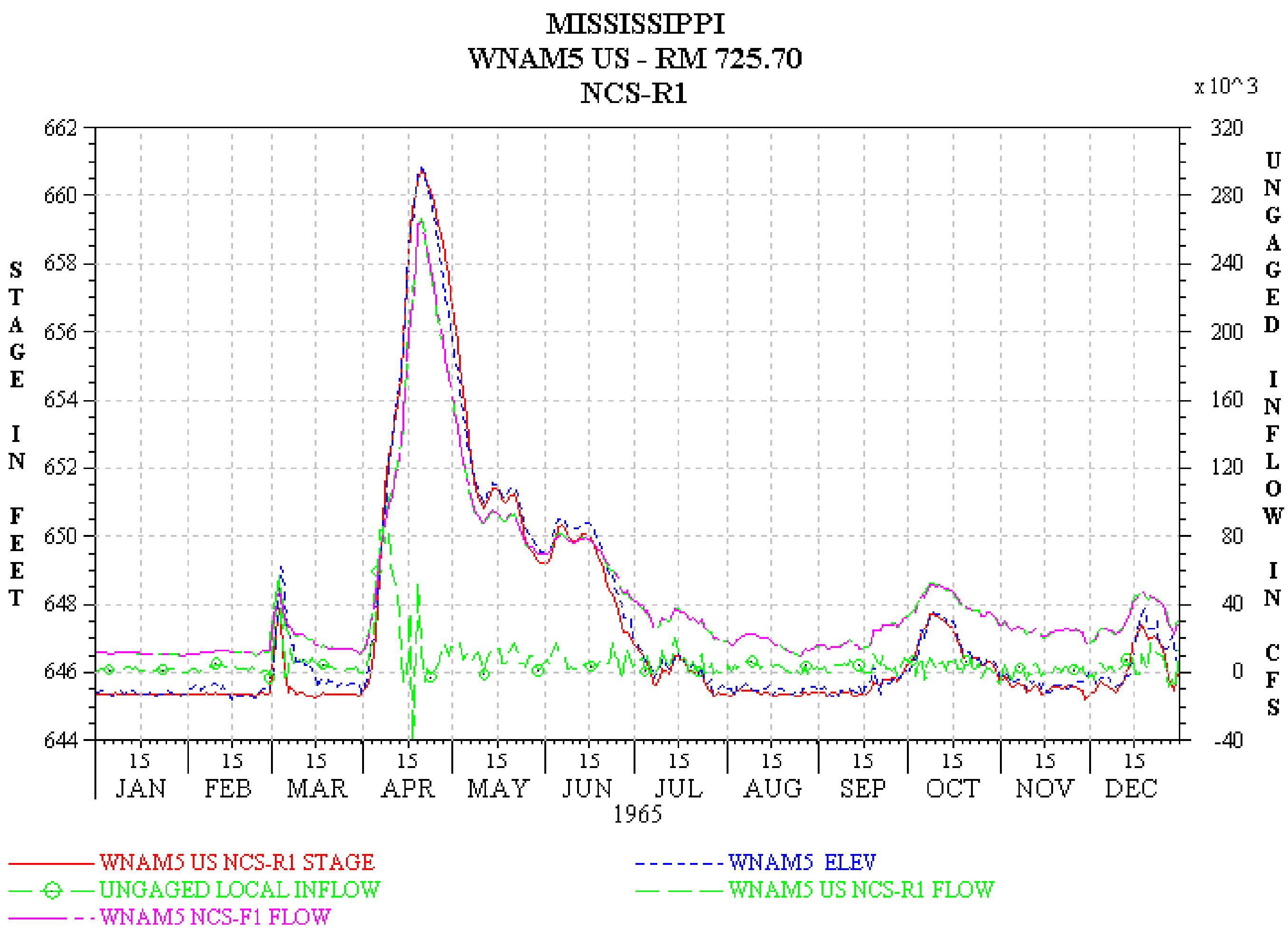
Upper Mississippi River
Flow Frequency Study

Attachment B4
St. Paul District
Mississippi River Ungaged Flow Hydrographs
Alongwith Observedand Computed Flow Hydrographs

LEGEND AND DESCRIPTION

STAGE AND DISCHARGE HYDROGRAPHS

WNAM5 US NCS-R1 STAGE	UNET computed stage for the upstream side of the Winona, Minnesota USGS gage.
UNGAGED LOCAL INFLOW	UNET computed local inflow for the upstream side of the Winona, Minnesota USGS gage.
WNAM5 NCS-F1 FLOW	Input flow for UNET. Also, historic observed flow based on USGS gage data.
WNAM5 ELEV	Historic observed water surface elevation.
WNAM5 US NCS-R1 FlOW	UNET computed flow for the upstream side of the Winona, Minnesota USGS gage.



MISSISSIPPI
WNAM5 US - RM 725.70
NCS-R1
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STAGE IN FEET
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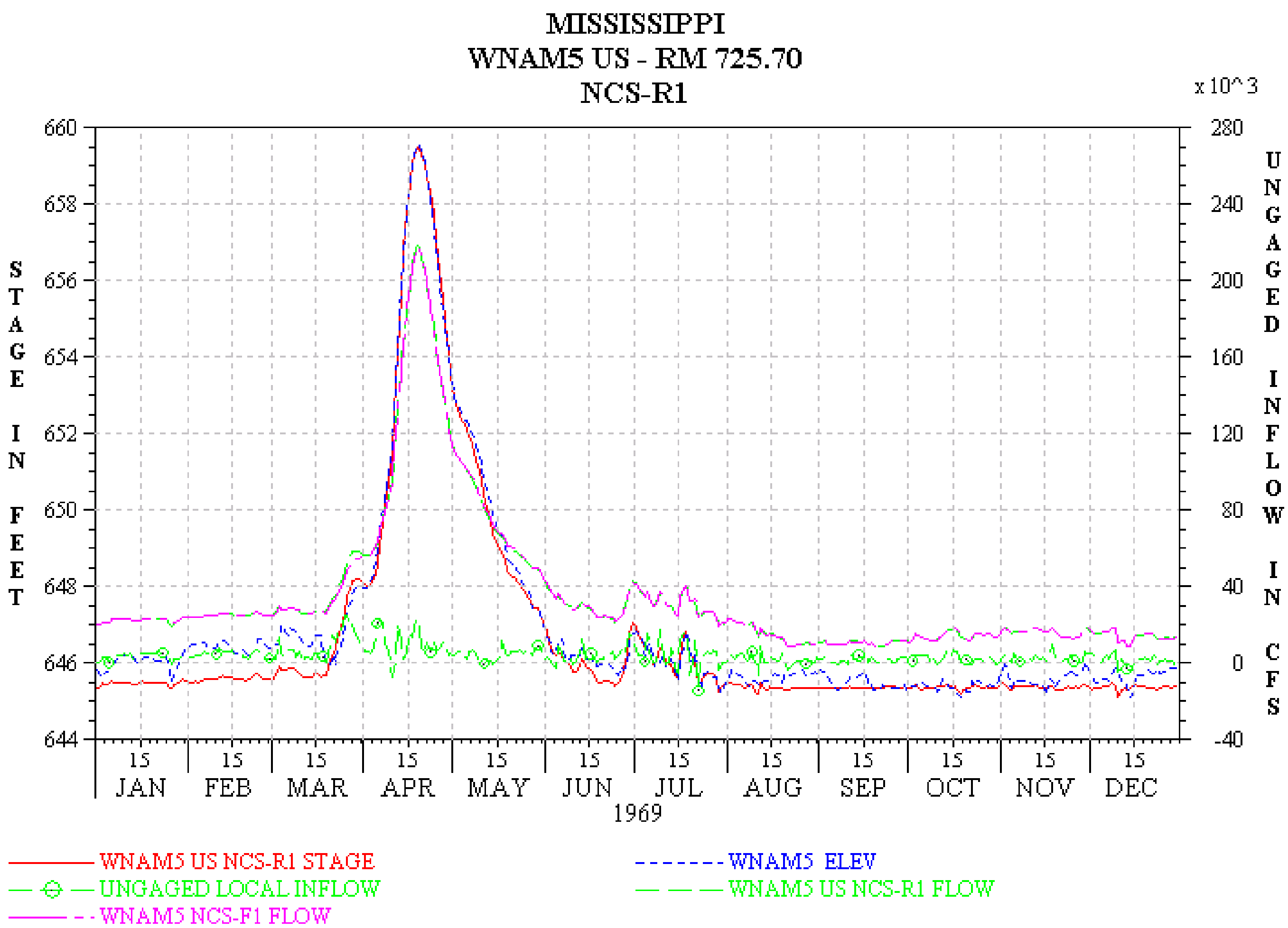
WNAM5 US NCS-R1 STAGE
WNAM5 ELEV
UNGAGED LOCAL INFLOW
WNAM5 US NCS-R1 FLOW
WNAM5 NCS-F1 FLOW



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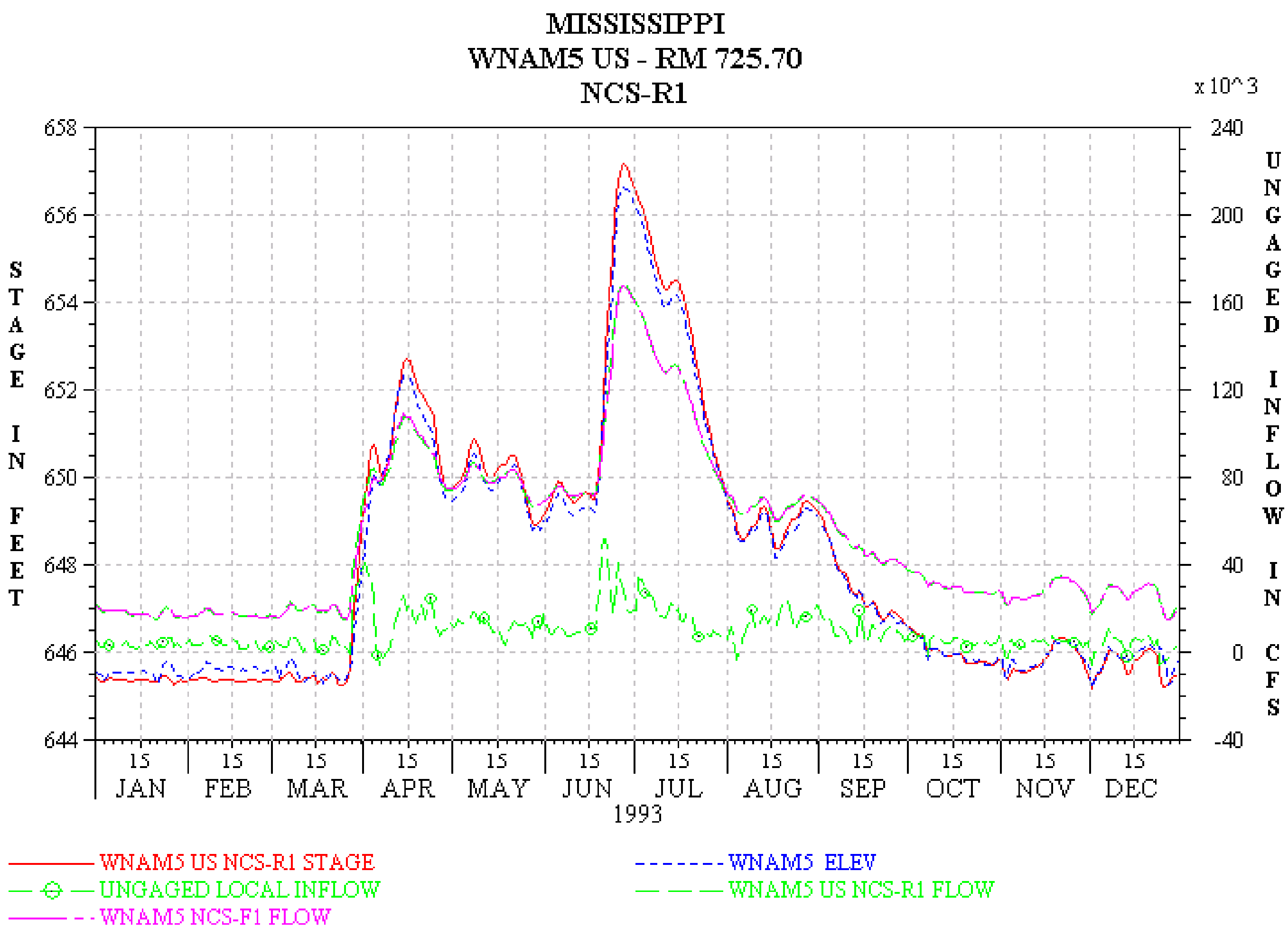
WNAM5 NCS-F1 FLOW



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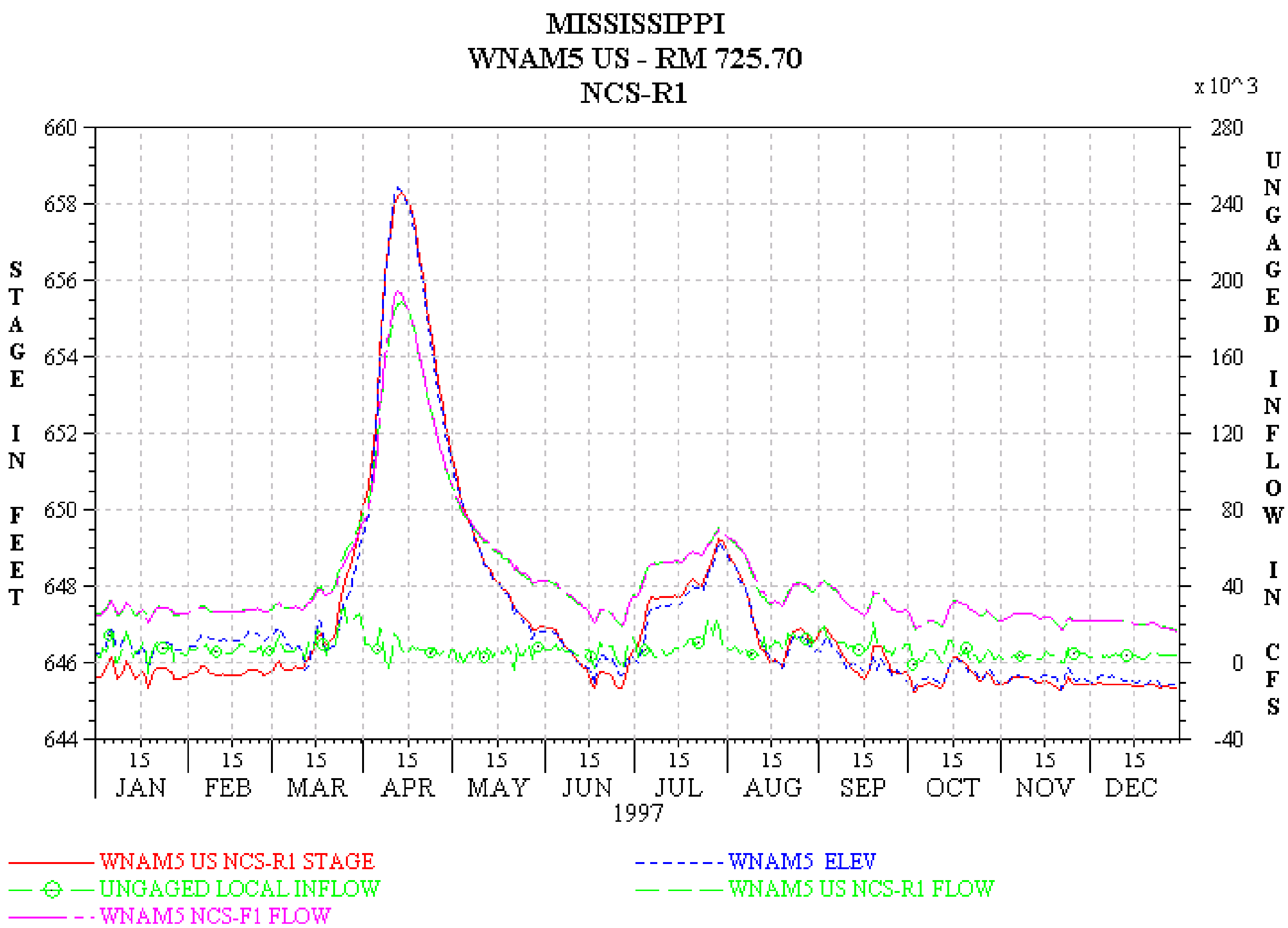
WNAM5 NCS-F1 FLOW



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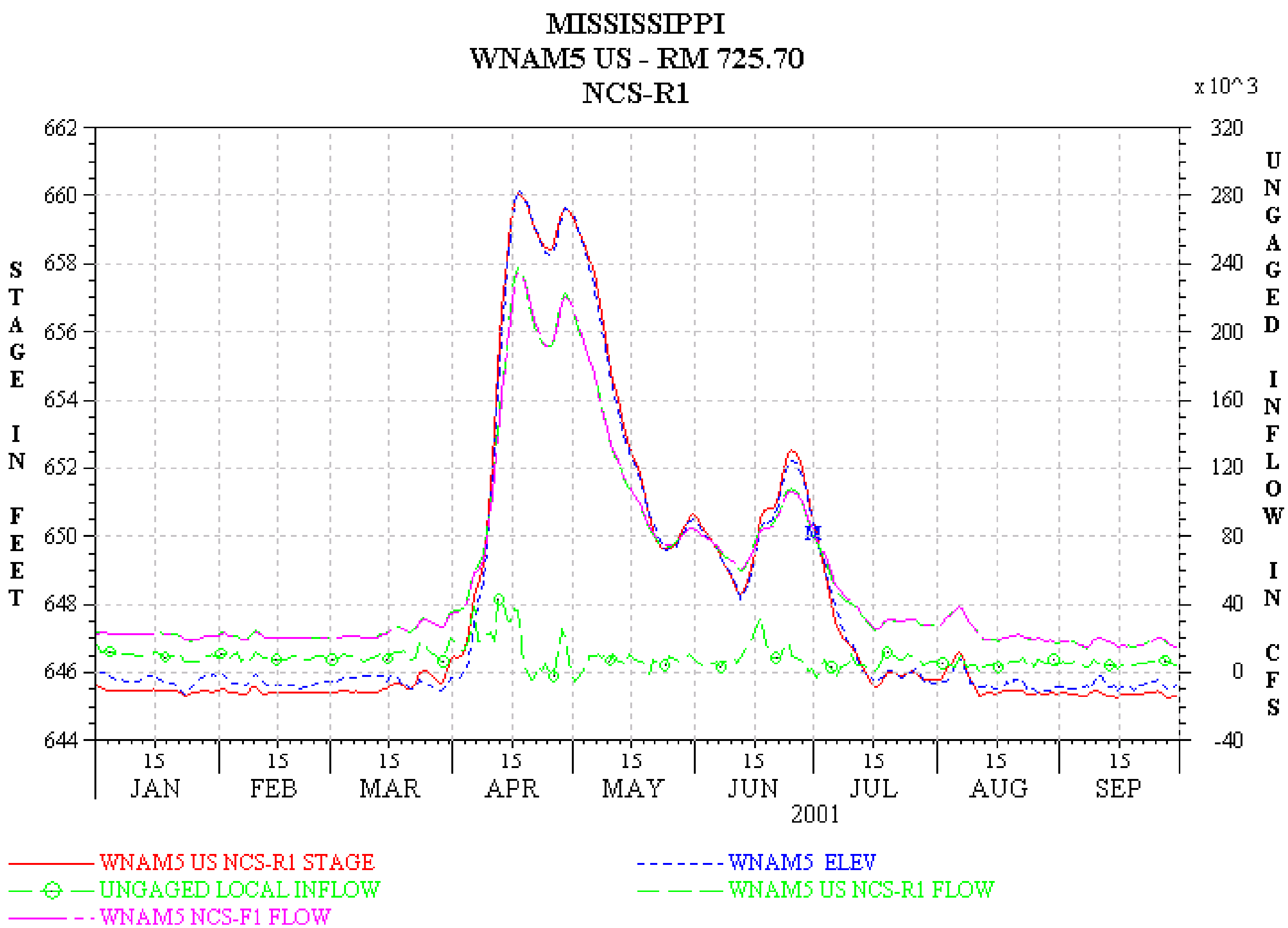

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UNGAGED LOCAL INFLOW
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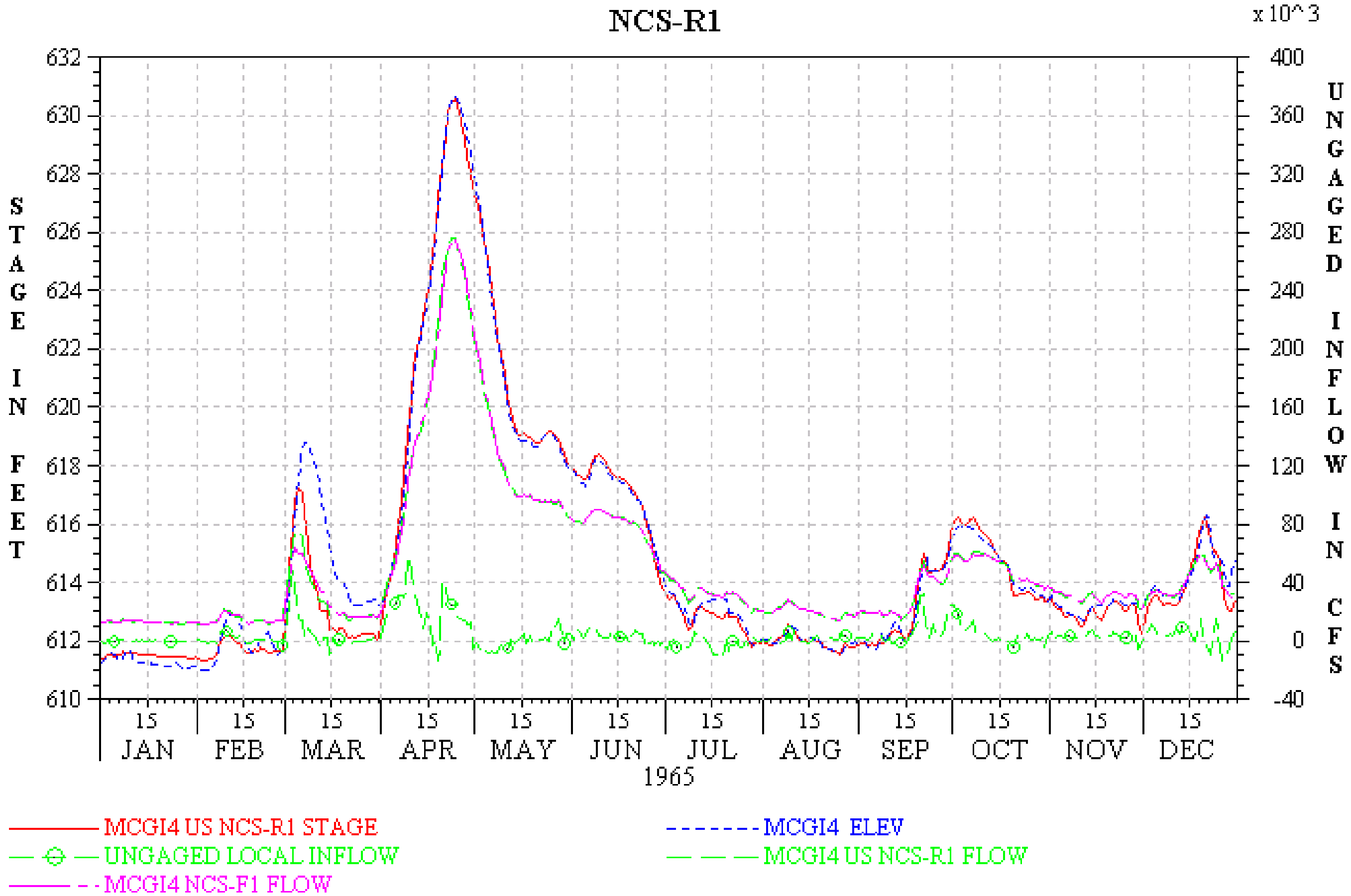
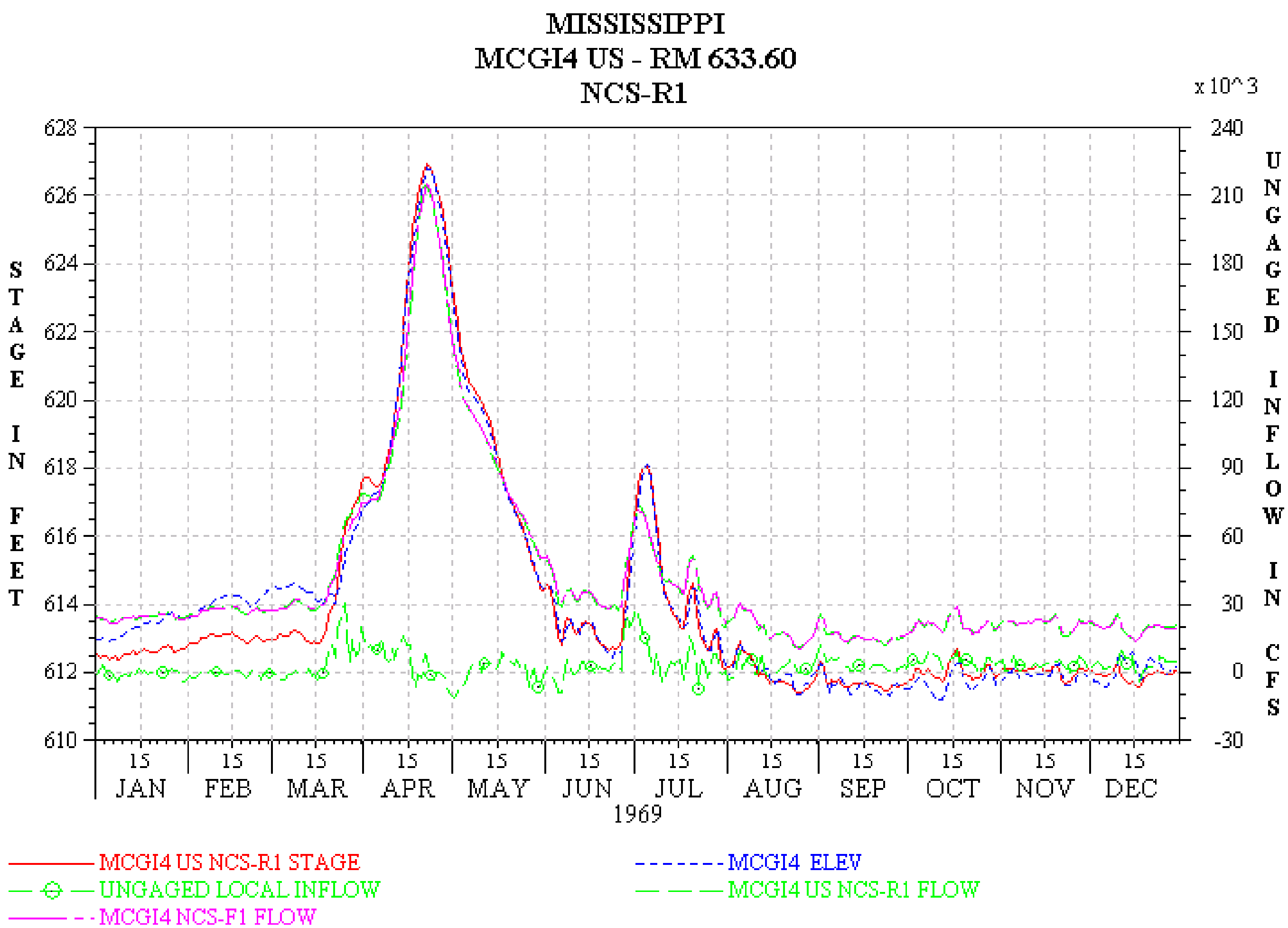
WNAM5 NCS-F1 FLOW

MISSISSIPPI
MCGI4 US - RM 633.60
NCS-R1

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MCGI4 US NCS-R1 STAGE
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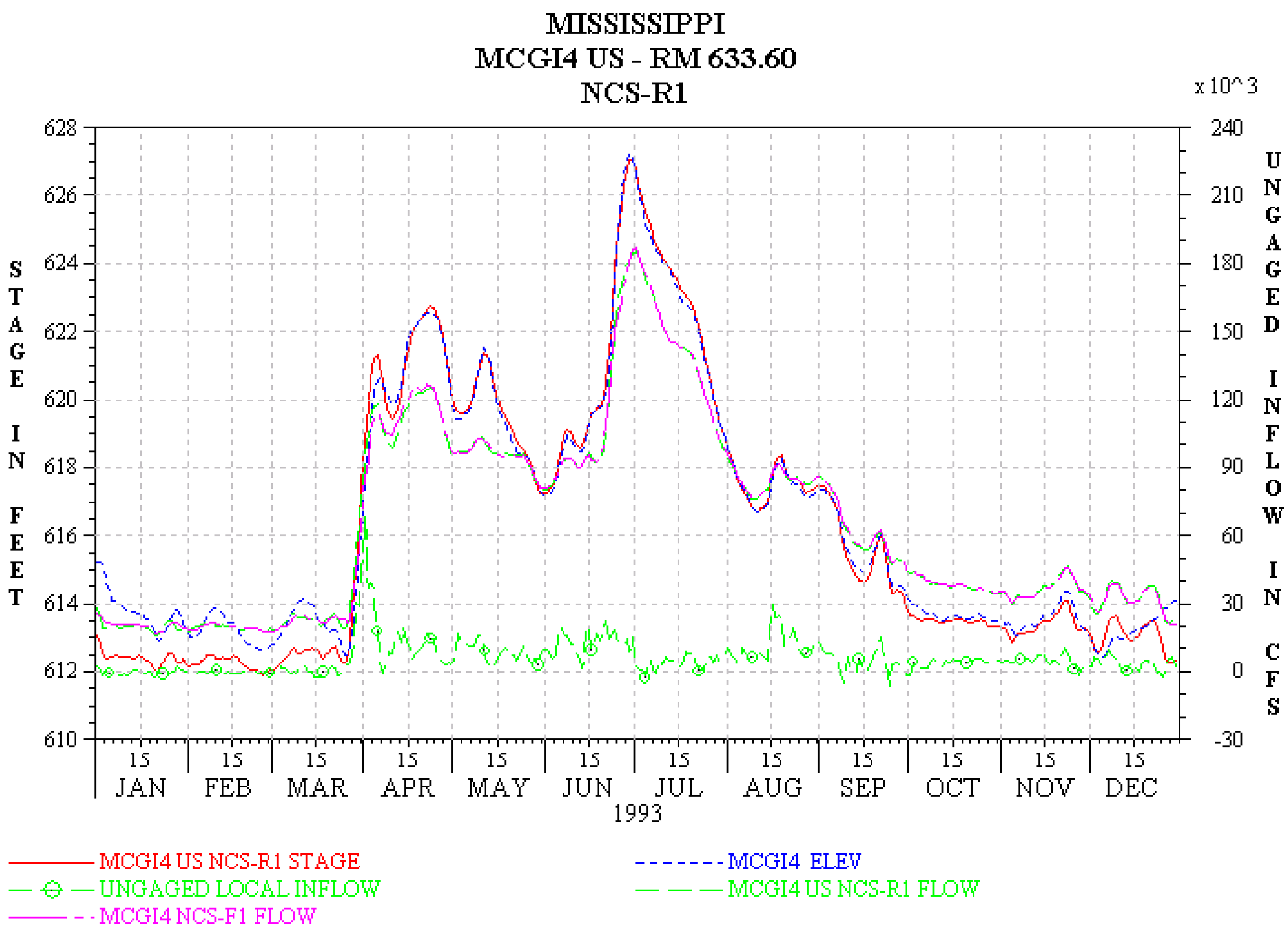
MCGI4 NCS-F1 FLOW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MCGI4 US - RM 633.60
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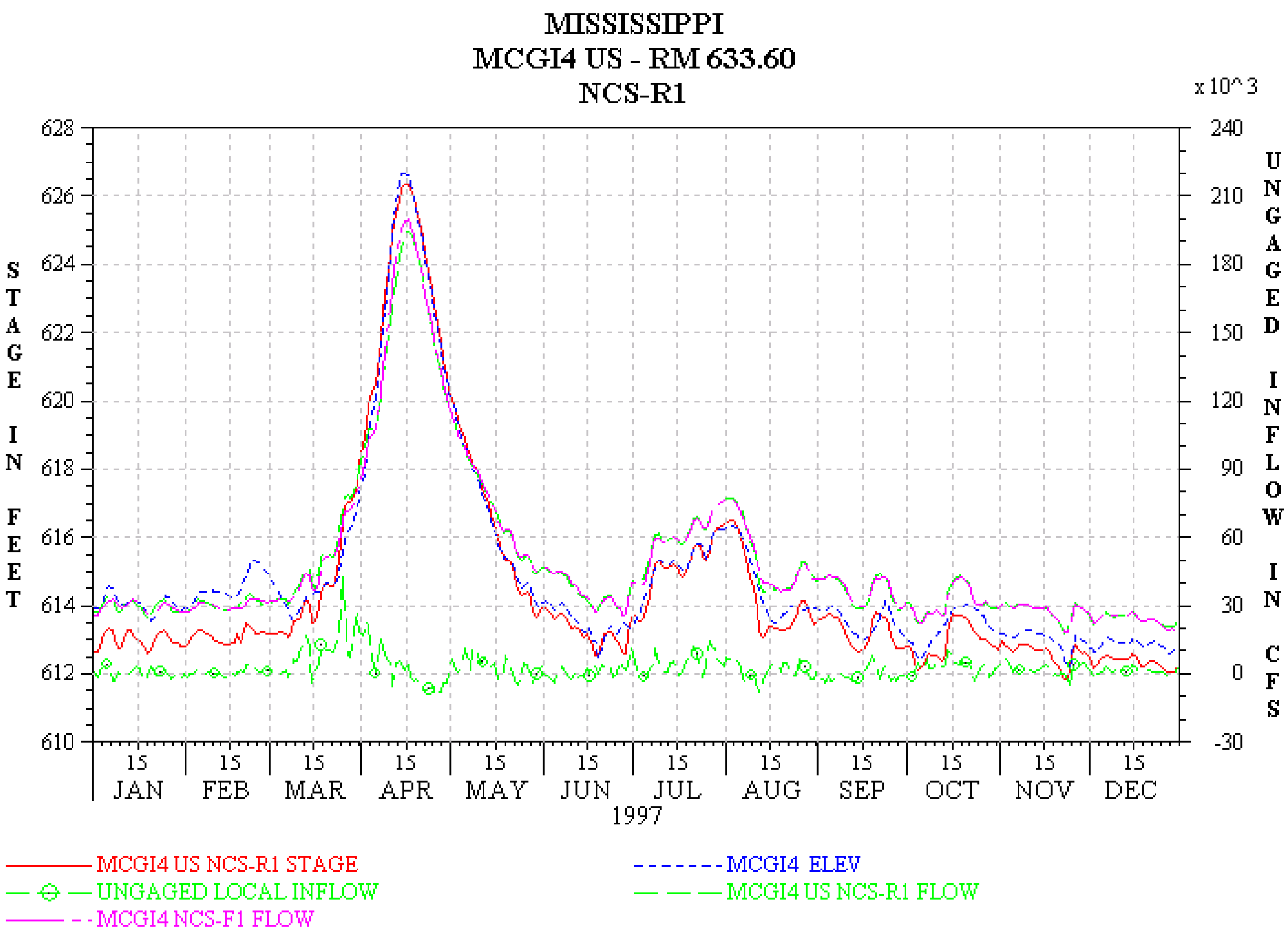
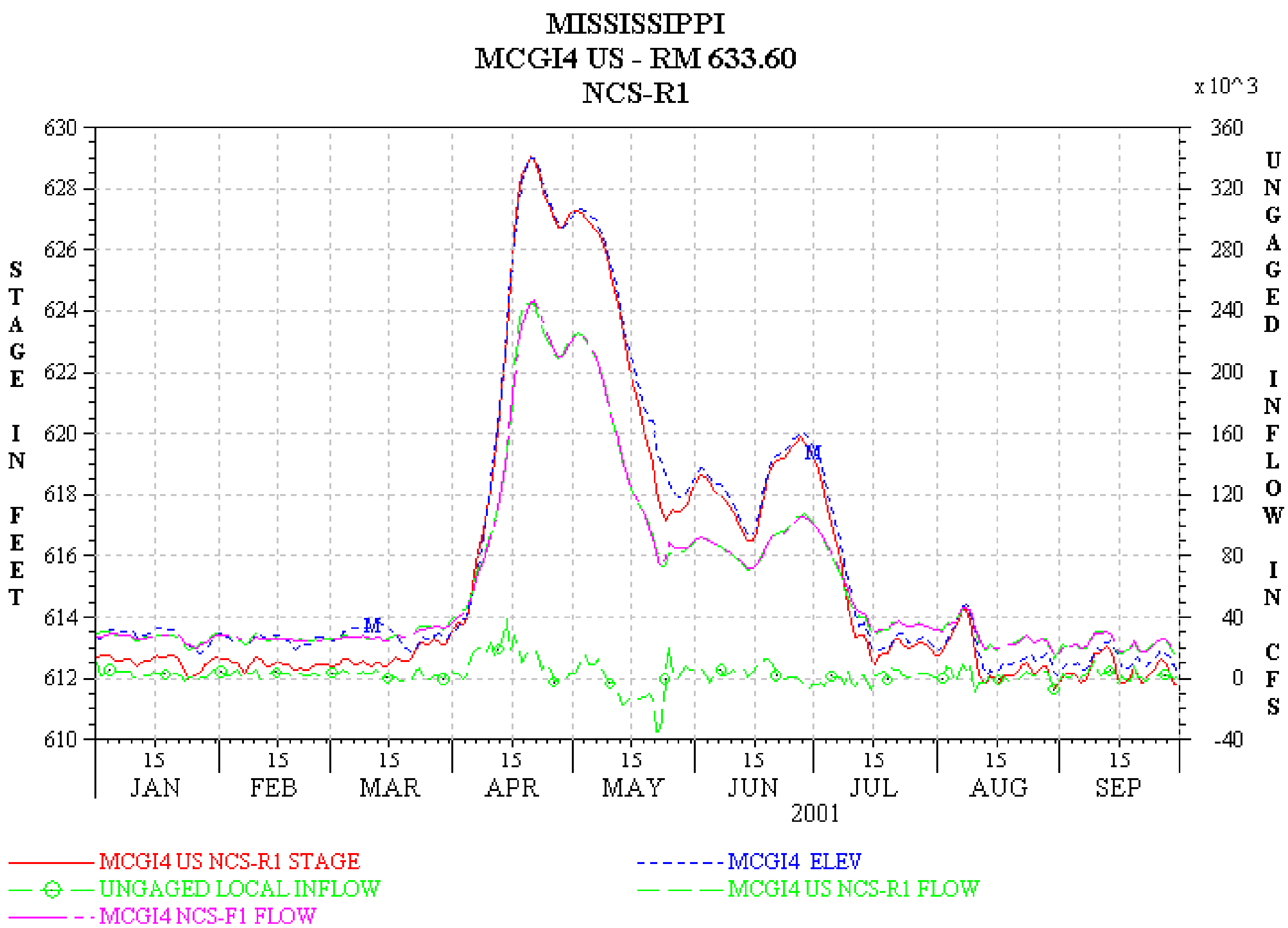
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
1993
MCGI4 US NCS-R1 STAGE
MCGI4 ELEV
UNGAGED LOCAL INFLOW
MCGI4 US NCS-R1 FLOW
MCGI4 NCS-F1 FLOW



MISSISSIPPI
MCGI4 US - RM 633.60
NCS-R1
x 10^3
STAGE IN FEET
UNGAGED INFLOW IN CFS
628
626
624
622
620
618
616
614
612
610
240
210
180
150
120
90
60
30
0
-30
15 JAN 15 FEB 15 MAR 15 APR 15 MAY 15 JUN 15 JUL 15 AUG 15 SEP 15 OCT 15 NOV 15 DEC
1997
MCGI4 US NCS-R1 STAGE
MCGI4 ELEV
UNGAGED LOCAL INFLOW
MCGI4 US NCS-R1 FLOW
MCGI4 NCS-F1 FLOW



MISSISSIPPI
MCGI4 US - RM 633.60
NCS-R1
x 10^ 3
STAGE IN FEET
UNGAGED INFLOW IN CFS
630
628
626
624
622
620
618
616
614
612
610
360
320
280
240
200
160
120
80
40
0
-40
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
2001
M
MCGI4 US NCS-R1 STAGE
UNGAGED LOCAL INFLOW
MCGI4 NCS-F1 FLOW
MCGI4 ELEV
MCGI4 US NCS-R1 FLOW

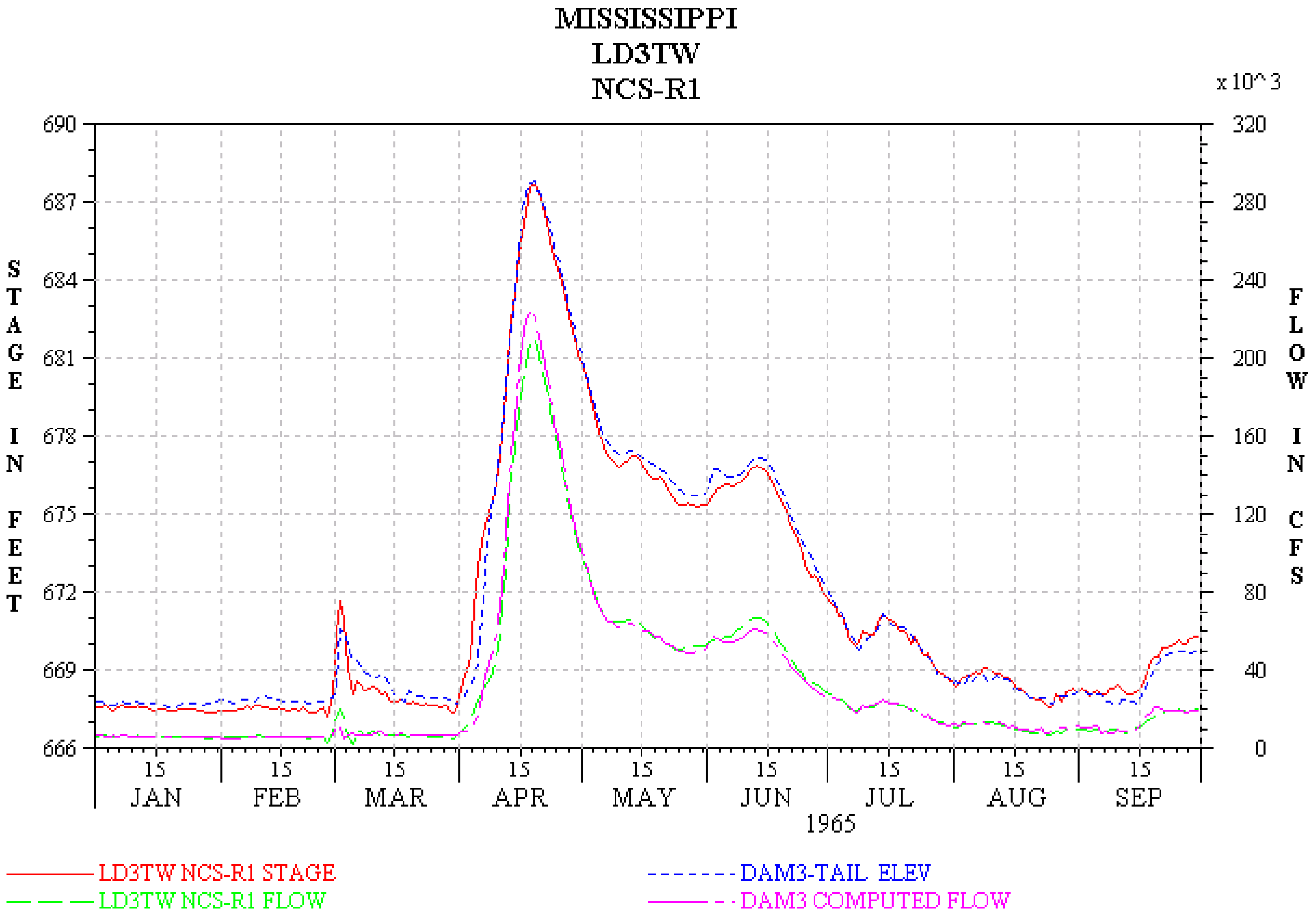
Upper Mississippi River
Flow Frequency Study

Attachment B5
St. Paul District
UNET RESULTS
Mississippi River Computed and Observed
Stage and Flow Hydrographs

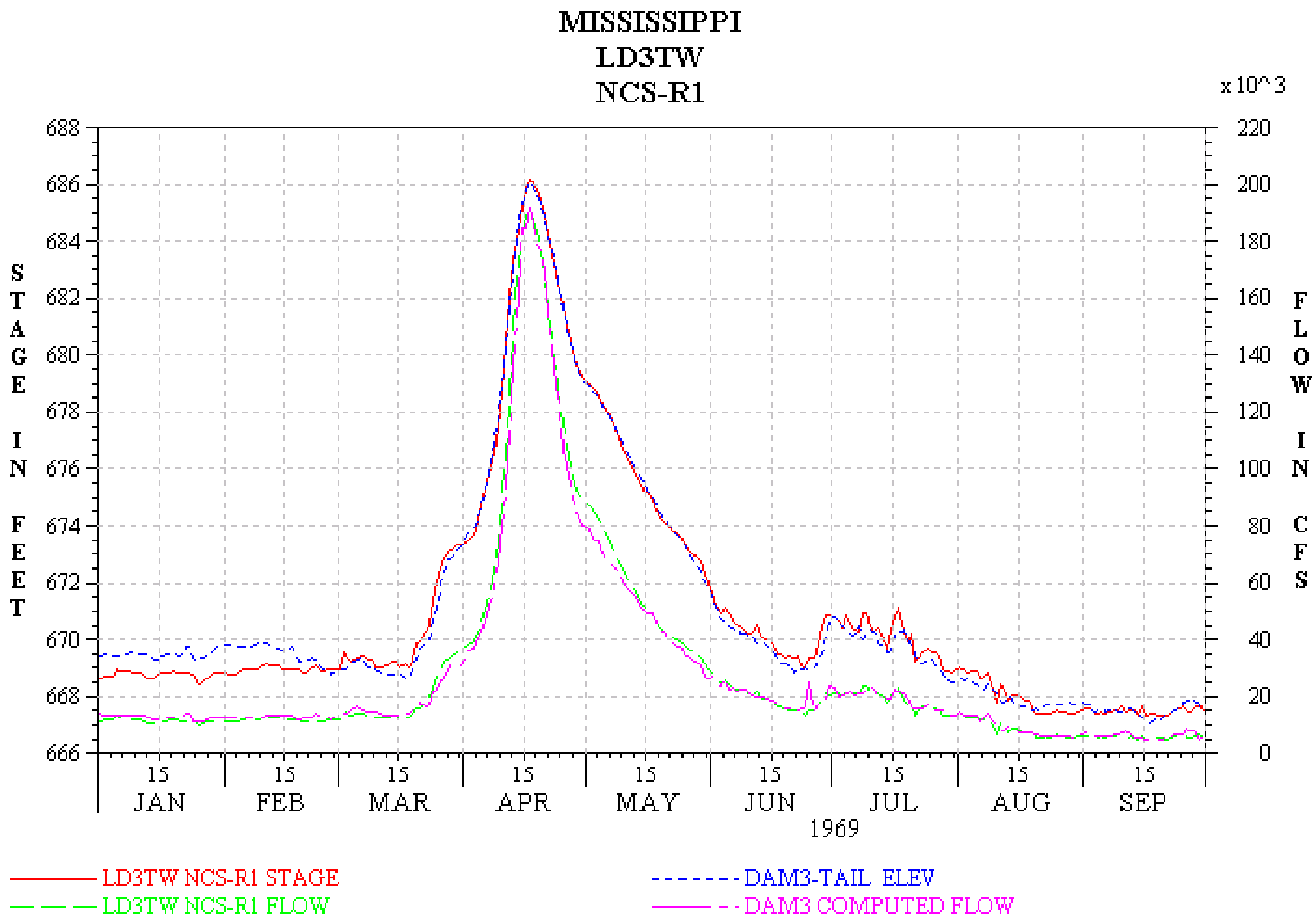
LEGEND AND DESCRIPTION

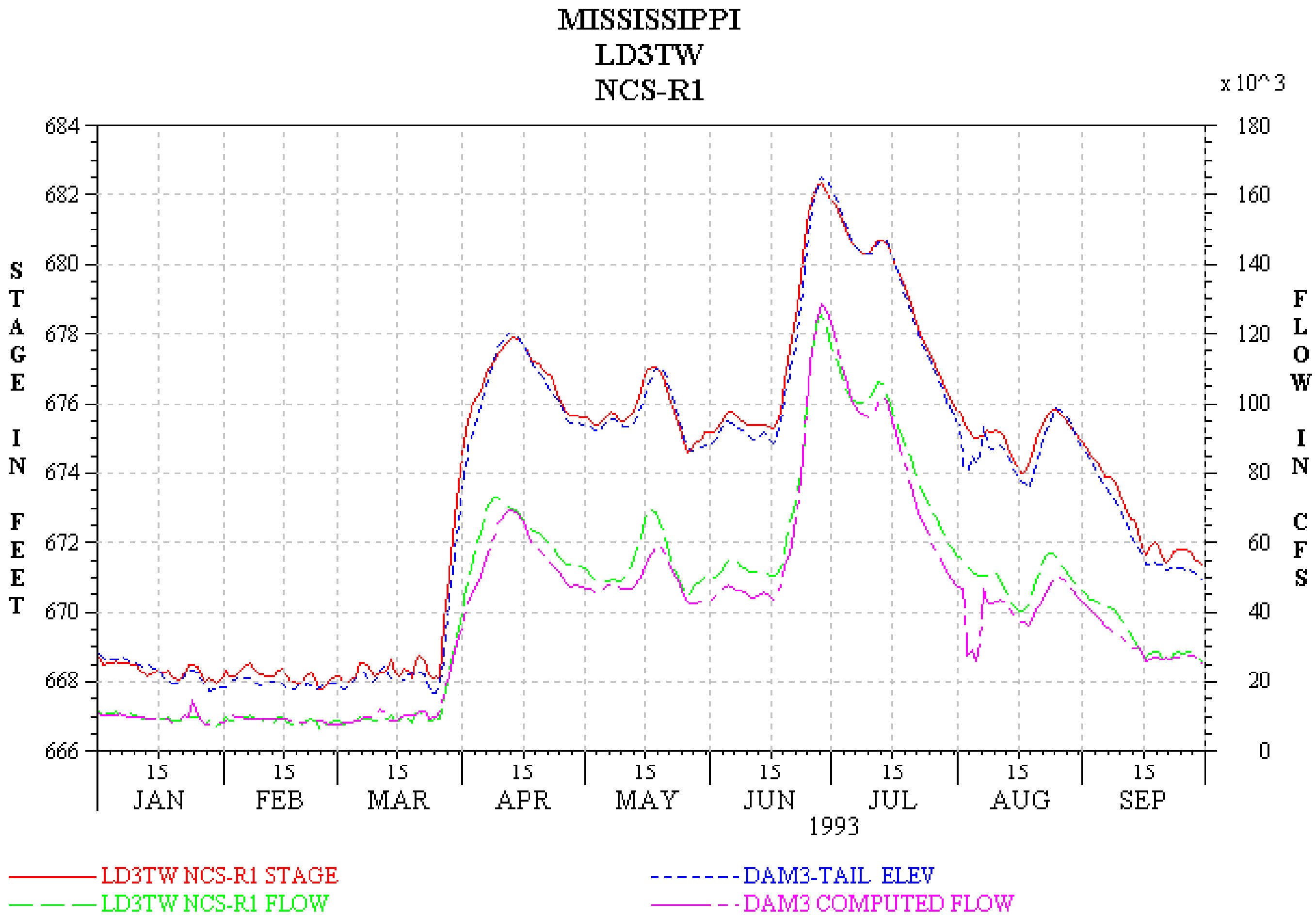
STAGE AND DISCHARGE HYDROGRAPHS

Line	Series	Description
______________	LD3TW NCS-R1 STAGE	UNET computed stage.
__ __ __ __ __	LD3TW NCS-R1 FLOW	UNET computed flow.
_ _ _ _ _ _ _ _	DAM3-TAIL ELEV	Historic observed tailwater elevation.
________ __ __	DAM3 COMPUTED FLOW	Historic observed flow from the St. Paul District Water Control Center

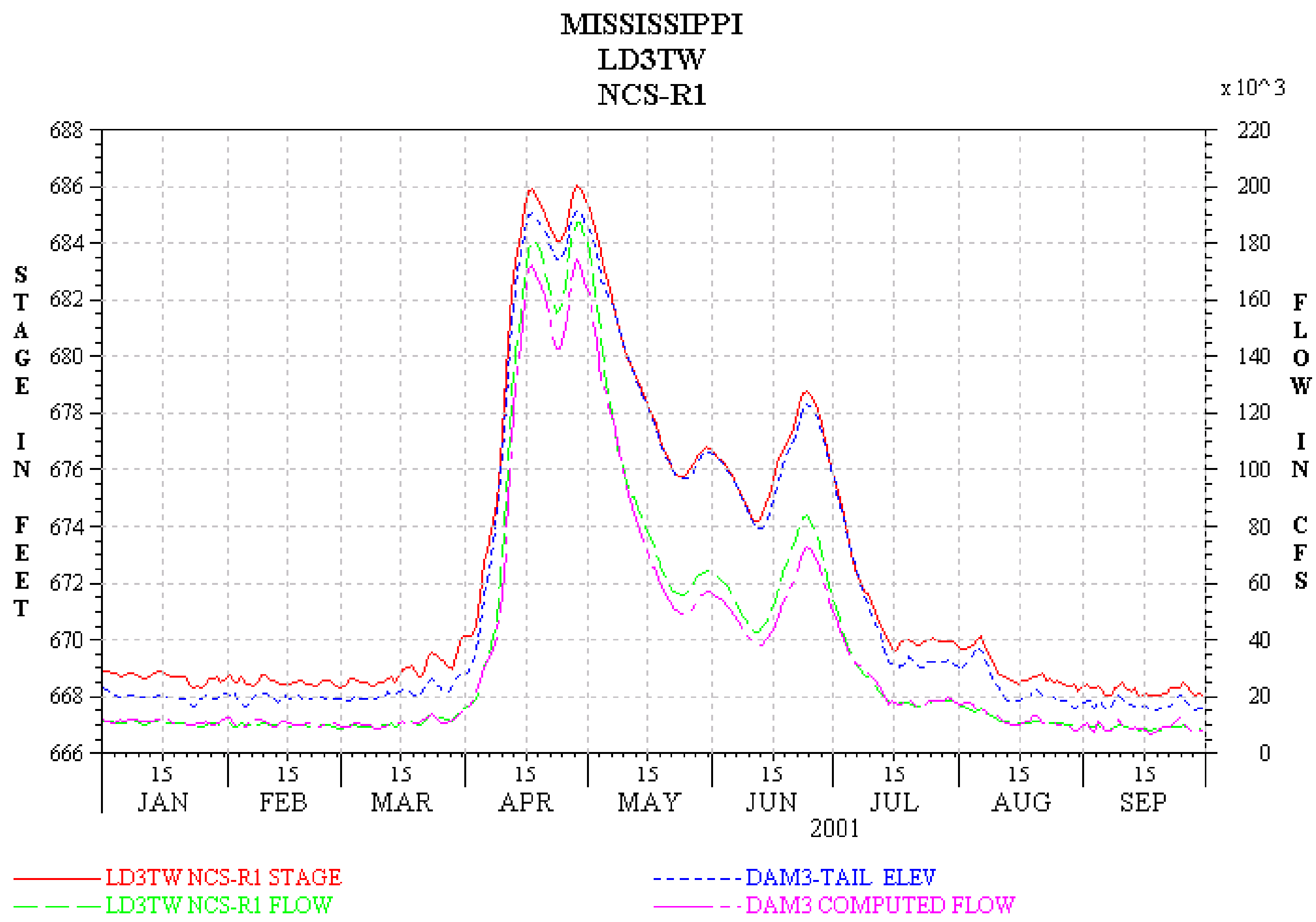


MISSISSIPPI
LD3TW
NCS-R1
x 10^ 3
690
687
684
681
678
675
672
669
666
320
280
240
200
160
120
80
40
0
STAGE IN FEET
FLOW IN CFS
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1965
LD3TW NCS-R1 STAGE
LD3TW NCS-R1 FLOW
DAM3-TAIL ELEV
DAM3 COMPUTED FLOW

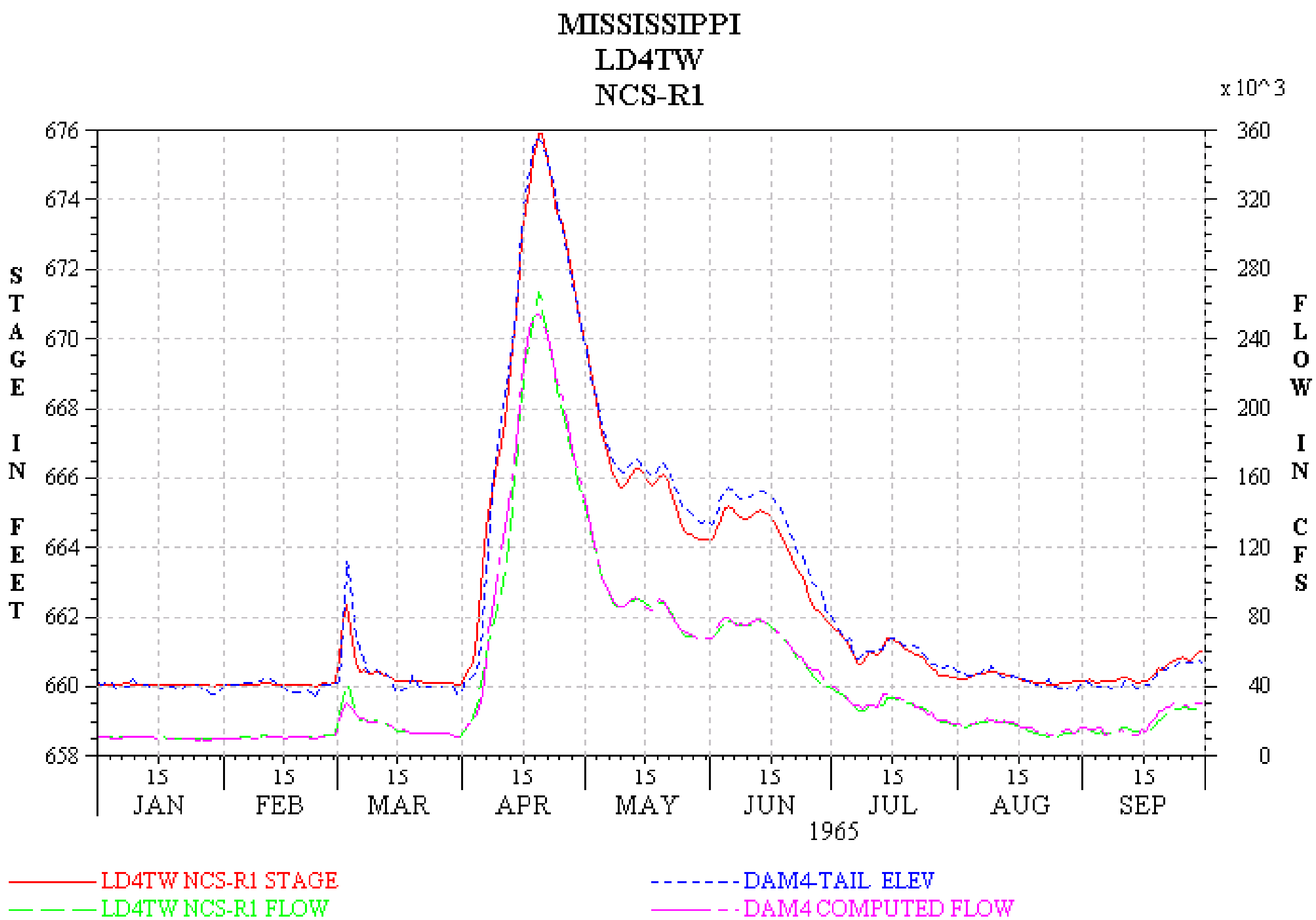

MISSISSIPPI
LD3TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
688
686
684
682
680
678
676
674
672
670
668
666
220
200
180
160
140
120
100
80
60
40
20
0
15 JAN
15 FEB
15 MAR
15 APR
15 MAY
15 JUN
15 JUL
15 AUG
15 SEP
1969
LD3TW NCS-R1 STAGE
LD3TW NCS-R1 FLOW
DAM3-TAIL ELEV
DAM3 COMPUTED FLOW



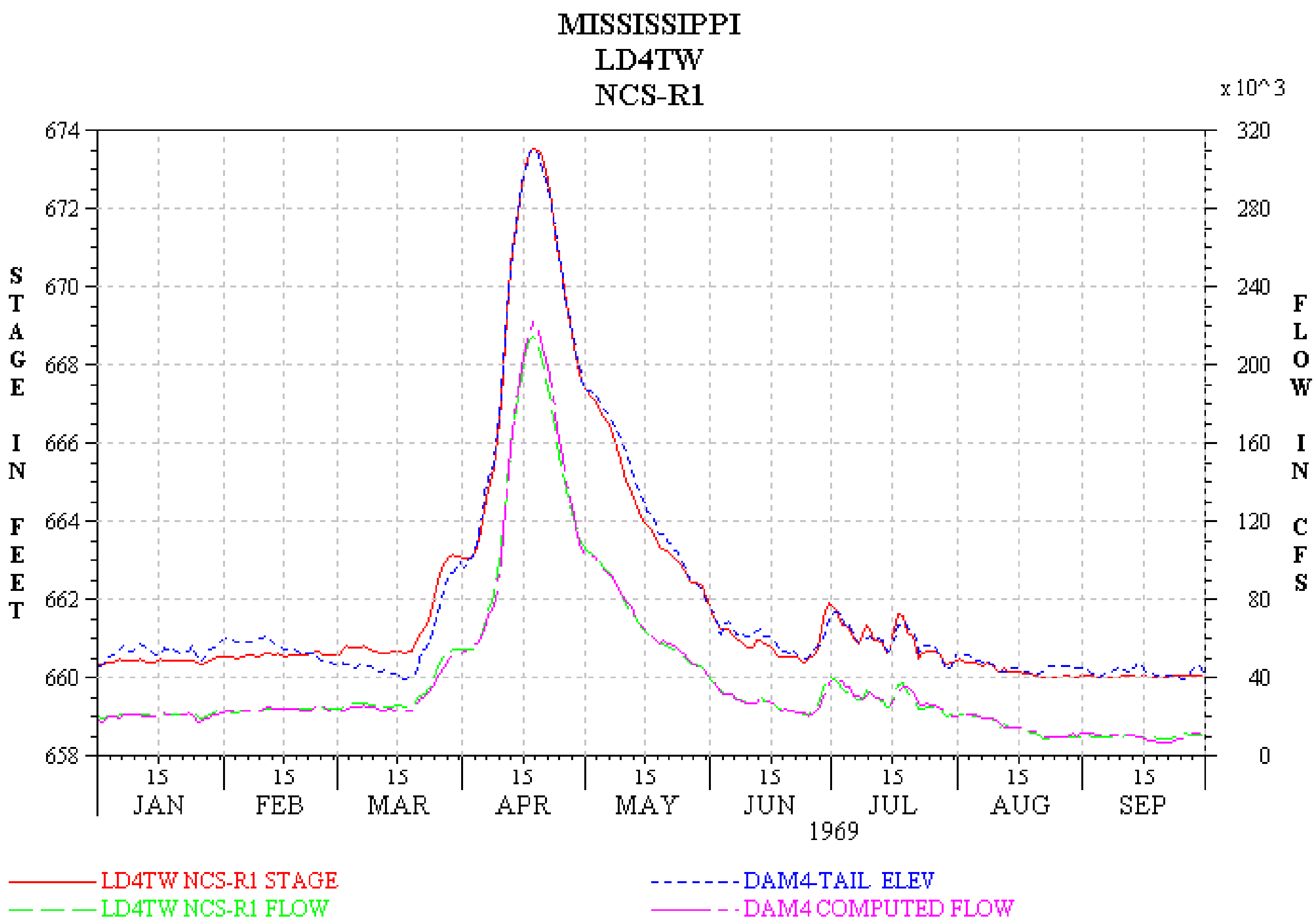
MISSISSIPPI
LD3TW
NCS-R1
STAGE IN FEET
FLOW IN CFS
x 10^3
684
682
680
678
676
674
672
670
668
666
180
160
140
120
100
80
60
40
20
0
15 15 15 15 15 15 15 15 15
JAN FEB MAR APR MAY JUN JUL AUG SEP
1993
LD3TW NCS-R1 STAGE
DAM3-TAIL ELEV
LD3TW NCS-R1 FLOW
DAM3 COMPUTED FLOW

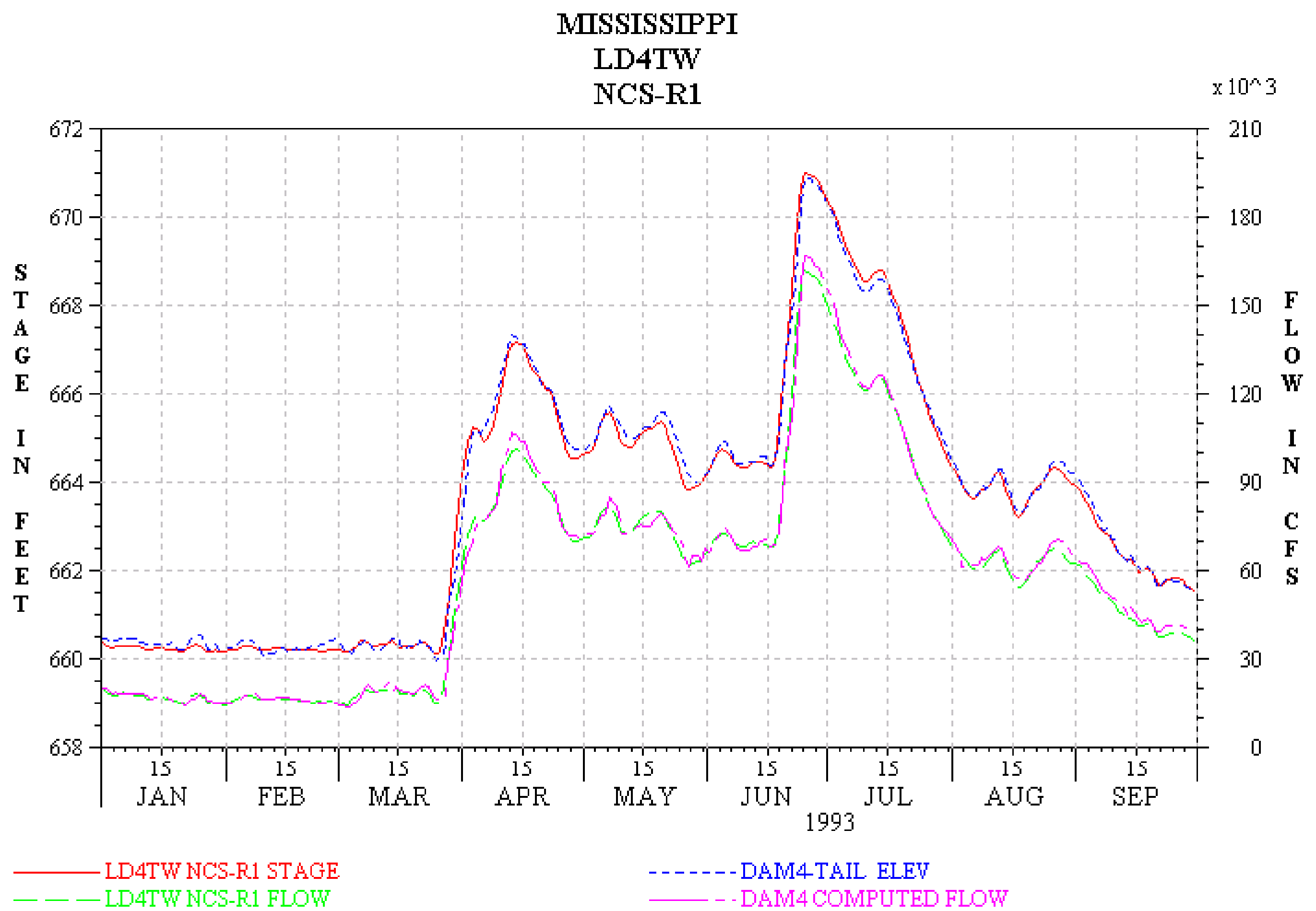


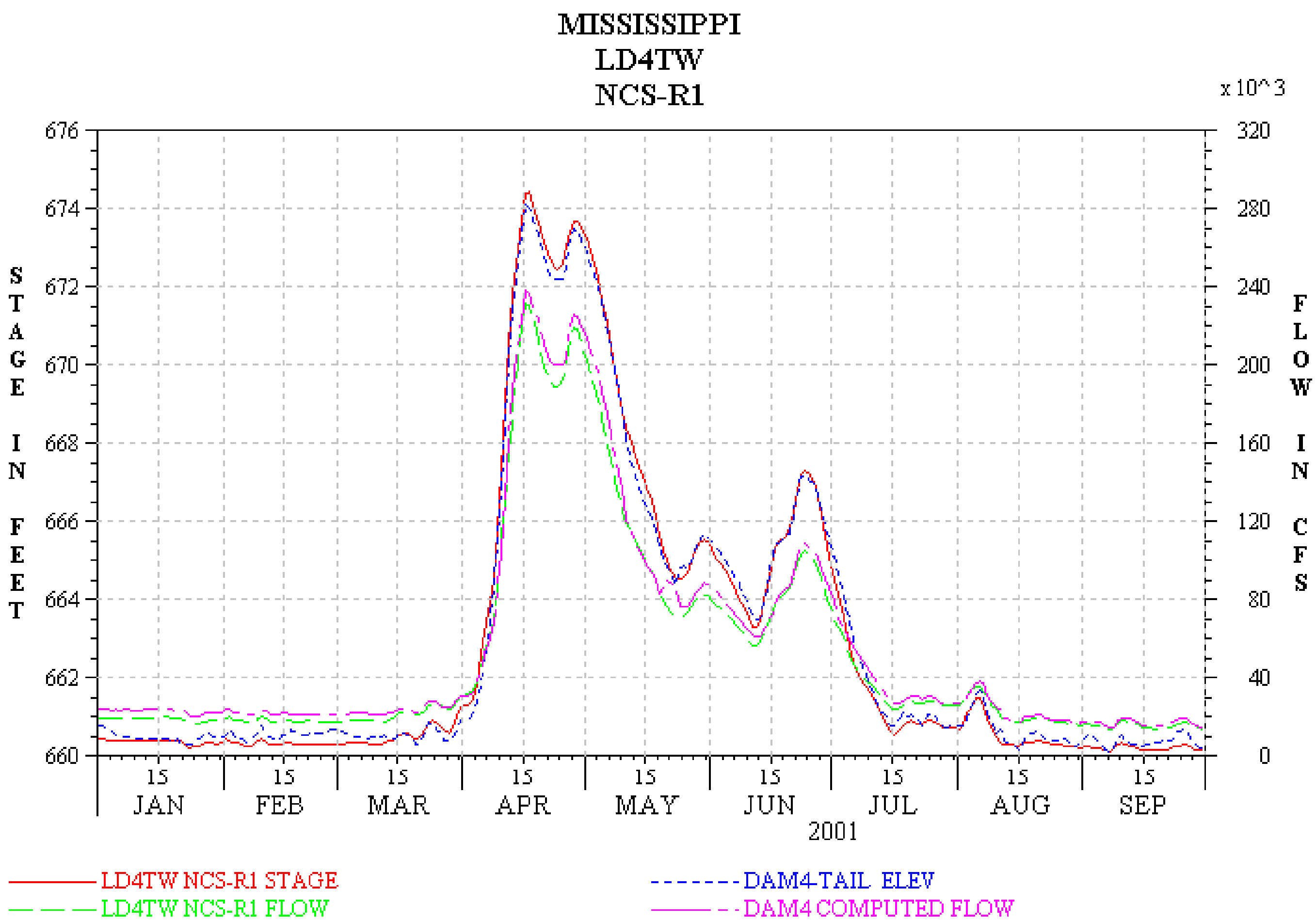
MISSISSIPPI
LD3TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
688
686
684
682
680
678
676
674
672
670
668
666
220
200
180
160
140
120
100
80
60
40
20
0
15
JAN FEB MAR APR MAY JUN JUL AUG SEP
2001
LD3TW NCS-R1 STAGE
LD3TW NCS-R1 FLOW
DAM3-TAIL ELEV
DAM3 COMPUTED FLOW

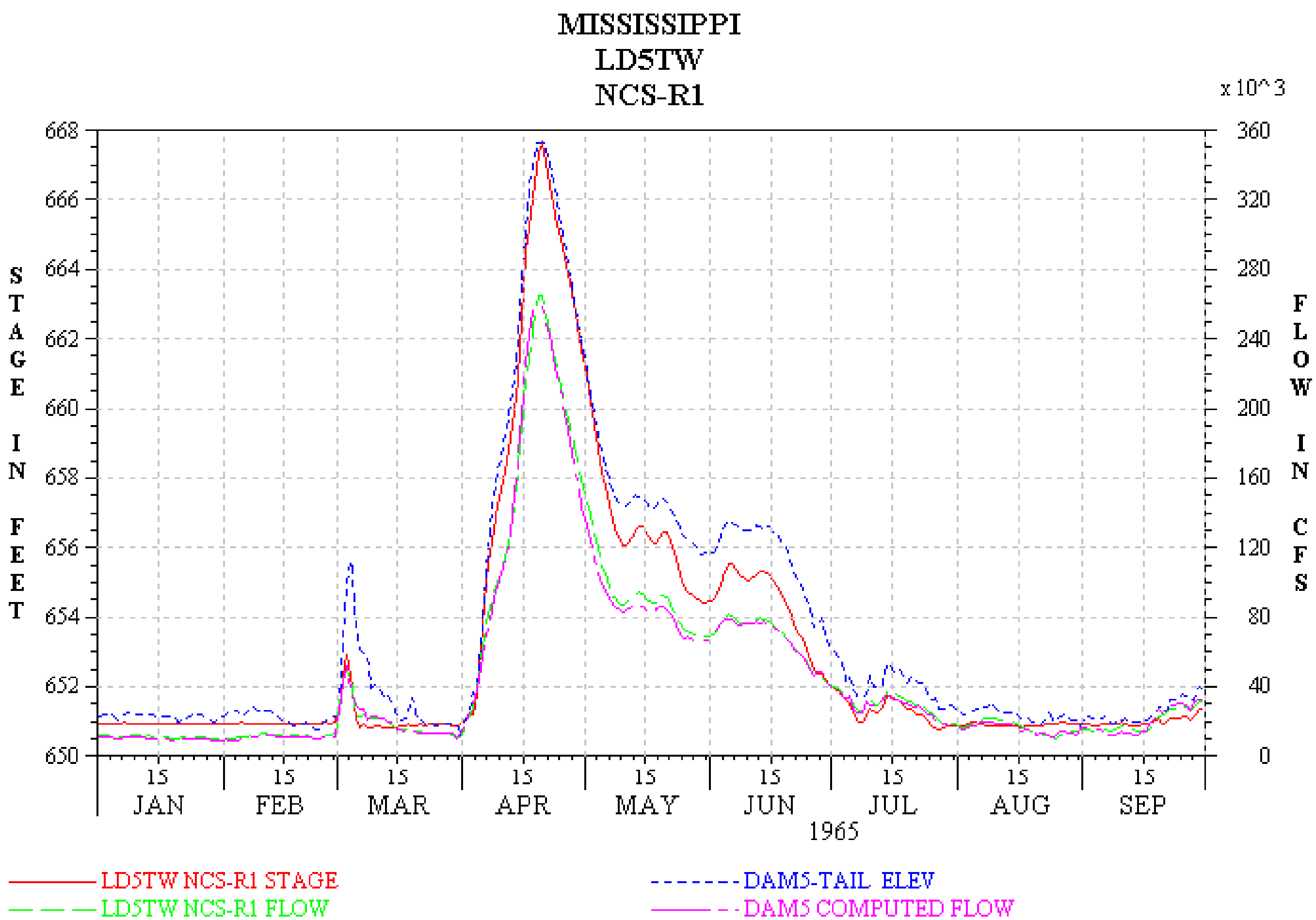


MISSISSIPPI
LD4TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
676
674
672
670
668
666
664
662
660
658
360
320
280
240
200
160
120
80
40
0
15 15 15 15 15 15 15 15 15
JAN FEB MAR APR MAY JUN JUL AUG SEP
1965
LD4TW NCS-R1 STAGE
LD4TW NCS-R1 FLOW
DAM4-TAIL ELEV
DAM4 COMPUTED FLOW

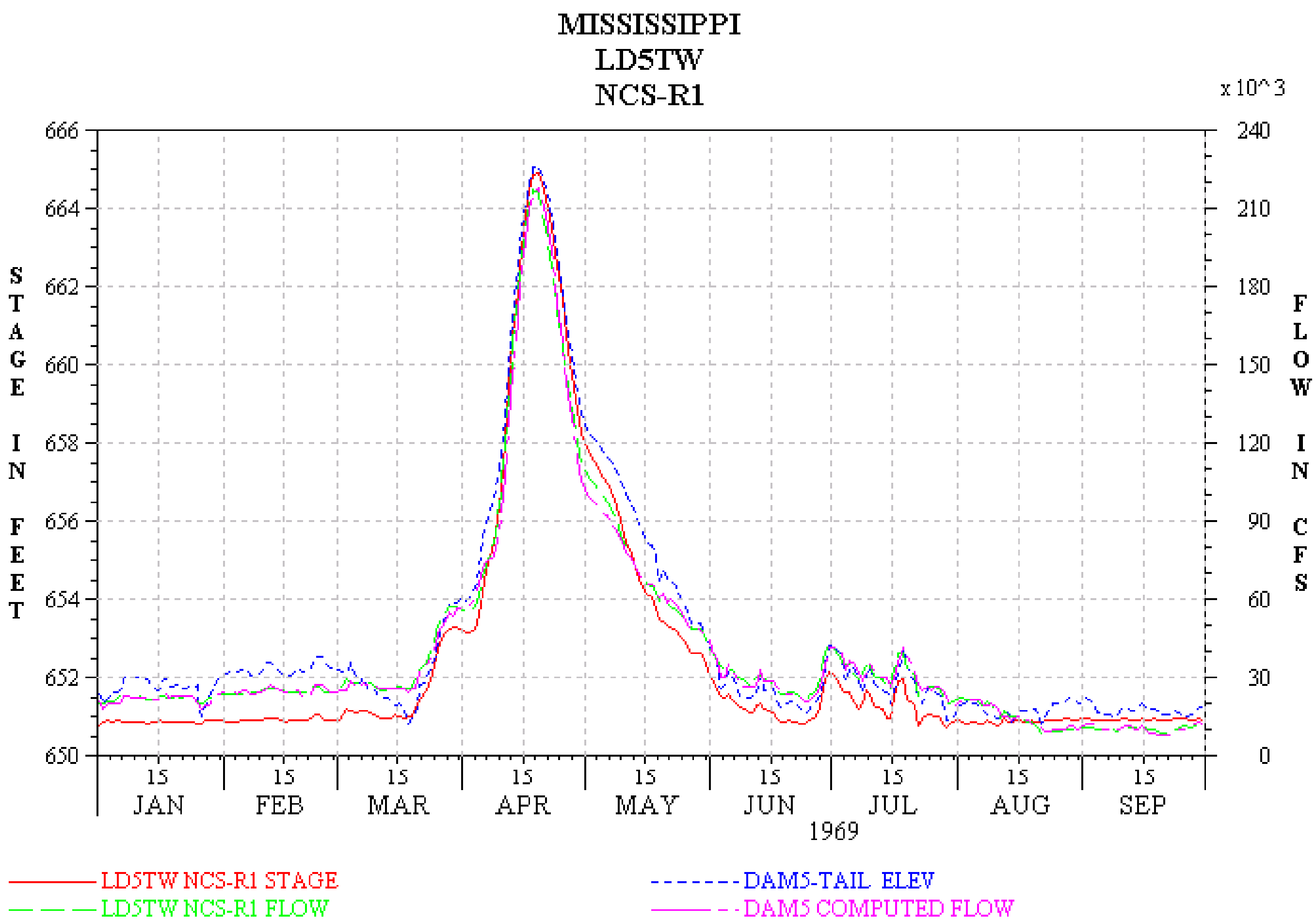

MISSISSIPPI
LD4TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
674
672
670
668
666
664
662
660
658
320
280
240
200
160
120
80
40
0
15 15 15 15 15 15 15 15 15
JAN FEB MAR APR MAY JUN JUL AUG SEP
1969
LD4TW NCS-R1 STAGE
DAM4-TAIL ELEV
LD4TW NCS-R1 FLOW
DAM4 COMPUTED FLOW

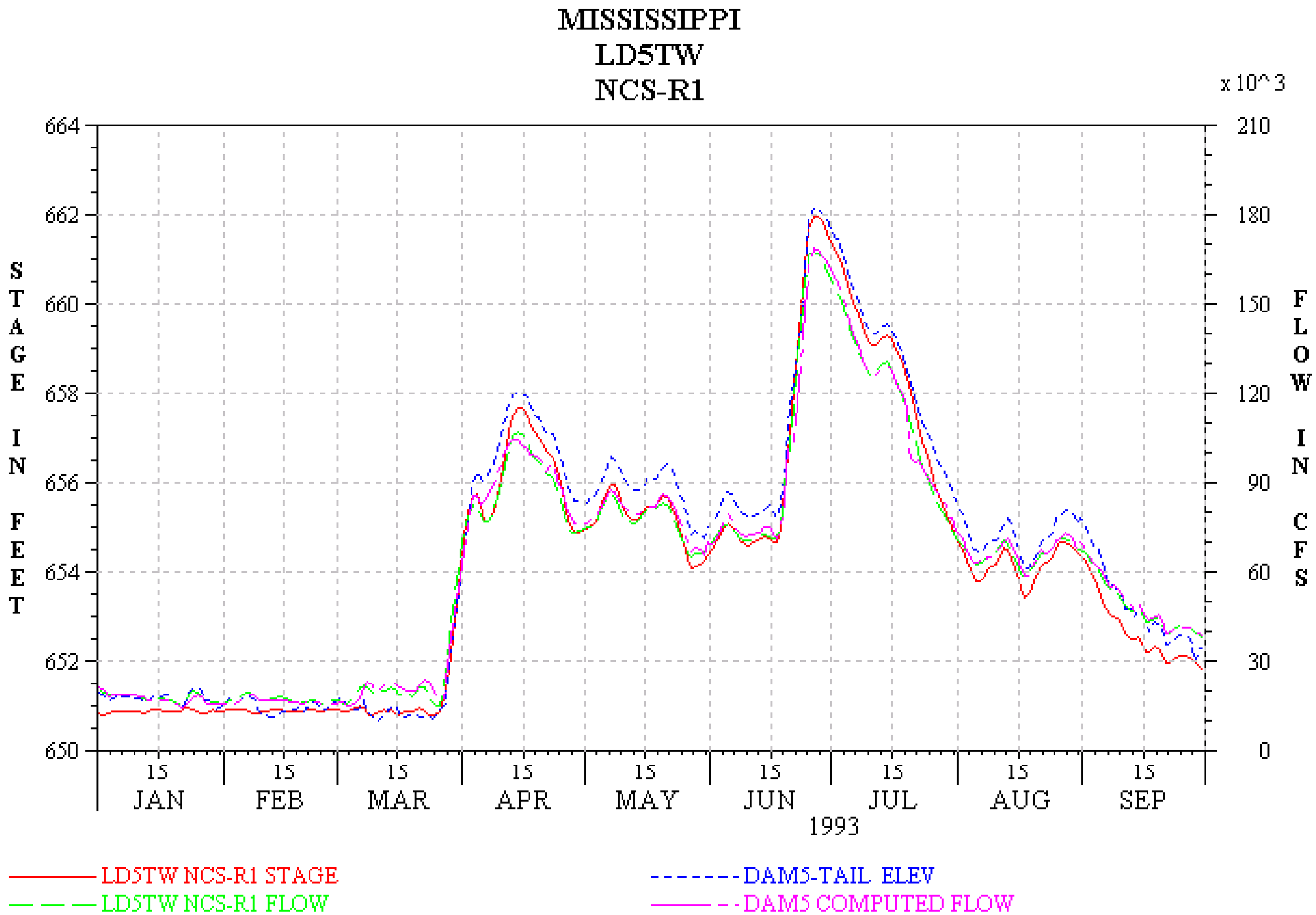

MISSISSIPPI
LD4TW
NCS-R1
STAGE IN FEET
FLOW IN CFS
x 10^3
672
670
668
666
664
662
660
658
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1993
LD4TW NCS-R1 STAGE
LD4TW NCS-R1 FLOW
DAM4-TAIL ELEV
DAM4 COMPUTED FLOW


MISSISSIPPI
LD4TW
NCS-R1
x 10^ 3
STAGE IN FEET
FLOW IN CFS
676
674
672
670
668
666
664
662
660
320
280
240
200
160
120
80
40
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
2001
LD4TW NCS-R1 STAGE
LD4TW NCS-R1 FLOW
DAM4-TAIL ELEV
DAM4 COMPUTED FLOW

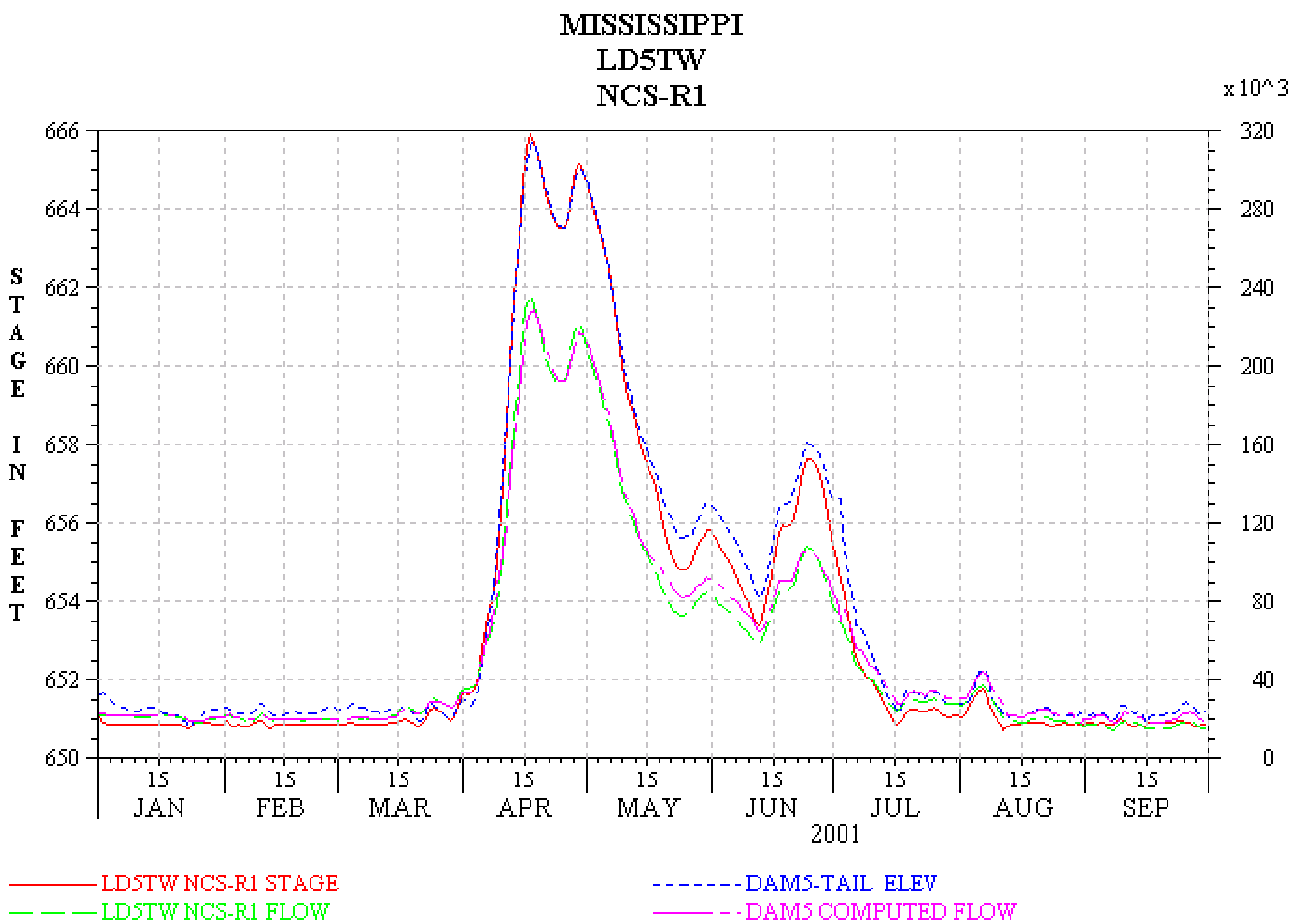


MISSISSIPPI
LD5TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
668
666
664
662
660
658
656
654
652
650
360
320
280
240
200
160
120
80
40
0
15 15 15 15 15 15 15 15 15
JAN FEB MAR APR MAY JUN JUL AUG SEP
1965
LD5TW NCS-R1 STAGE
LD5TW NCS-R1 FLOW
DAM5-TAIL ELEV
DAM5 COMPUTED FLOW


MISSISSIPPI
LD5TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
666
664
662
660
658
656
654
652
650
240
210
180
150
120
90
60
30
0
15 JAN
15 FEB
15 MAR
15 APR
15 MAY
15 JUN
15 JUL
15 AUG
15 SEP
1969
LD5TW NCS-R1 STAGE
LD5TW NCS-R1 FLOW
DAM5-TAIL ELEV
DAM5 COMPUTED FLOW



MISSISSIPPI
LD5TW
NCS-R1
x 10^ 3
STAGE IN FEET
FLOW IN CFS
664
662
660
658
656
654
652
650
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1993
LD5TW NCS-R1 STAGE
LD5TW NCS-R1 FLOW
DAM5-TAIL ELEV
DAM5 COMPUTED FLOW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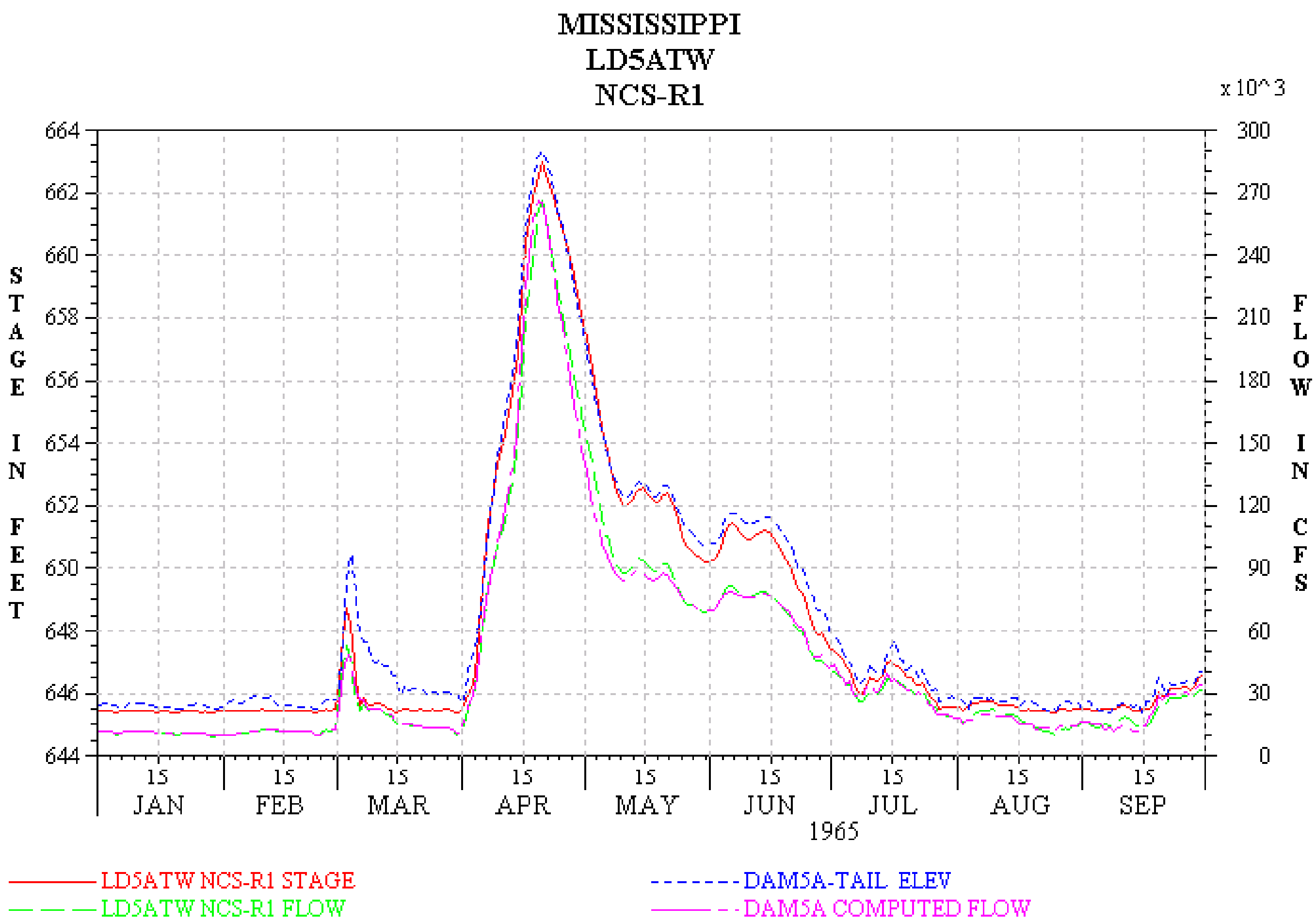
LD5TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
666
664
662
660
658
656
654
652
650
320
280
240
200
160
120
80
40
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
2001
LD5TW NCS-R1 STAGE
LD5TW NCS-R1 FLOW
DAM5-TAIL ELEV
DAM5 COMPUTED FLOW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NCS-R1
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STAGE IN FEET
FLOW IN CFS
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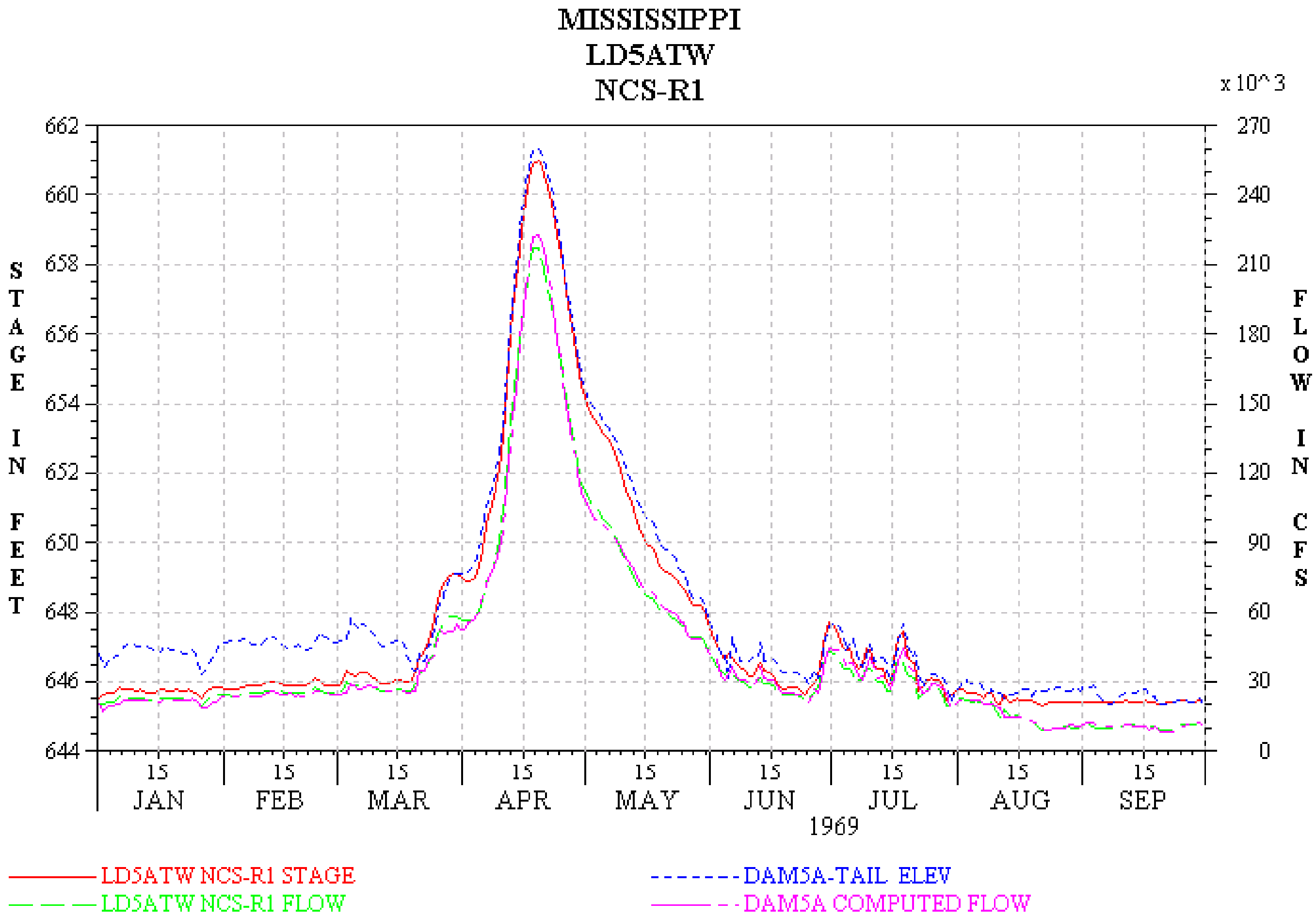
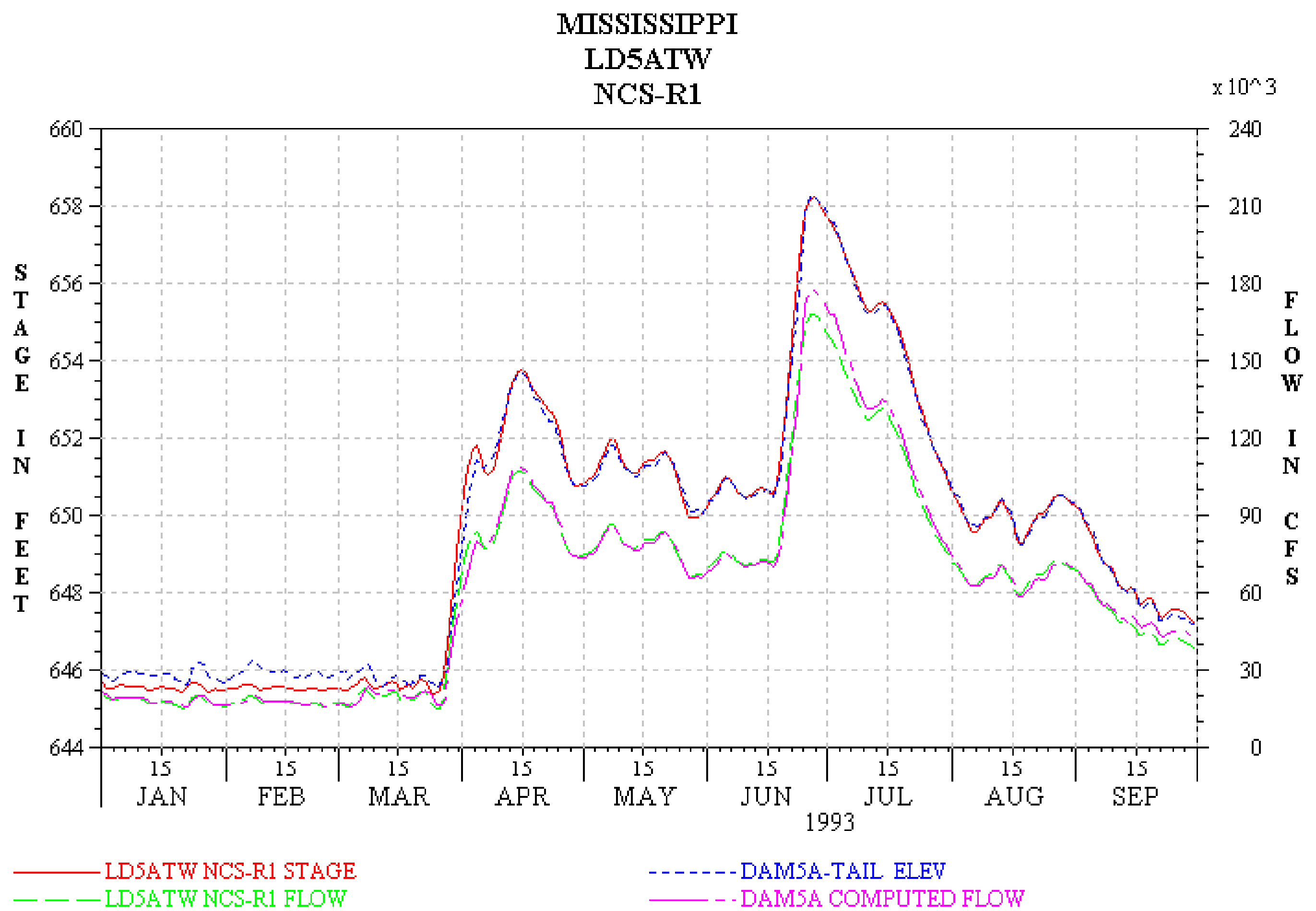
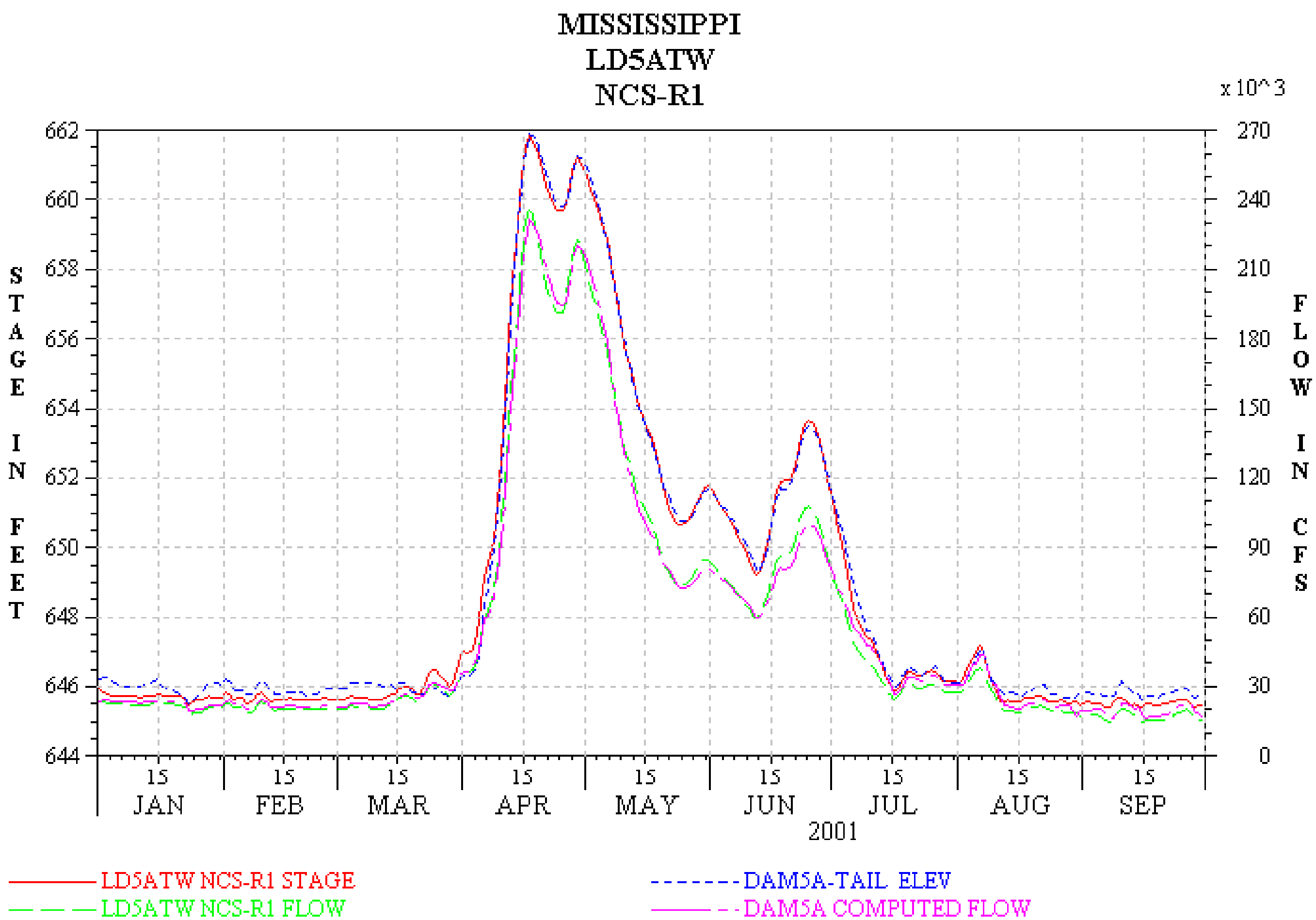
662
660
658
656
654
652
650
648
646
644
300
270
240
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1965
LD5ATW NCS-R1 STAGE
LD5ATW NCS-R1 FLOW
DAM5A-TAIL ELEV
DAM5A COMPUTED FLOW


MISSISSIPPI
LD5ATW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
662
660
658
656
654
652
650
648
646
644
270
240
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1969
LD5ATW NCS-R1 STAGE
LD5ATW NCS-R1 FLOW
DAM5A-TAIL ELEV
DAM5A COMPUTED FLOW



MISSISSIPPI
LD5ATW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
660
658
656
654
652
650
648
646
644
240
210
180
150
120
90
60
30
0
15 15 15 15 15 15 15 15 15
JAN FEB MAR APR MAY JUN JUL AUG SEP
1993
LD5ATW NCS-R1 STAGE
LD5ATW NCS-R1 FLOW
DAM5A-TAIL ELEV
DAM5A COMPUTED FLOW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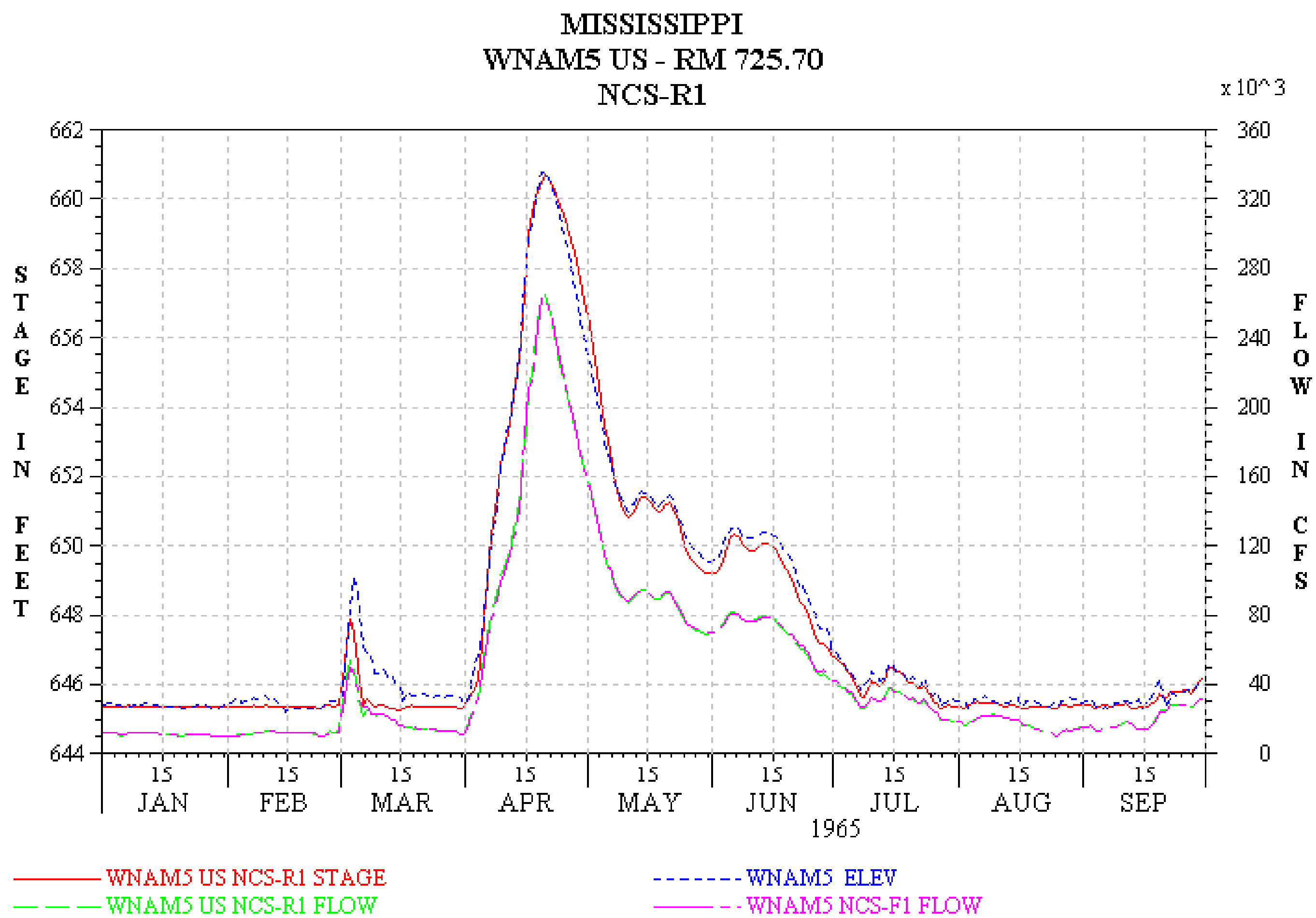
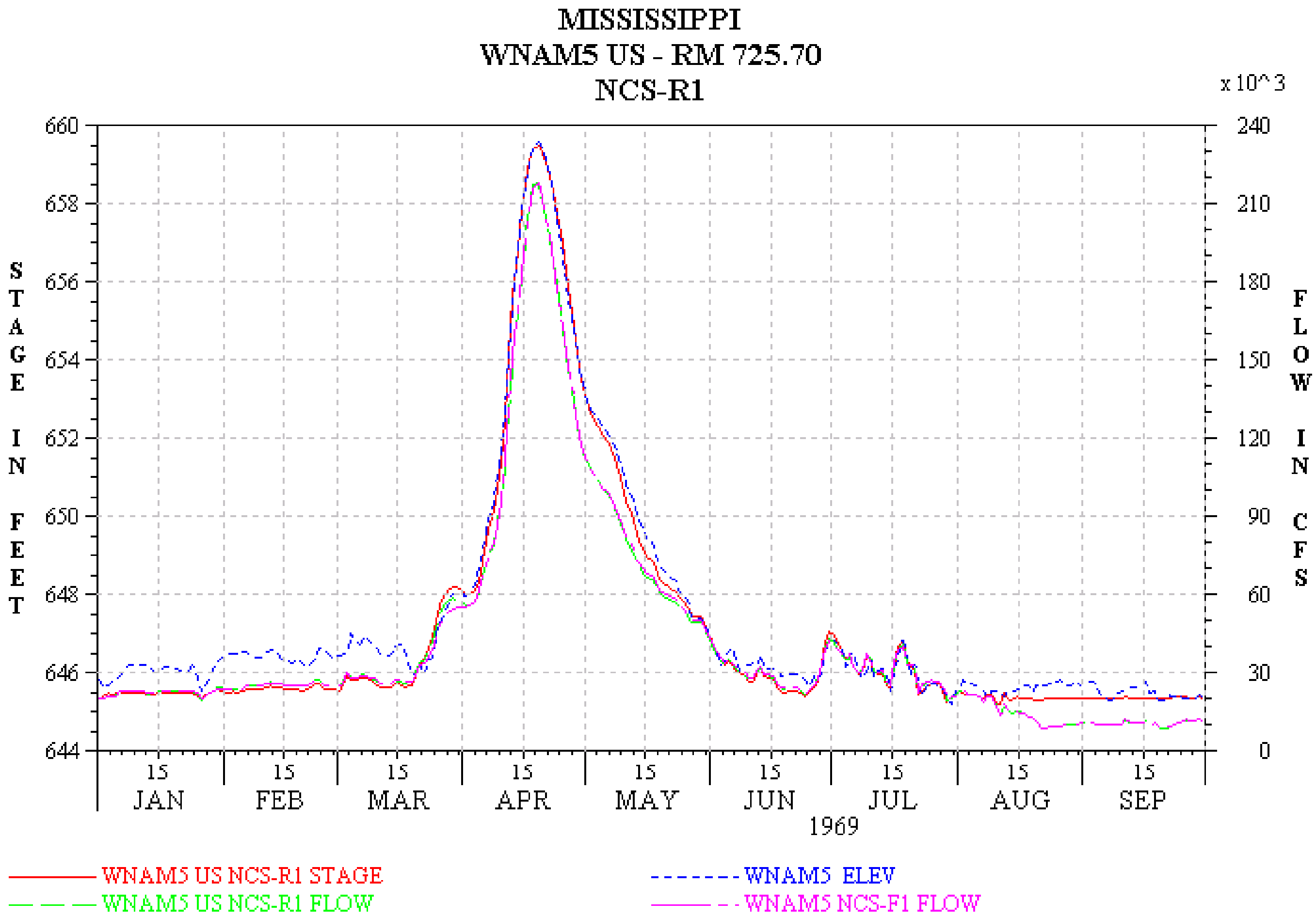
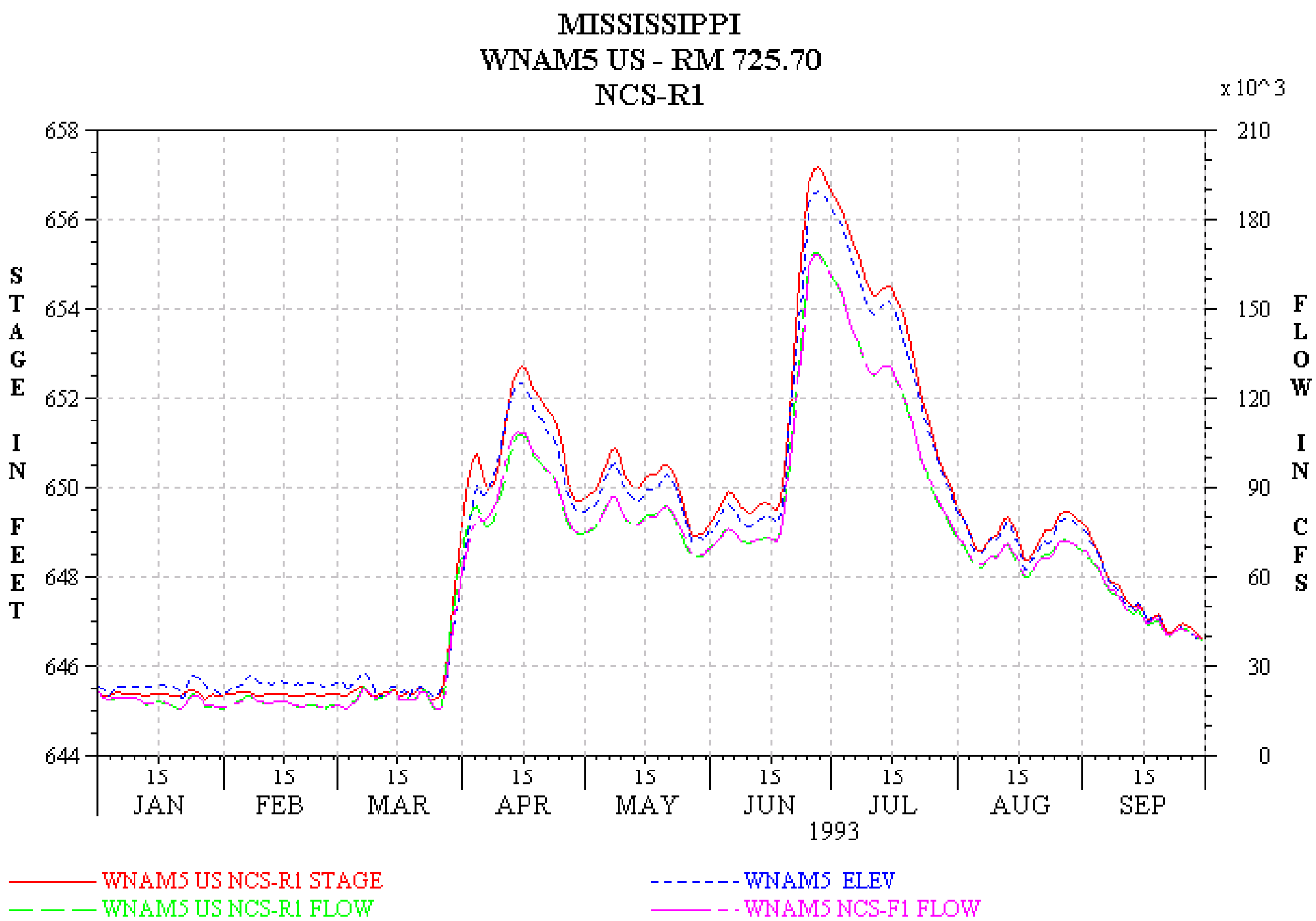
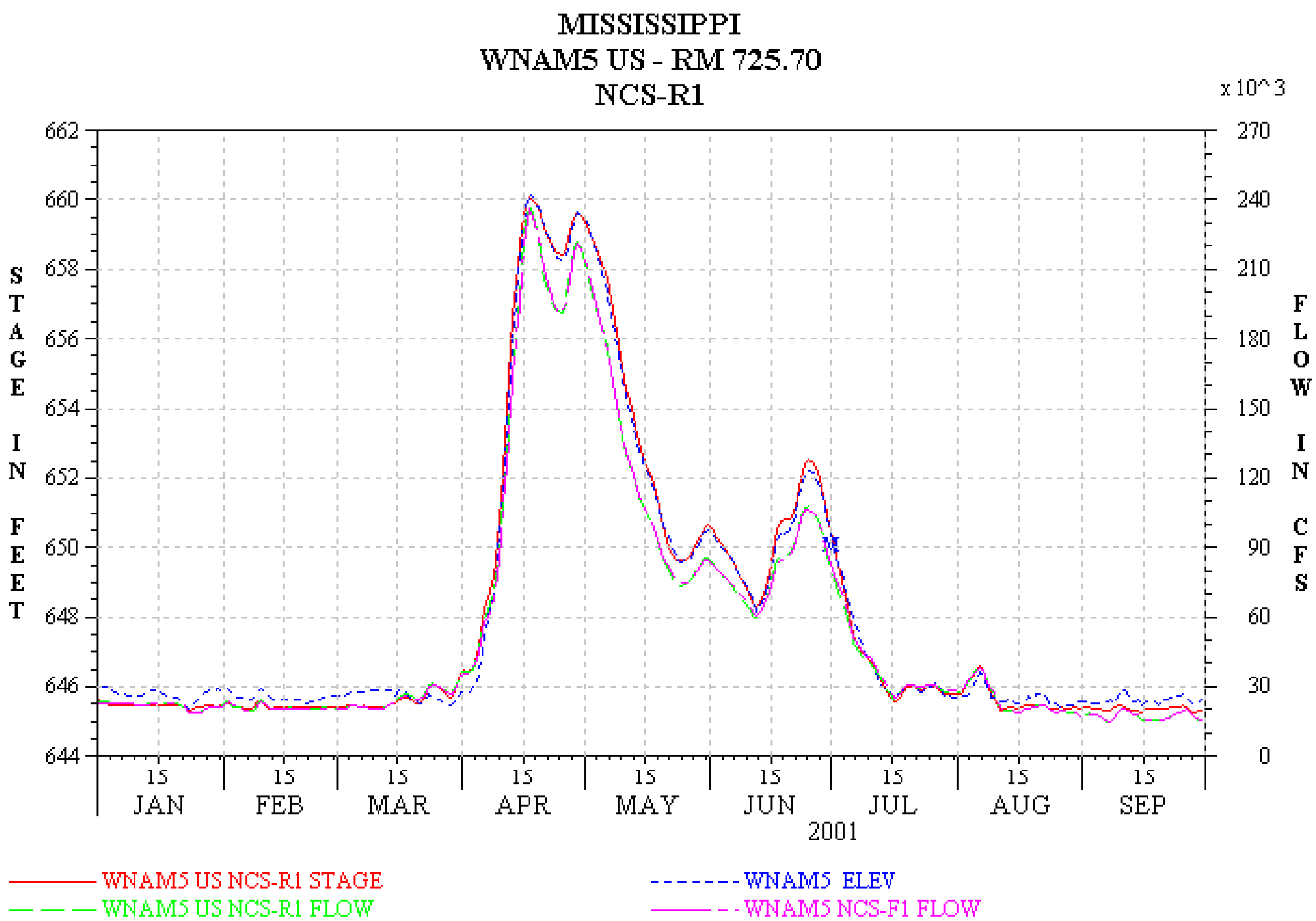
LD5ATW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
662
660
658
656
654
652
650
648
646
644
270
240
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
2001
LD5ATW NCS-R1 STAGE
LD5ATW NCS-R1 FLOW
DAM5A-TAIL ELEV
DAM5A COMPUTED FLOW

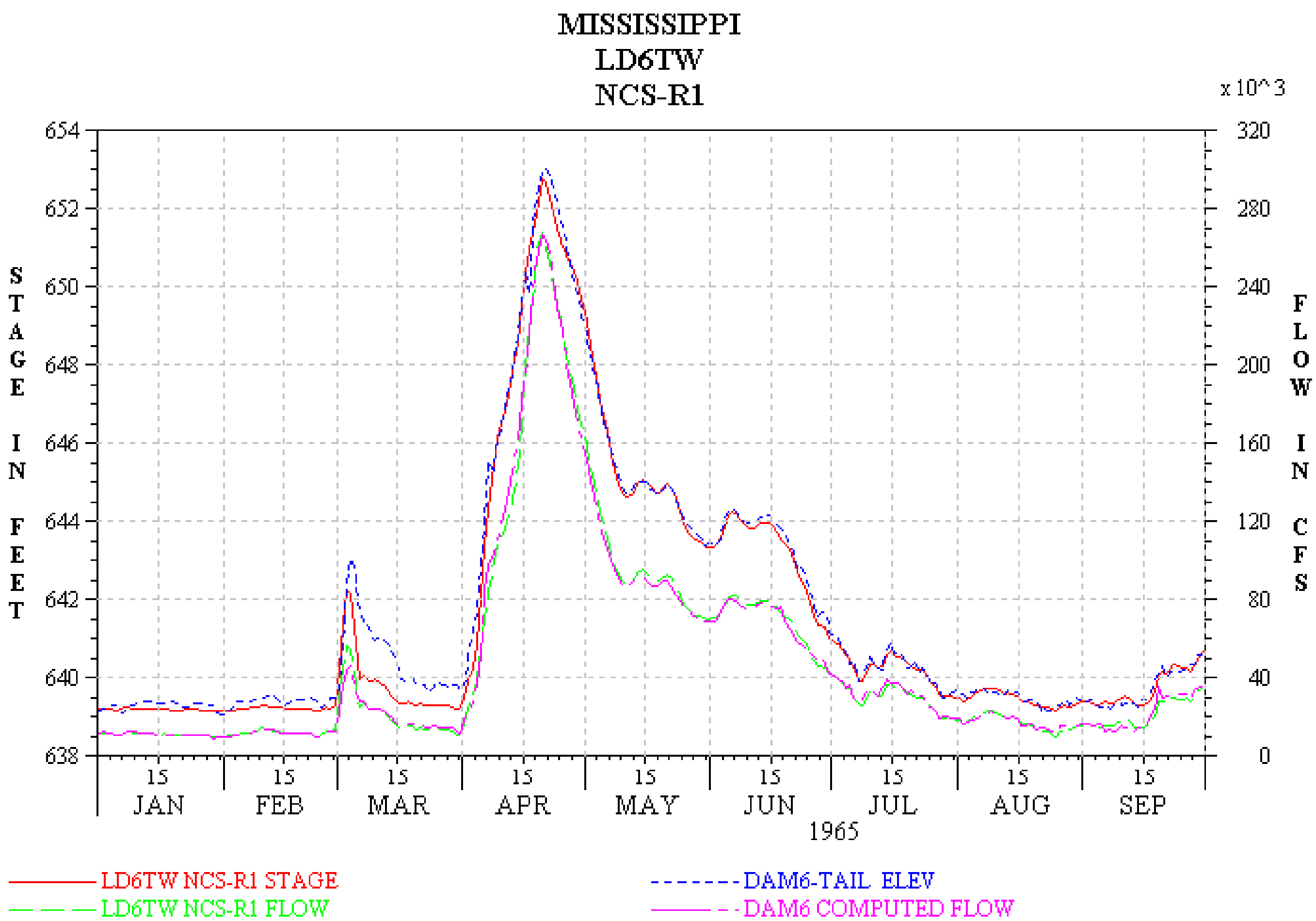


MISSISSIPPI
WNAM5 US - RM 725.70
NCS-R1
x 10^ 3
STAGE IN FEET
FLOW IN CFS
662
660
658
656
654
652
650
648
646
644
360
320
280
240
200
160
120
80
40
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1965
WNAM5 US NCS-R1 STAGE
WNAM5 US NCS-R1 FLOW
WNAM5 ELEV
WNAM5 NCS-F1 FLOW

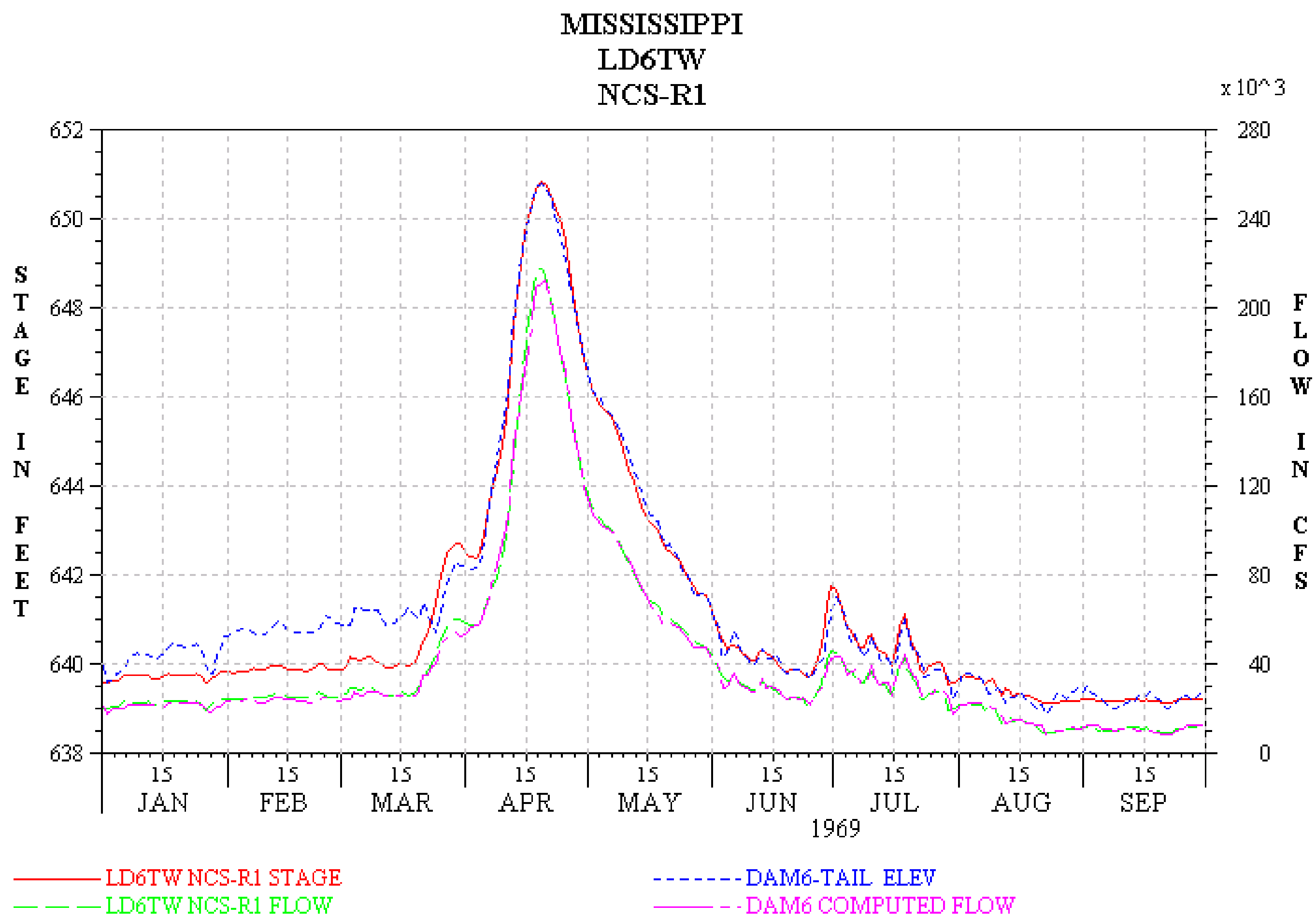

MISSISSIPPI
WNAM5 US - RM 725.70
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
660
658
656
654
652
650
648
646
644
240
210
180
150
120
90
60
30
0
15 JAN
15 FEB
15 MAR
15 APR
15 MAY
15 JUN
15 JUL
15 AUG
15 SEP
1969
WNAM5 US NCS-R1 STAGE
WNAM5 ELEV
WNAM5 US NCS-R1 FLOW
WNAM5 NCS-F1 FLOW


MISSISSIPPI
WNAM5 US - RM 725.70
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
658
656
654
652
650
648
646
644
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1993
WNAM5 US NCS-R1 STAGE
WNAM5 ELEV
WNAM5 US NCS-R1 FLOW
WNAM5 NCS-F1 FLOW

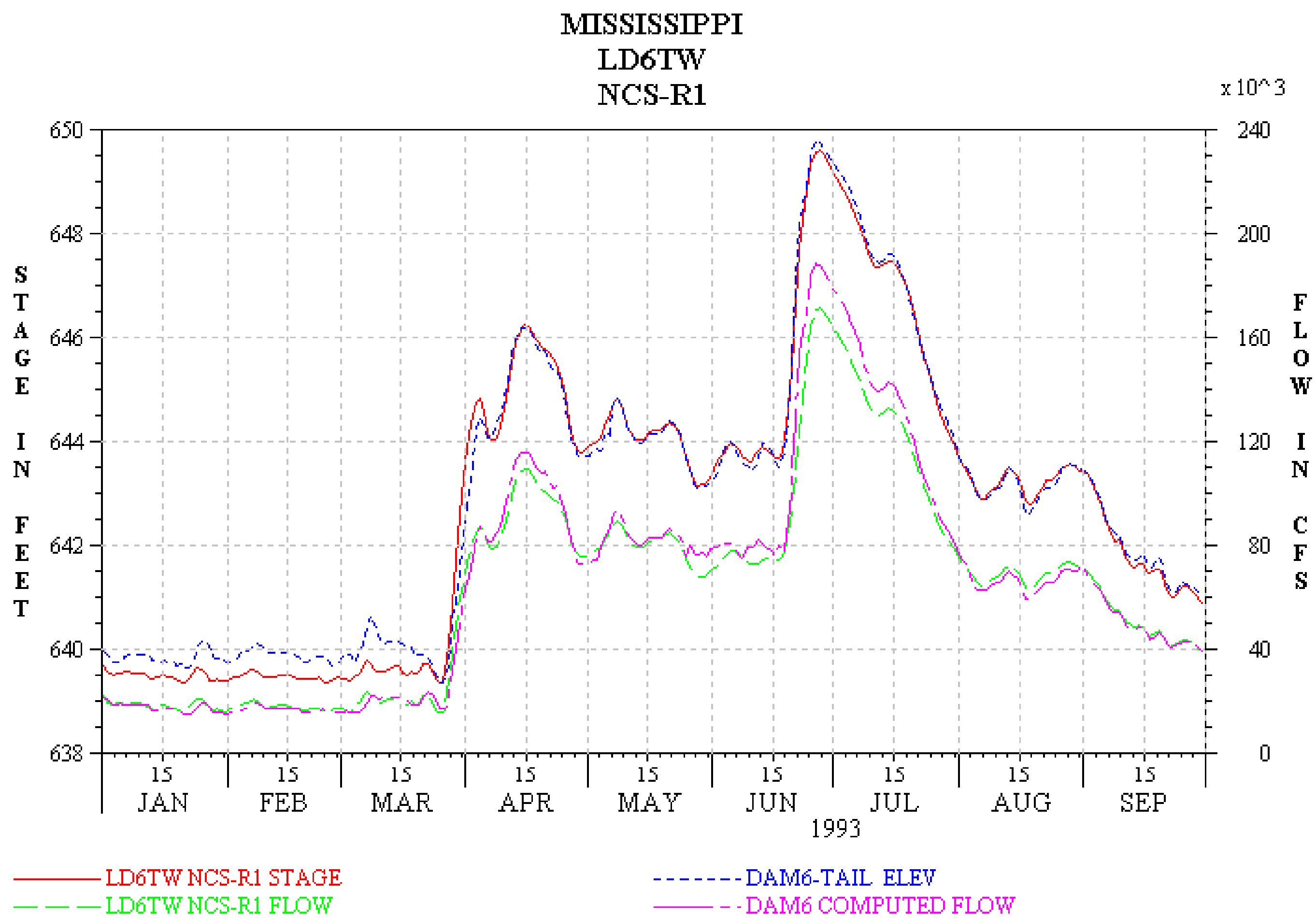

MISSISSIPPI
WNAM5 US - RM 725.70
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
662
660
658
656
654
652
650
648
646
644
270
240
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
2001
WNAM5 US NCS-R1 STAGE
WNAM5 US NCS-R1 FLOW
WNAM5 ELEV
WNAM5 NCS-F1 FLOW



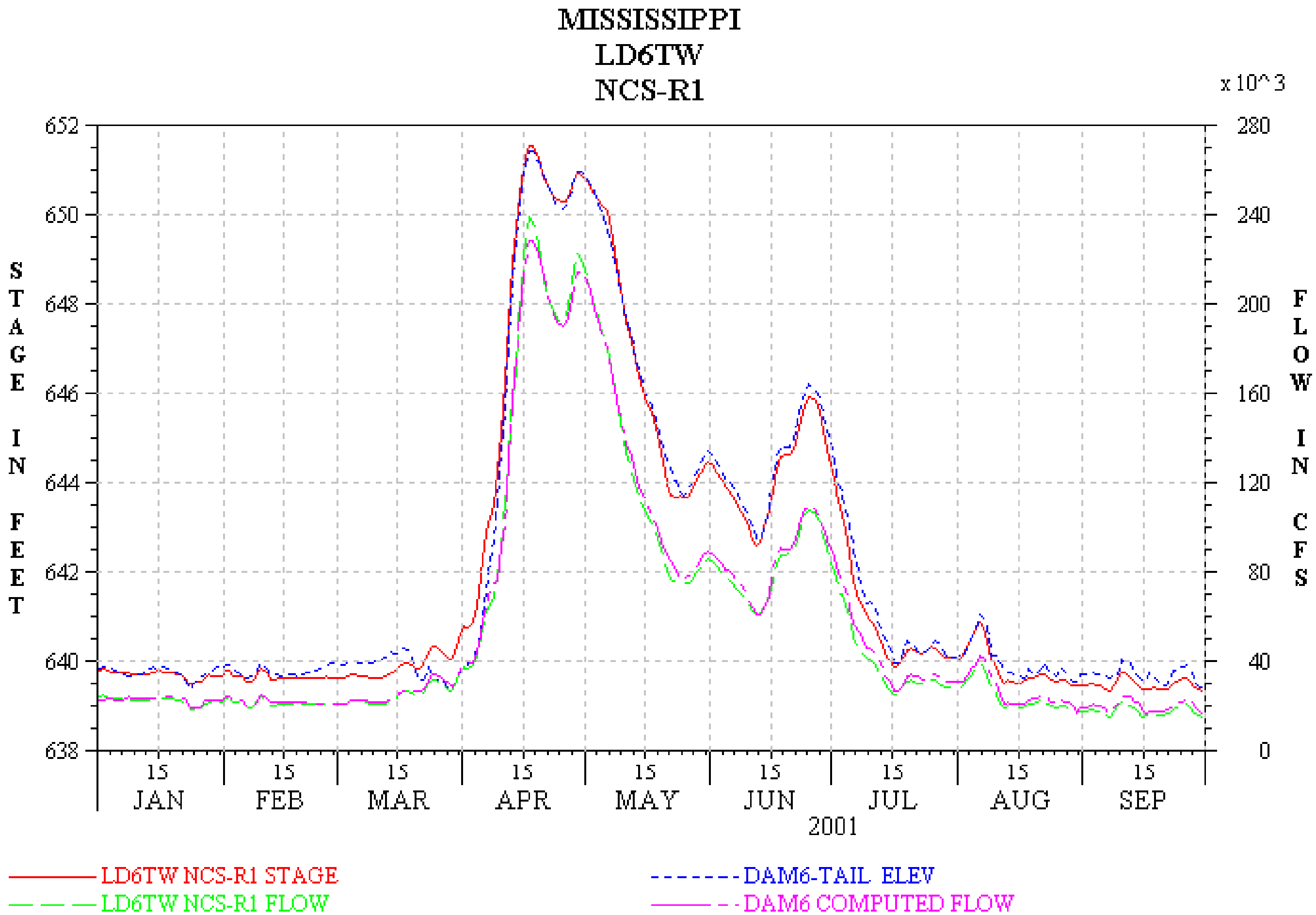
MISSISSIPPI
LD6TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
654
652
650
648
646
644
642
640
638
320
280
240
200
160
120
80
40
0
15 15 15 15 15 15 15 15 15
JAN FEB MAR APR MAY JUN JUL AUG SEP
1965
LD6TW NCS-R1 STAGE
LD6TW NCS-R1 FLOW
DAM6-TAIL ELEV
DAM6 COMPUTED FLOW

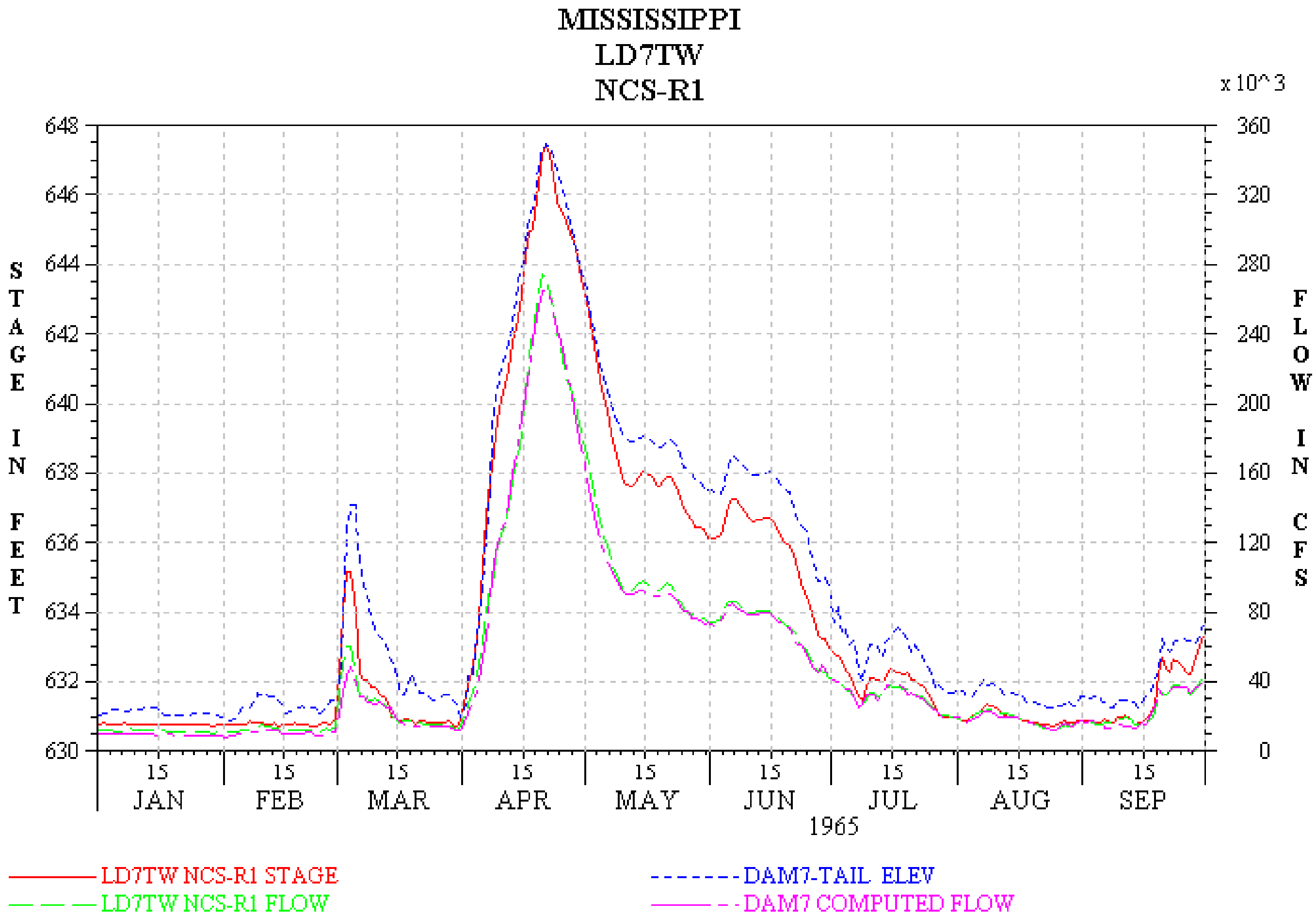


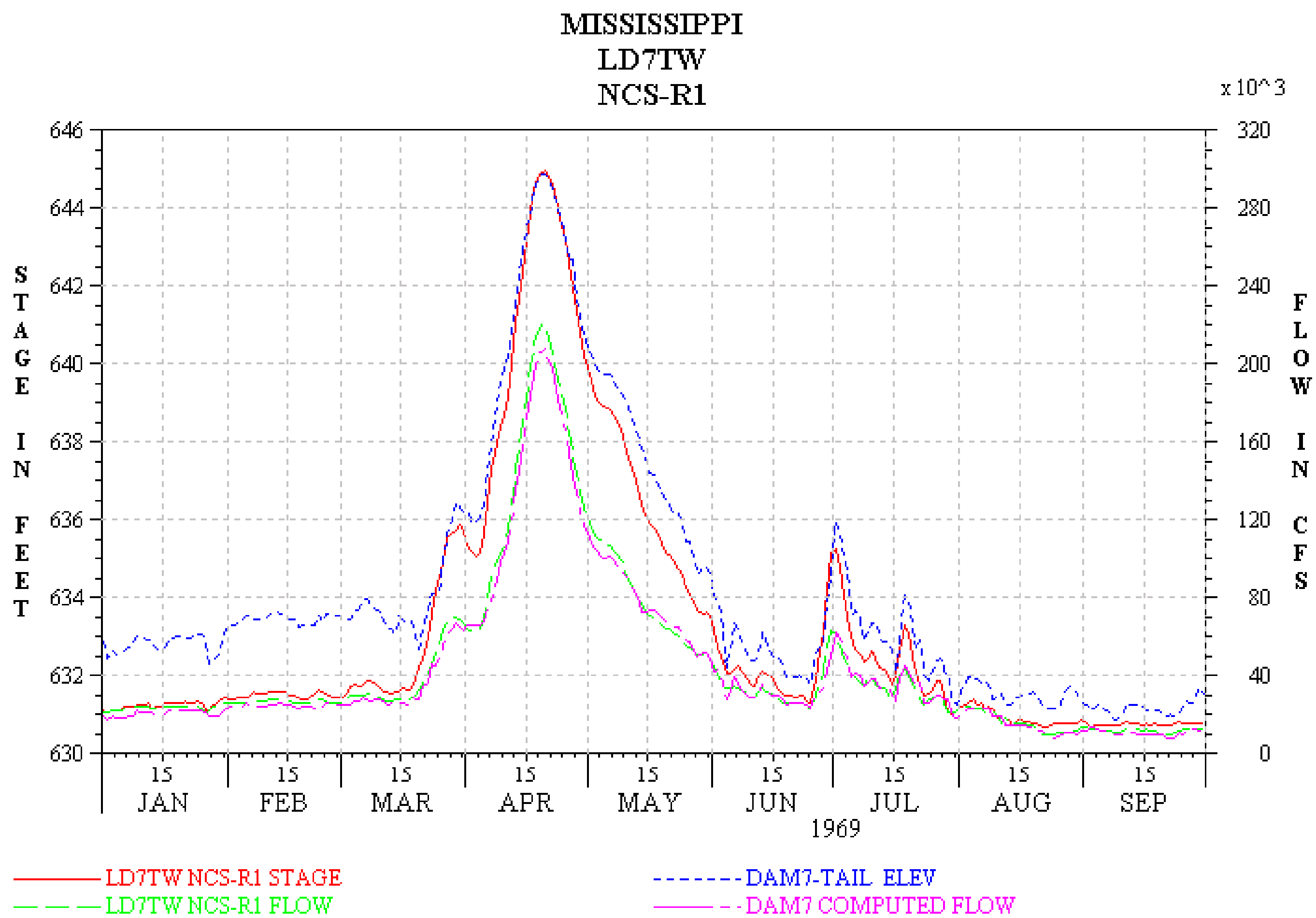
MISSISSIPPI
LD6TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
652
650
648
646
644
642
640
638
280
240
200
160
120
80
40
0
15 JAN
15 FEB
15 MAR
15 APR
15 MAY
15 JUN
15 JUL
15 AUG
15 SEP
1969
LD6TW NCS-R1 STAGE
LD6TW NCS-R1 FLOW
DAM6-TAIL ELEV
DAM6 COMPUTED FLOW

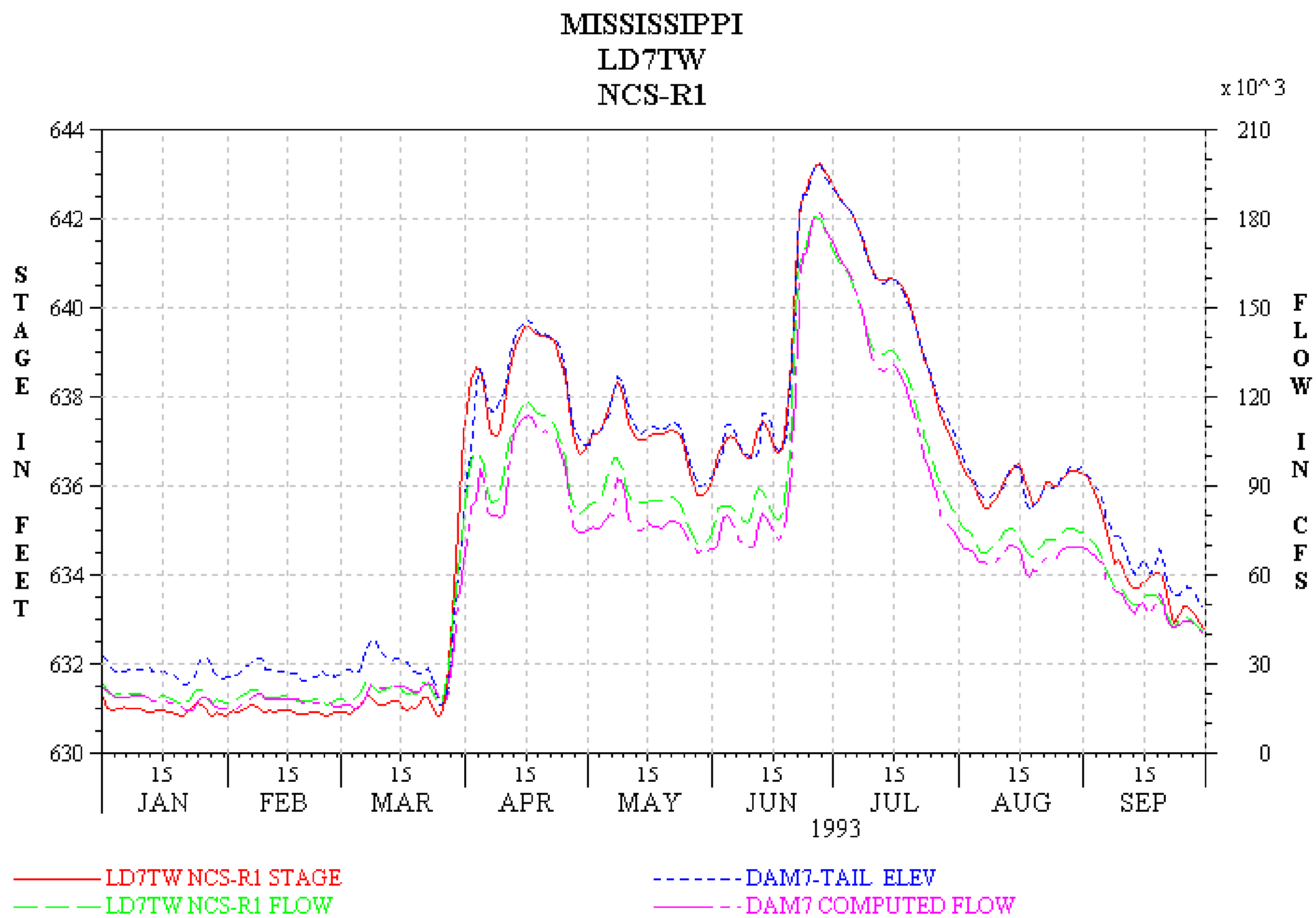


MISSISSIPPI
LD6TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
650
648
646
644
642
640
638
240
200
160
120
80
40
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1993
LD6TW NCS-R1 STAGE
LD6TW NCS-R1 FLOW
DAM6-TAIL ELEV
DAM6 COMPUTED FLOW

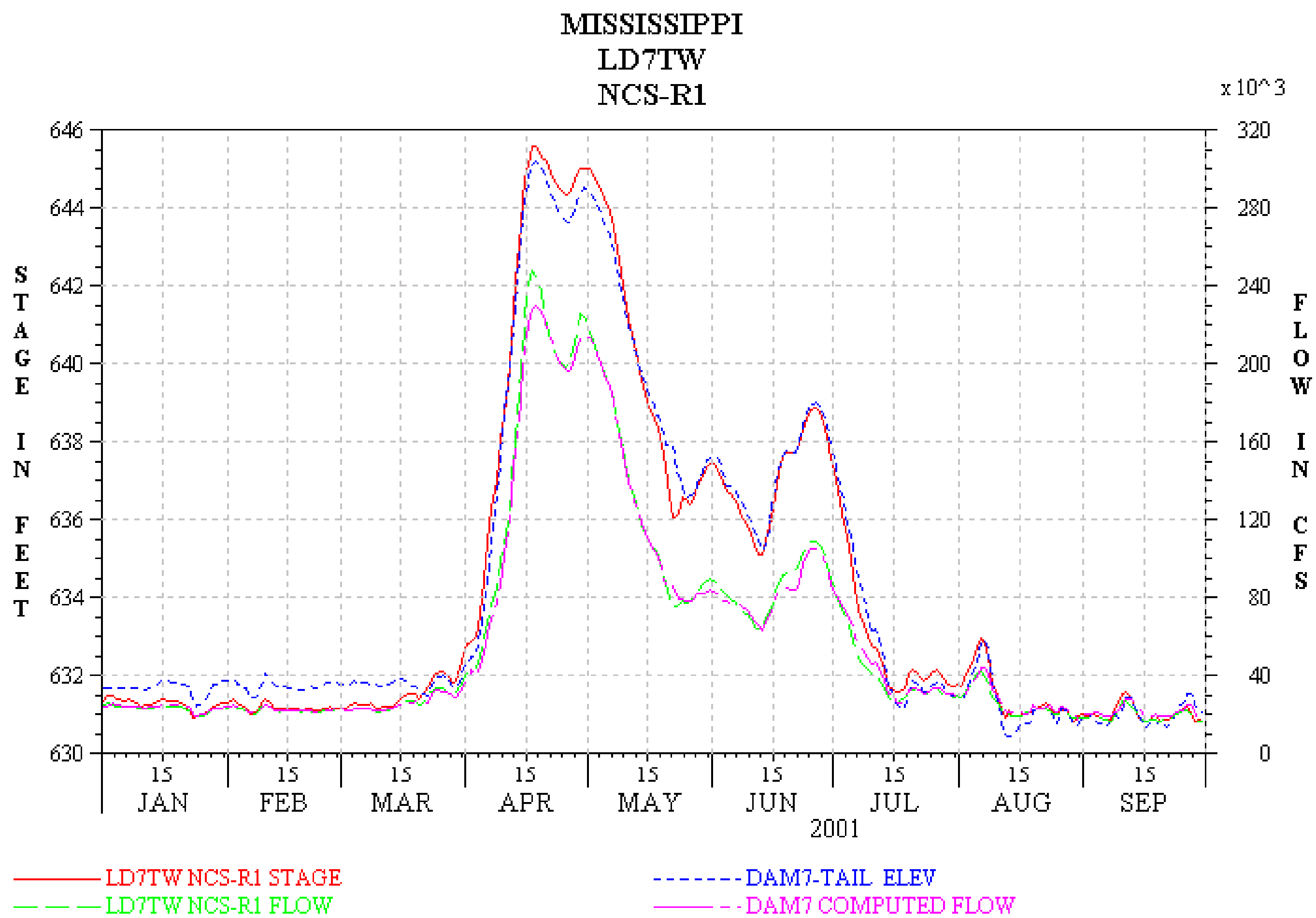

MISSISSIPPI
LD6TW
NCS-R1
x 10^3
652
650
648
646
644
642
640
638
STAGE IN FEET
280
240
200
160
120
80
40
0
FLOW IN CFS
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
2001
LD6TW NCS-R1 STAGE
LD6TW NCS-R1 FLOW
DAM6-TAIL ELEV
DAM6 COMPUTED FLOW


MISSISSIPPI
LD7TW
NCS-R1
x 10^ 3
STAGE IN FEET
FLOW IN CFS
648
646
644
642
640
638
636
634
632
630
360
320
280
240
200
160
120
80
40
0
15 JAN
15 FEB
15 MAR
15 APR
15 MAY
15 JUN
15 JUL
15 AUG
15 SEP
1965
LD7TW NCS-R1 STAGE
LD7TW NCS-R1 FLOW
DAM7-TAIL ELEV
DAM7 COMPUTED FLOW


MISSISSIPPI
LD7TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
646
644
642
640
638
636
634
632
630
320
280
240
200
160
120
80
40
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1969
LD7TW NCS-R1 STAGE
LD7TW NCS-R1 FLOW
DAM7-TAIL ELEV
DAM7 COMPUTED FLOW



MISSISSIPPI
LD7TW
NCS-R1
STAGE IN FEET
FLOW IN CFS
x 10^3
644
642
640
638
636
634
632
630
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1993
LD7TW NCS-R1 STAGE
LD7TW NCS-R1 FLOW
DAM7-TAIL ELEV
DAM7 COMPUTED FLOW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LD7TW
NCS-R1
x 10^3
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642
640
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636
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630
320
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200
160
120
80
40
0
STAGE IN FEET
FLOW IN CFS
15
JAN
FEB
MAR
APR
MAY
JUN
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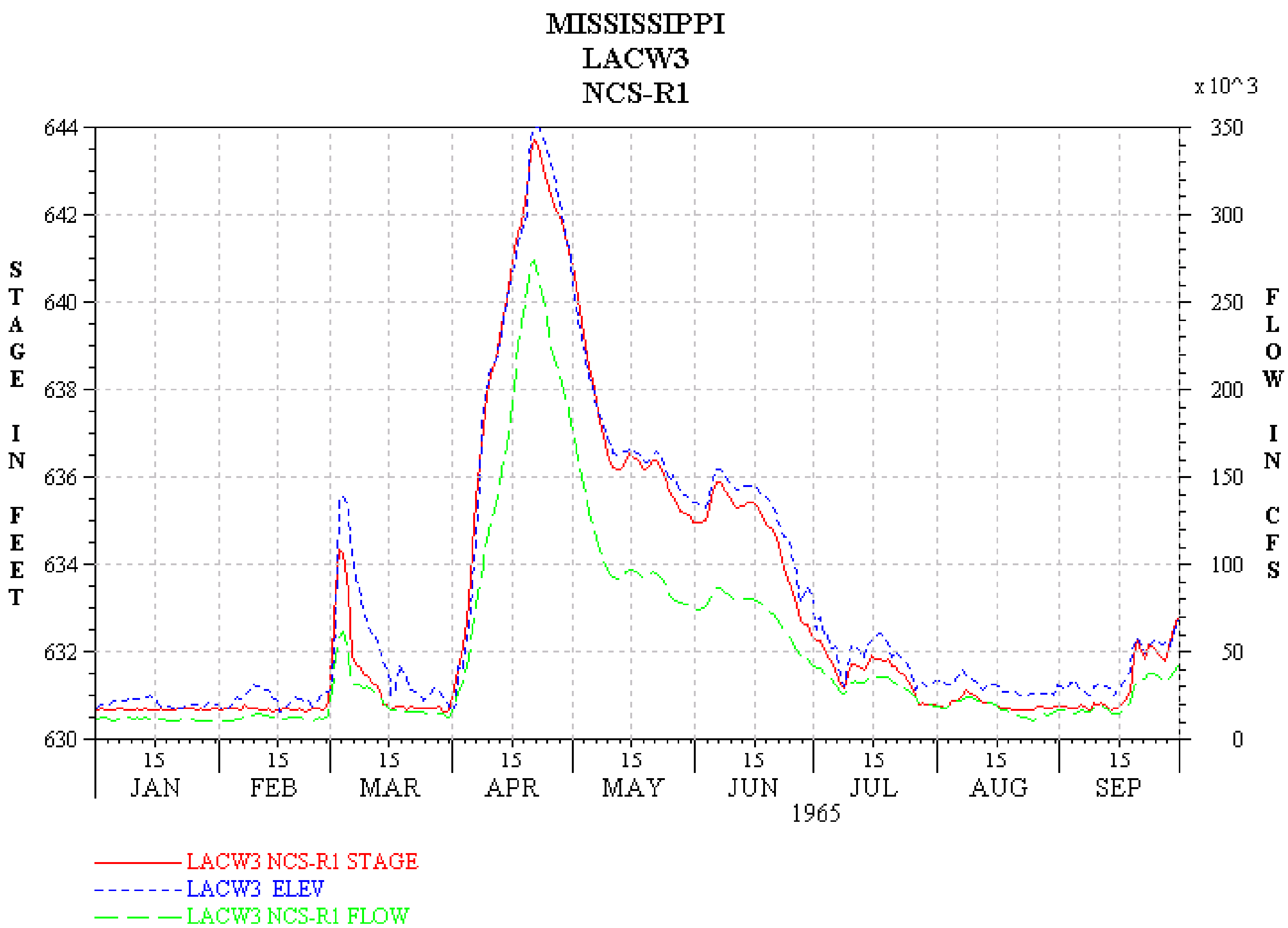
AUG
SEP
2001
LD7TW NCS-R1 STAGE
LD7TW NCS-R1 FLOW
DAM7-TAIL ELEV
DAM7 COMPUTED FLOW



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LACW3
NCS-R1
x 10^ 3
STAGE IN FEET
FLOW IN CFS
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642
640
638
636
634
632
630
350
300
250
200
150
100
50
0
15
JAN
FEB
MAR
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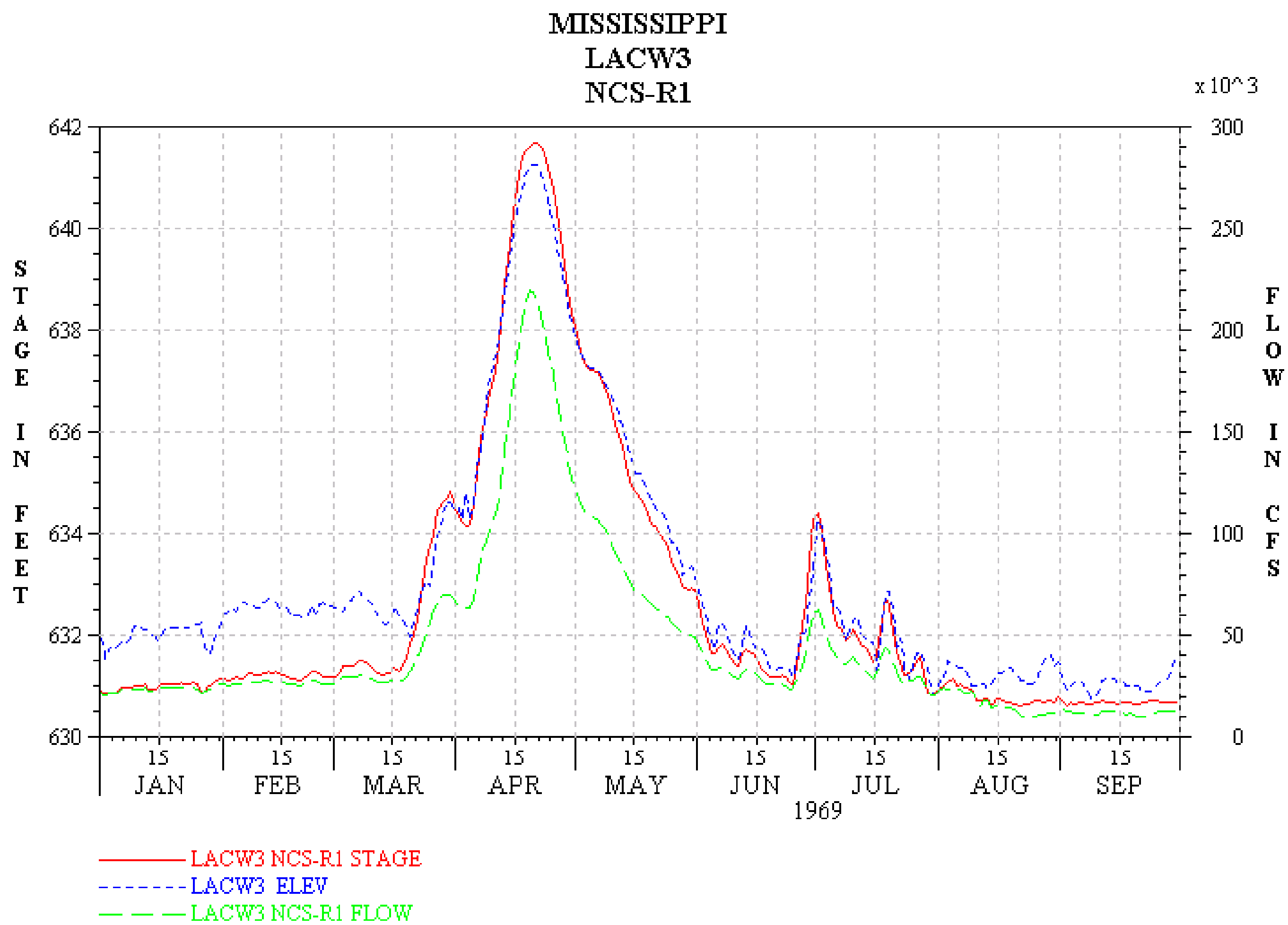
JUL
AUG
SEP
1965
LACW3 NCS-R1 STAGE
LACW3 ELEV
LACW3 NCS-R1 FLOW



MISSISSIPPI
LACW3
NCS-R1
x 10^ 3
STAGE IN FEET
FLOW IN CFS
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638
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632
630
300
250
200
150
100
50
0
15
JAN
FEB
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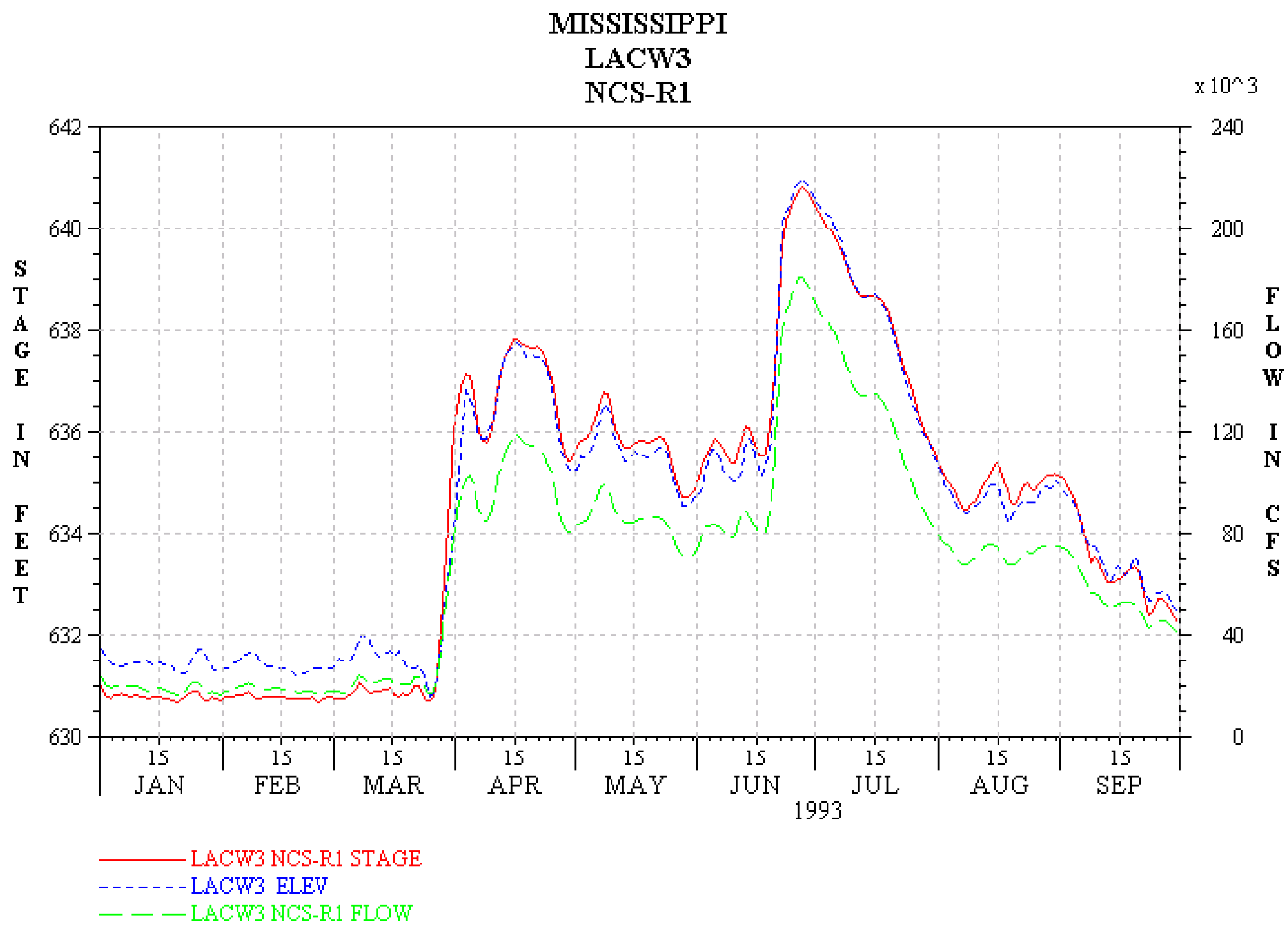
APR
MAY
JUN
JUL
AUG
SEP
1969
LACW3 NCS-R1 STAGE
LACW3 ELEV
LACW3 NCS-R1 FLOW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NCS-R1
x 10^3
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640
638
636
634
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STAGE IN FEET
FLOW IN CFS
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JAN
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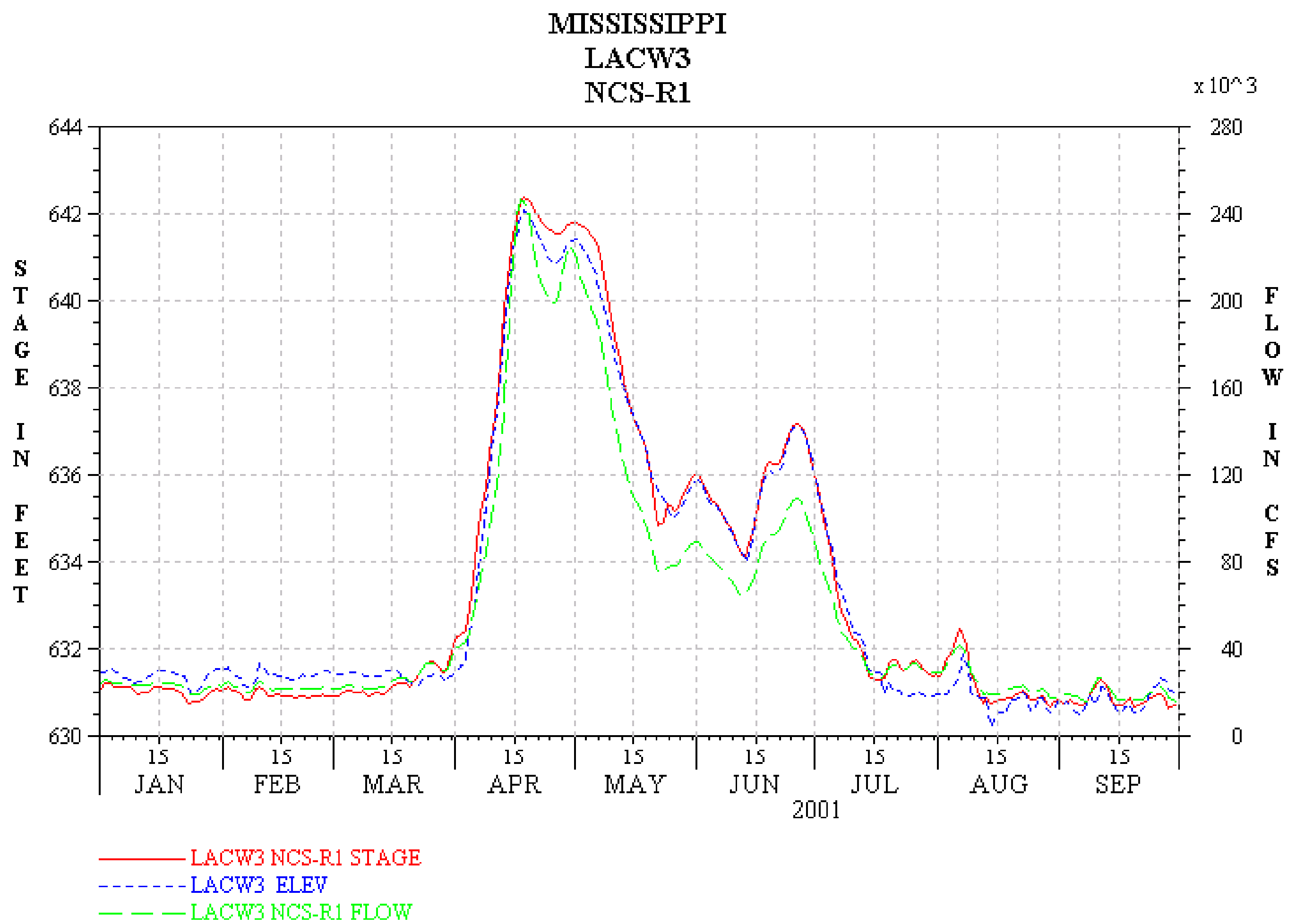
SEP
1993
LACW3 NCS-R1 STAGE
LACW3 ELEV
LACW3 NCS-R1 FLOW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x 10^3
STAGE IN FEET
FLOW IN CFS
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632
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280
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200
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JAN
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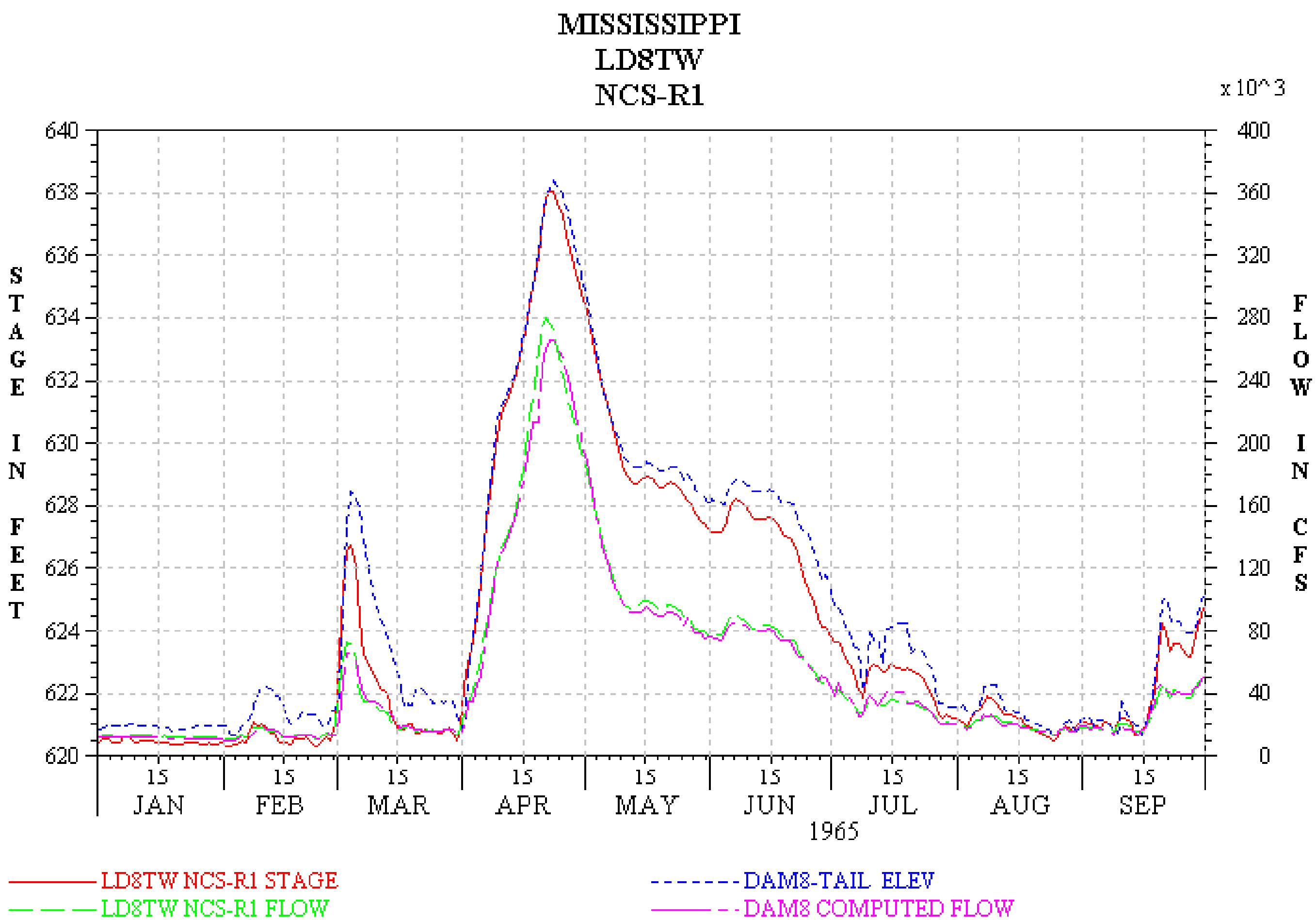
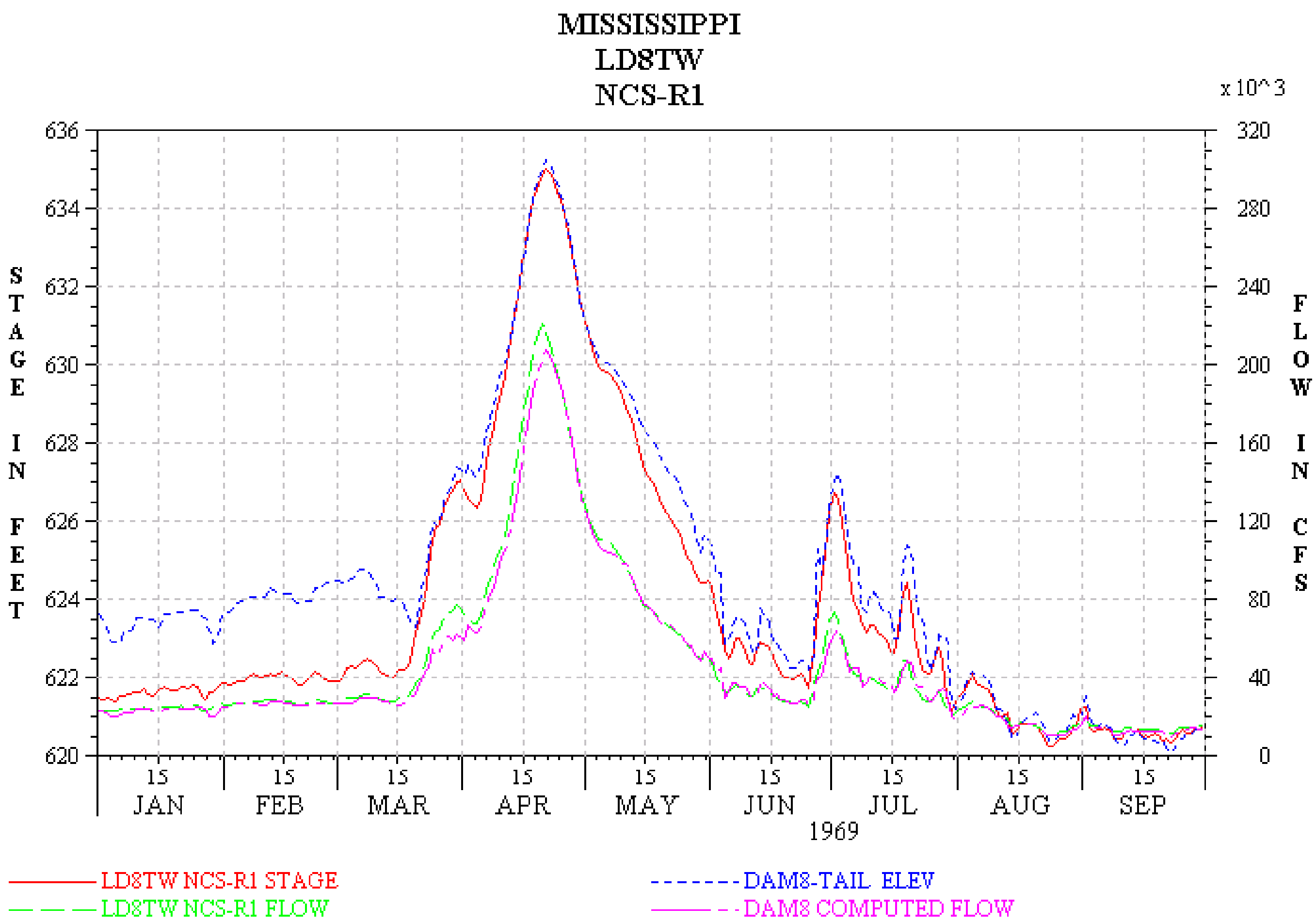
MAY
JUN
JUL
AUG
SEP
2001
LACW3 NCS-R1 STAGE
LACW3 ELEV
LACW3 NCS-R1 FLOW



MISSISSIPPI
LD8TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
640
638
636
634
632
630
628
626
624
622
620
400
360
320
280
240
200
160
120
80
40
0
15 15 15 15 15 15 15 15 15
JAN FEB MAR APR MAY JUN JUL AUG SEP
1965
LD8TW NCS-R1 STAGE
LD8TW NCS-R1 FLOW
DAM8-TAIL ELEV
DAM8 COMPUTED FLOW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LD8TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
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628
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624
622
620
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280
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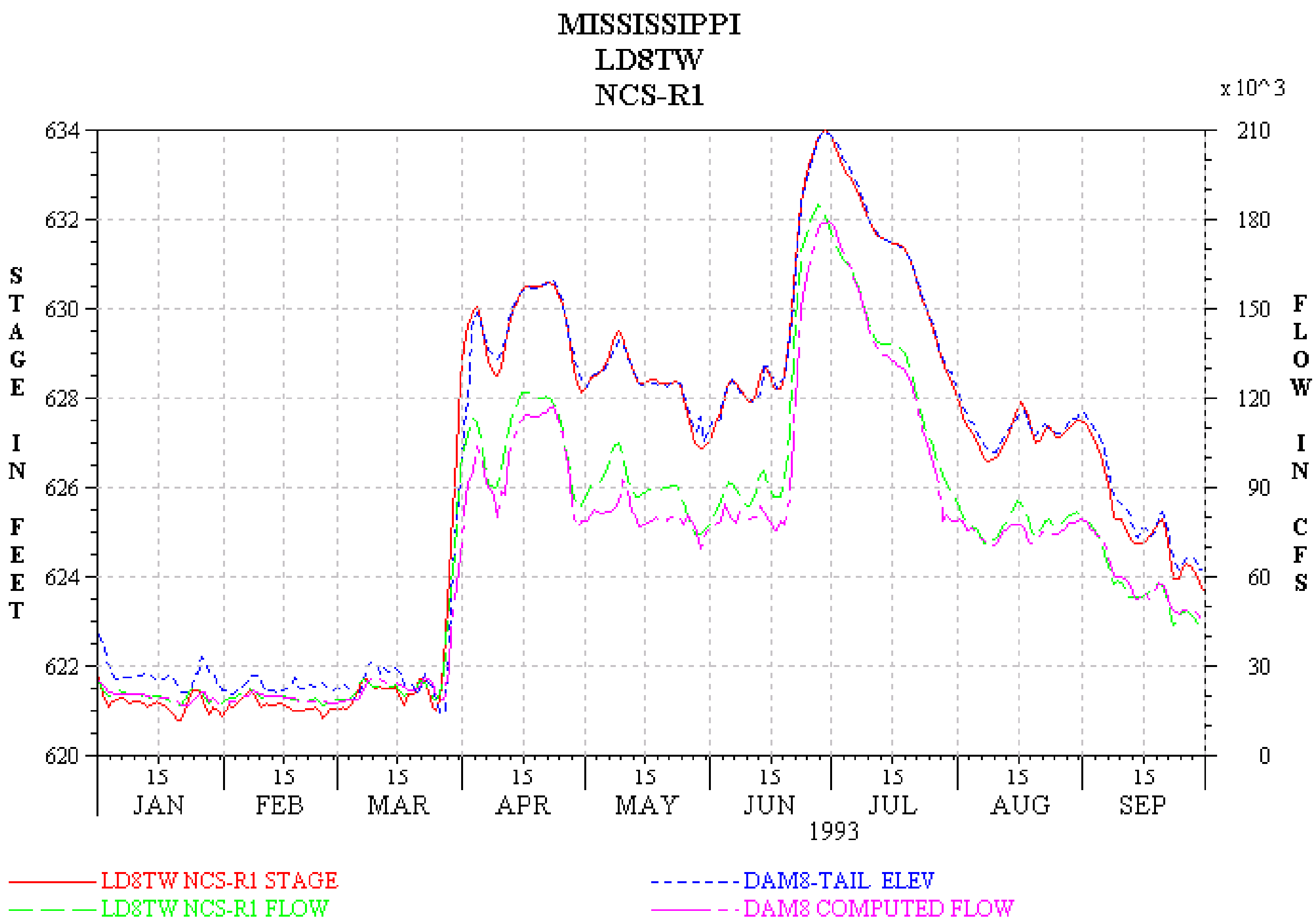
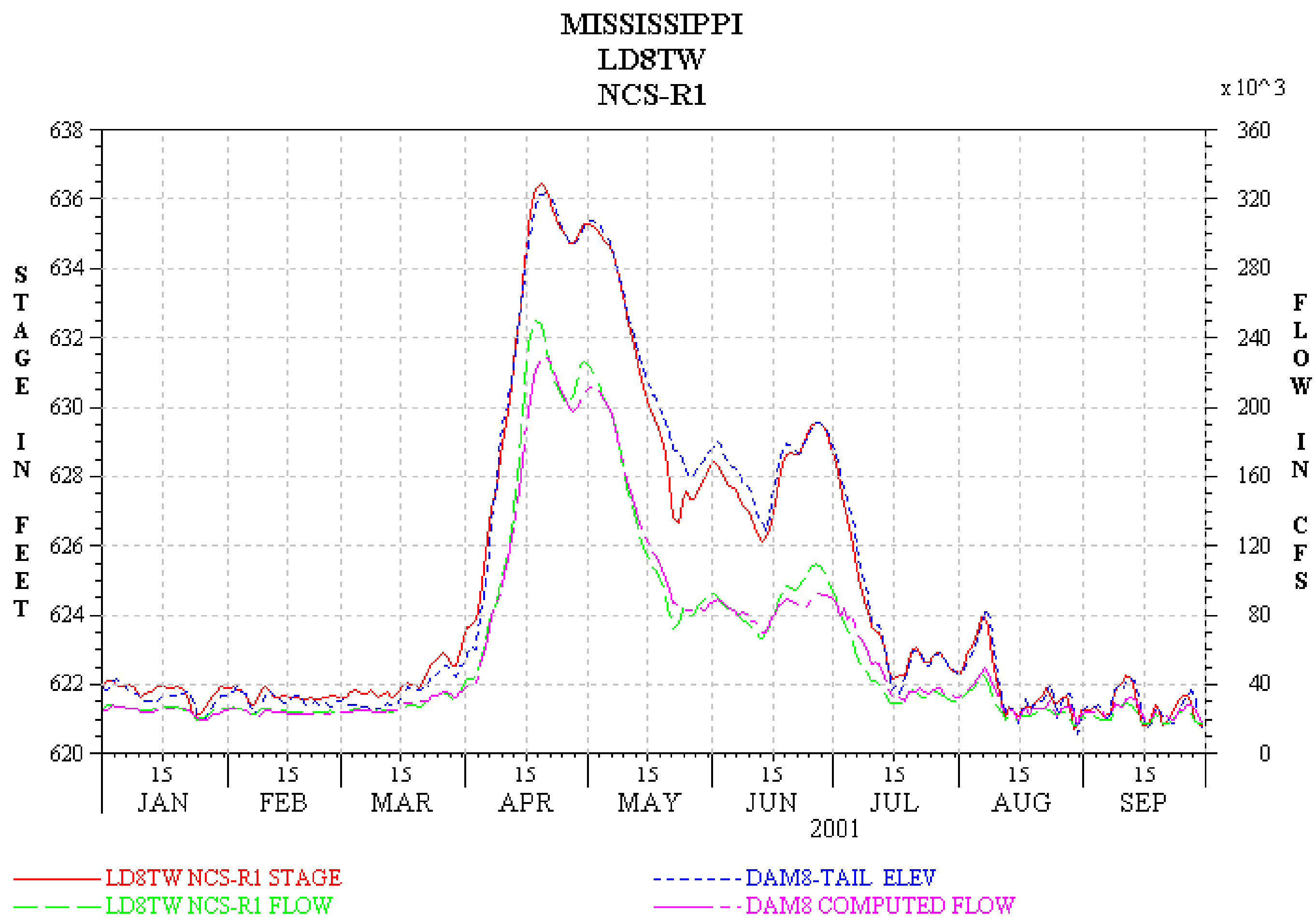
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1969
LD8TW NCS-R1 STAGE
LD8TW NCS-R1 FLOW
DAM8-TAIL ELEV
DAM8 COMPUTED FLOW



MISSISSIPPI
LD8TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
634
632
630
628
626
624
622
620
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1993
LD8TW NCS-R1 STAGE
LD8TW NCS-R1 FLOW
DAM8-TAIL ELEV
DAM8 COMPUTED FLOW



MISSISSIPPI
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NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
638
636
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632
630
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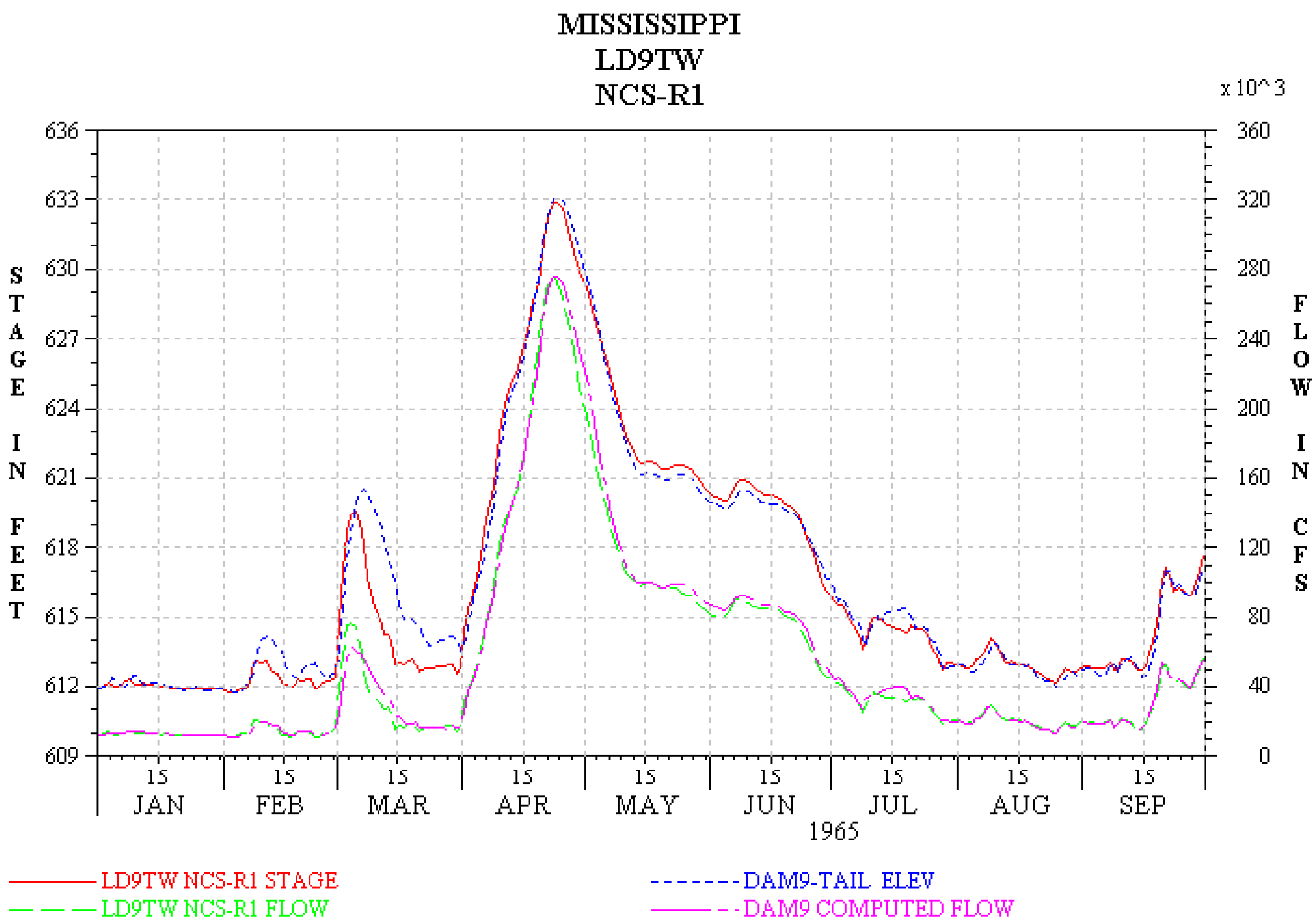
626
624
622
620
360
320
280
240
200
160
120
80
40
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
2001
LD8TW NCS-R1 STAGE
LD8TW NCS-R1 FLOW
DAM8-TAIL ELEV
DAM8 COMPUTED FLOW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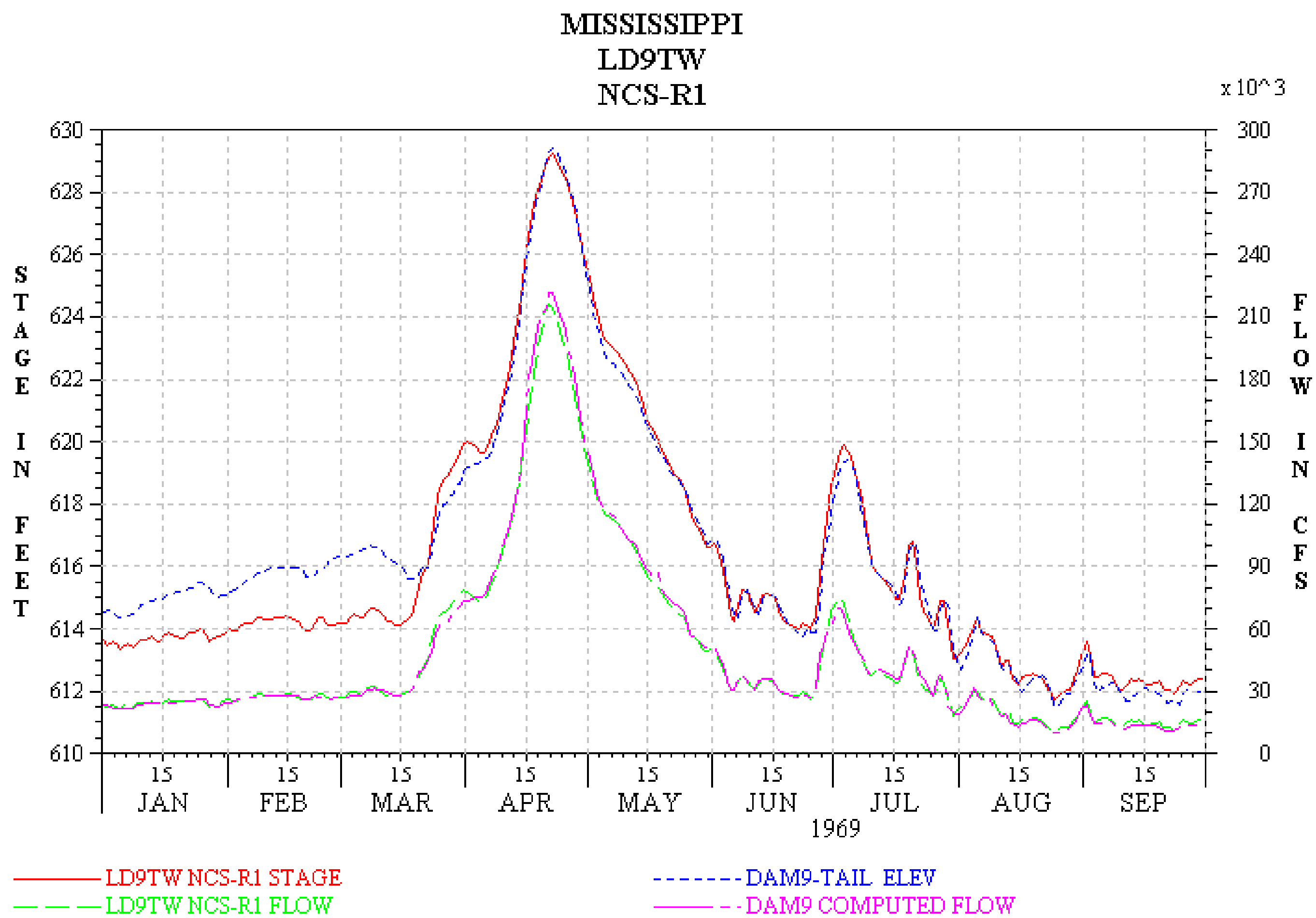
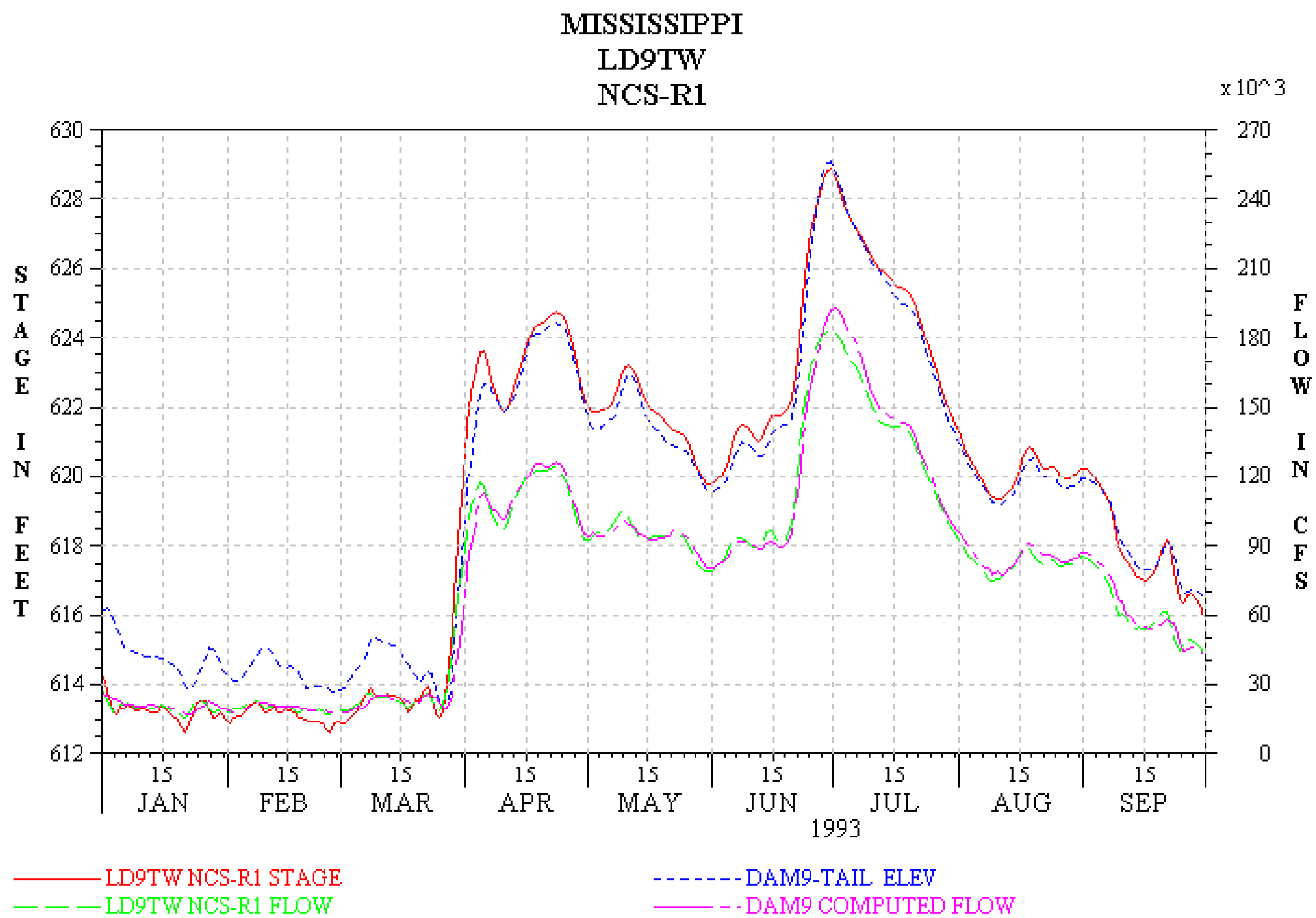
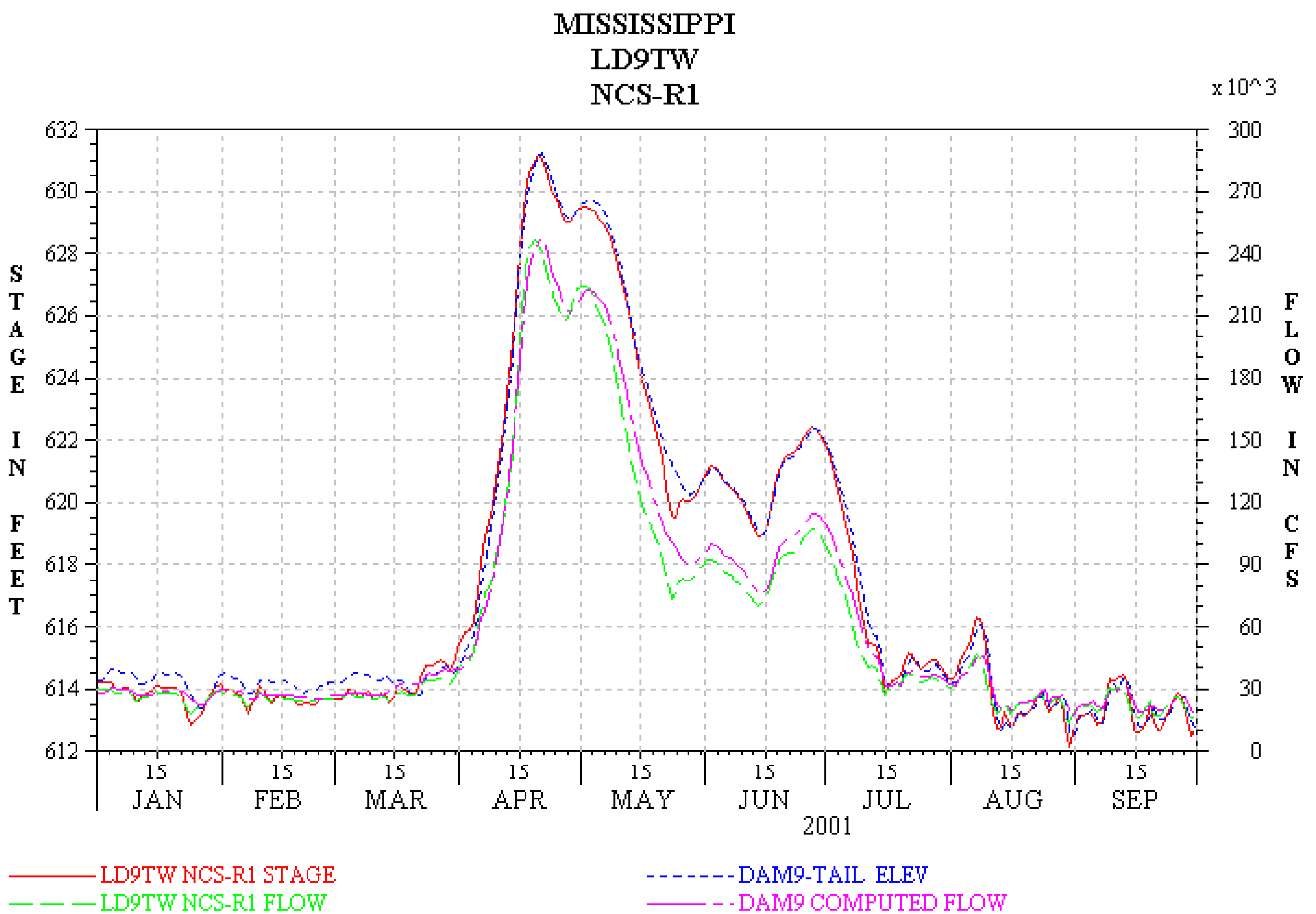
LD9TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
636
633
630
627
624
621
618
615
612
609
360
320
280
240
200
160
120
80
40
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1965
LD9TW NCS-R1 STAGE
LD9TW NCS-R1 FLOW
DAM9-TAIL ELEV
DAM9 COMPUTED FLOW



MISSISSIPPI
LD9TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
630
628
626
624
622
620
618
616
614
612
610
300
270
240
210
180
150
120
90
60
30
0
15 JAN
15 FEB
15 MAR
15 APR
15 MAY
15 JUN
15 JUL
15 AUG
15 SEP
1969
LD9TW NCS-R1 STAGE
LD9TW NCS-R1 FLOW
DAM9-TAIL ELEV
DAM9 COMPUTED FLOW



MISSISSIPPI
LD9TW
NCS-R1
STAGE IN FEET
FLOW IN CFS
x 10^ 3
630
628
626
624
622
620
618
616
614
612
270
240
210
180
150
120
90
60
30
0
15 15 15 15 15 15 15 15 15
JAN FEB MAR APR MAY JUN JUL AUG SEP
1993
LD9TW NCS-R1 STAGE
LD9TW NCS-R1 FLOW
DAM9-TAIL ELEV
DAM9 COMPUTED FLOW



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NCS-R1
x 10^ 3
STAGE IN FEET
FLOW IN CFS
632
630
628
626
624
622
620
618
616
614
612
300
270
240
210
180
150
120
90
60
30
0
15 JAN
15 FEB
15 MAR
15 APR
15 MAY
15 JUN
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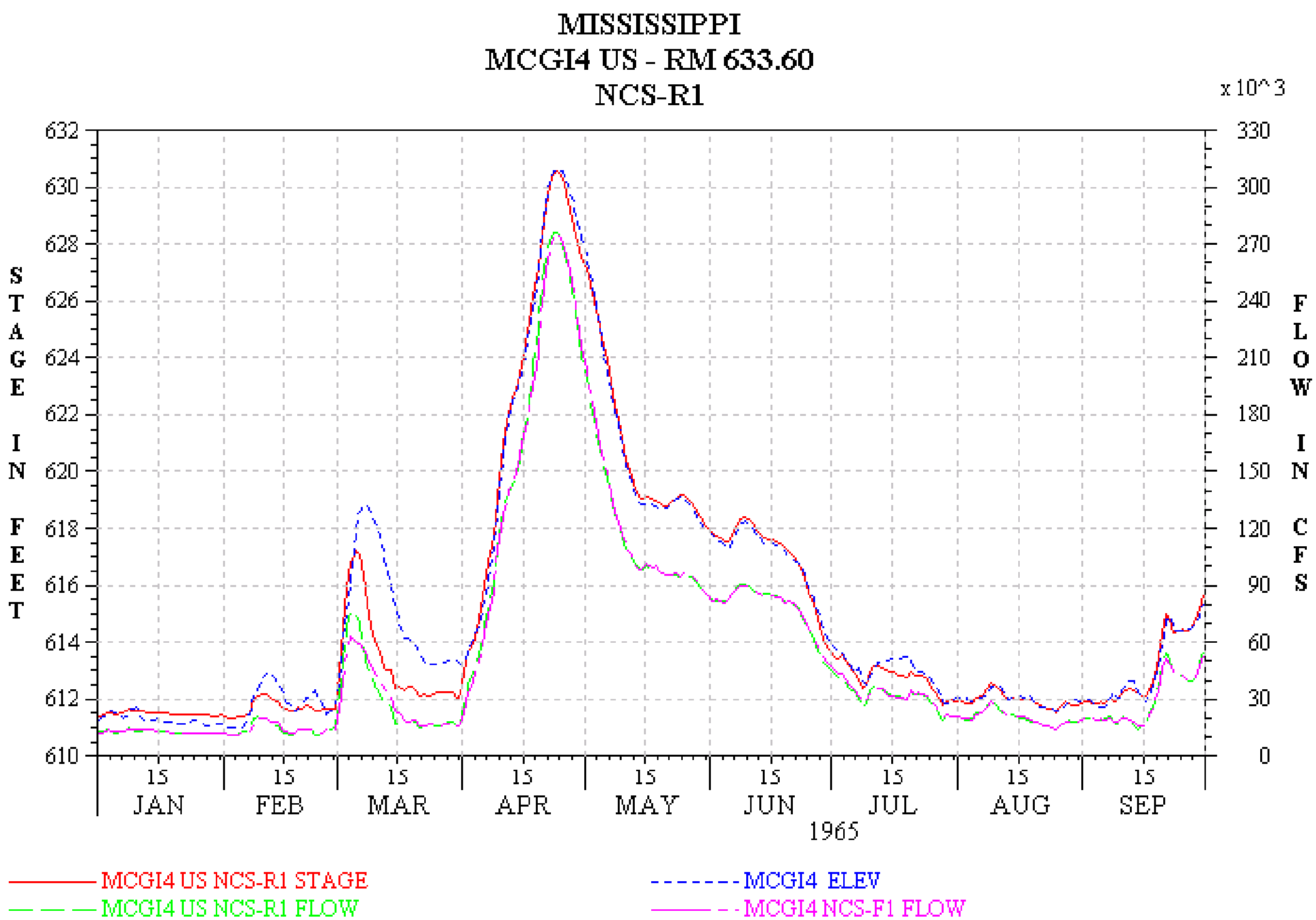
15 AUG
15 SEP
2001
LD9TW NCS-R1 STAGE
LD9TW NCS-R1 FLOW
DAM9-TAIL ELEV
DAM9 COMPUTED FLOW



MISSISSIPPI
MCGI4 US - RM 633.60
NCS-R1
STAGE IN FEET
FLOW IN CFS
x 10^3
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622
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618
616
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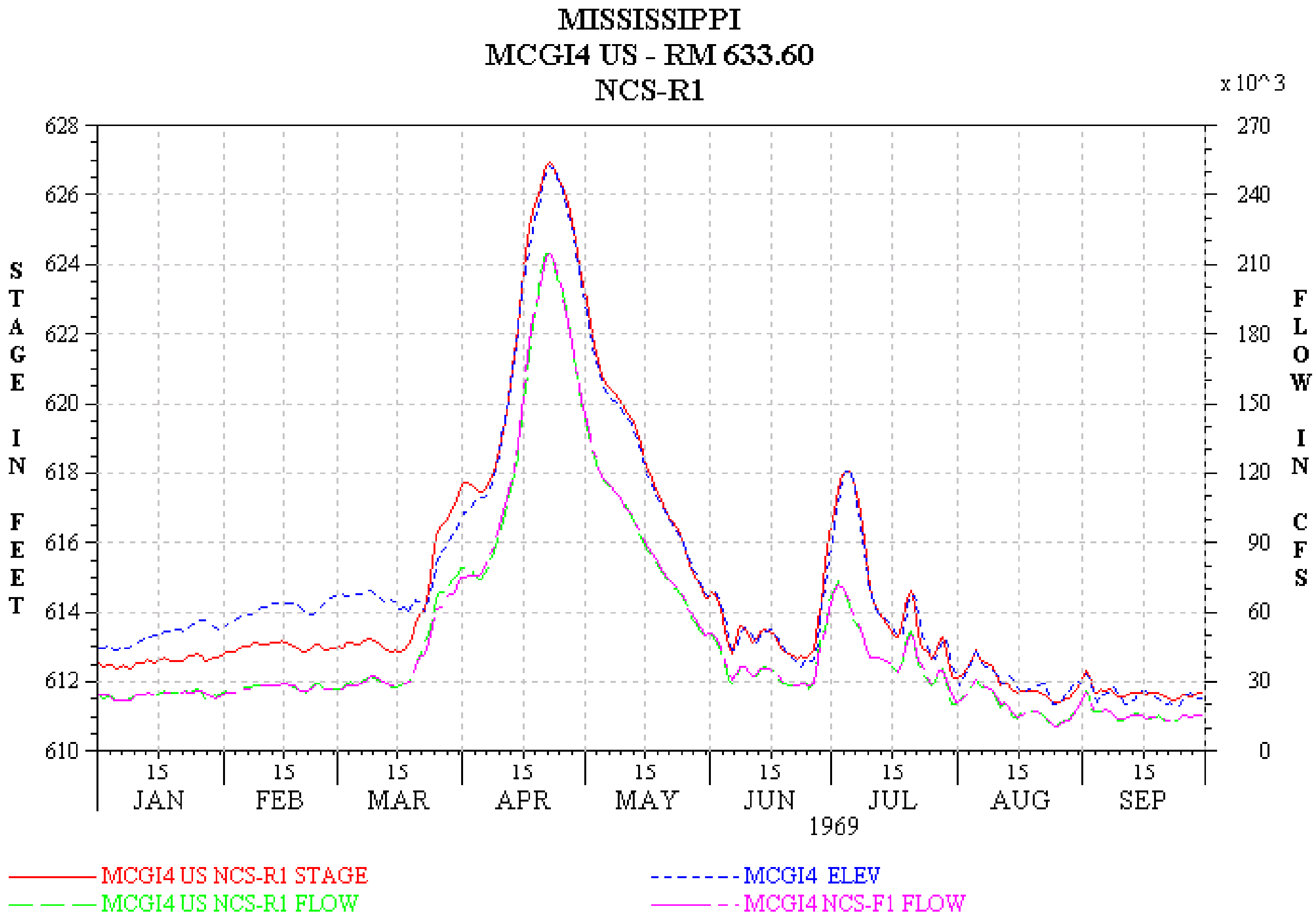
612
610
330
300
270
240
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1965
MCGI4 US NCS-R1 STAGE
MCGI4 US NCS-R1 FLOW
MCGI4 ELEV
MCGI4 NCS-F1 FLOW



MISSISSIPPI
MCGI4 US - RM 633.60
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
628
626
624
622
620
618
616
614
612
610
270
240
210
180
150
120
90
60
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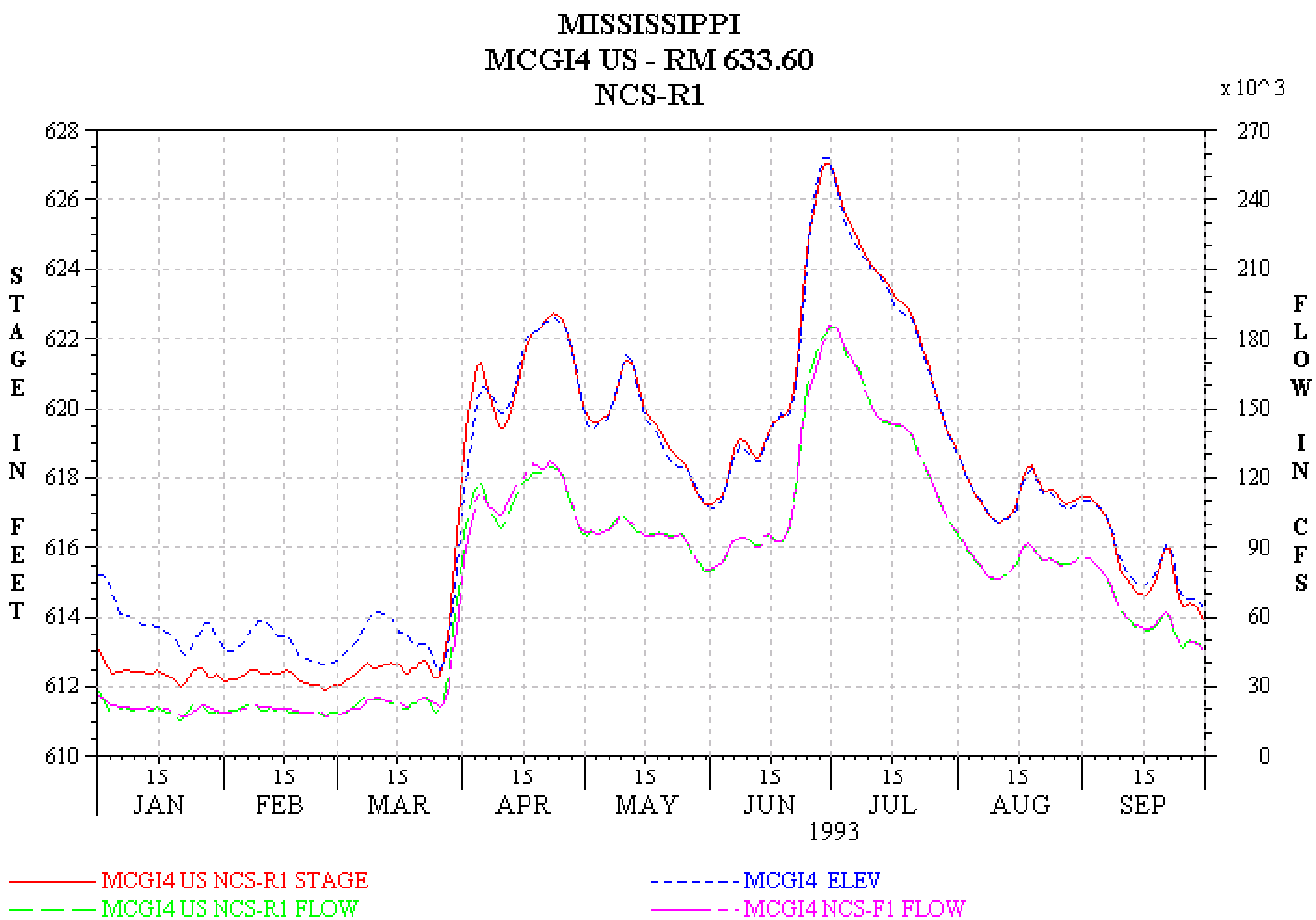
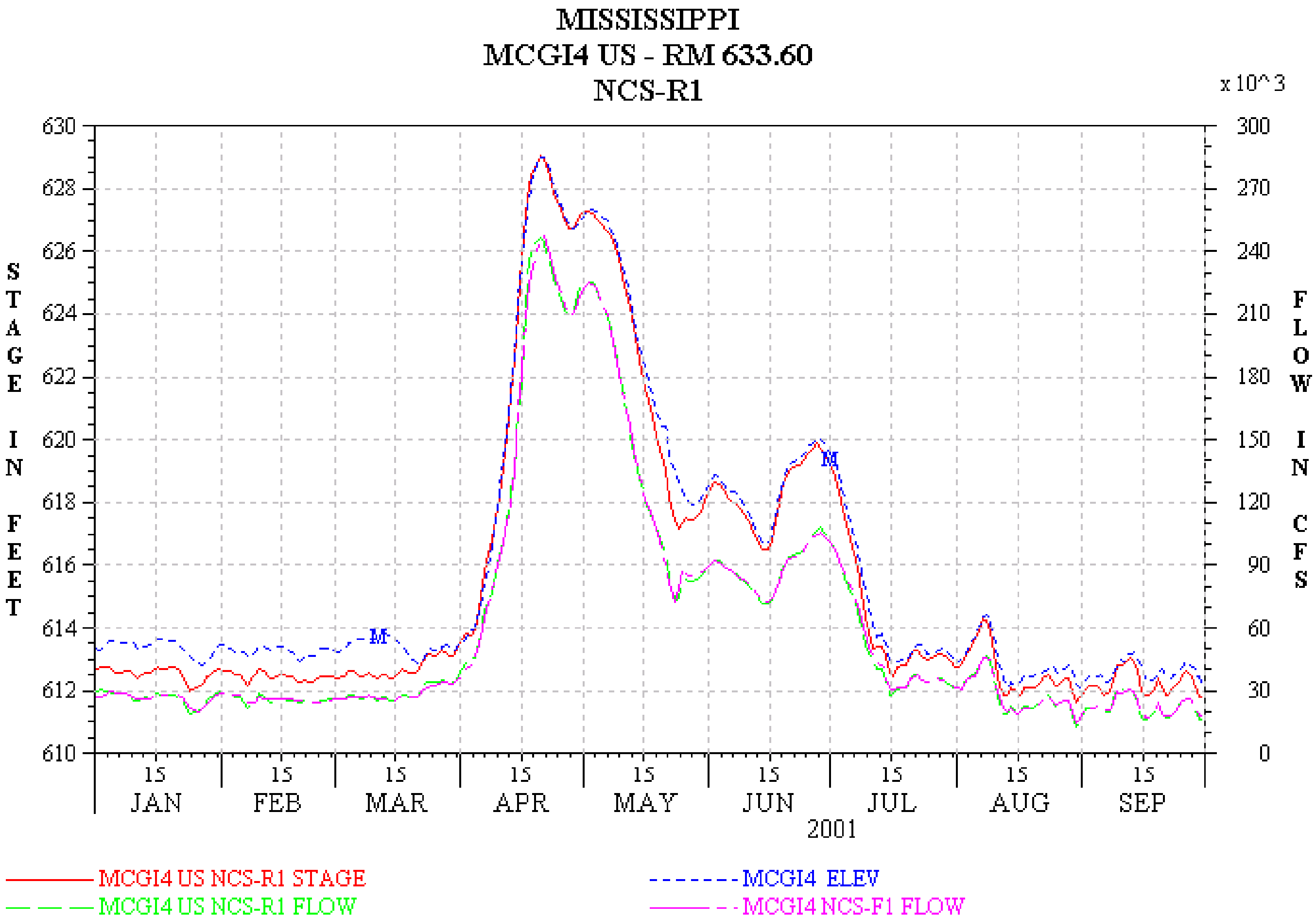
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1969
MCGI4 US NCS-R1 STAGE
MCGI4 US NCS-R1 FLOW
MCGI4 ELEV
MCGI4 NCS-F1 FLOW



MISSISSIPPI
MCGI4 US - RM 633.60
NCS-R1
x 10^ 3
STAGE IN FEET
FLOW IN CFS
628
626
624
622
620
618
616
614
612
610
270
240
210
180
150
120
90
60
30
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1993
MCGI4 US NCS-R1 STAGE
MCGI4 US NCS-R1 FLOW
MCGI4 ELEV
MCGI4 NCS-F1 FLOW


MISSISSIPPI
MCGI4 US - RM 633.60
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
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618
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614
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610
300
270
240
210
180
150
120
90
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15 FEB
15 MAR
15 APR
15 MAY
15 JUN
15 JUL
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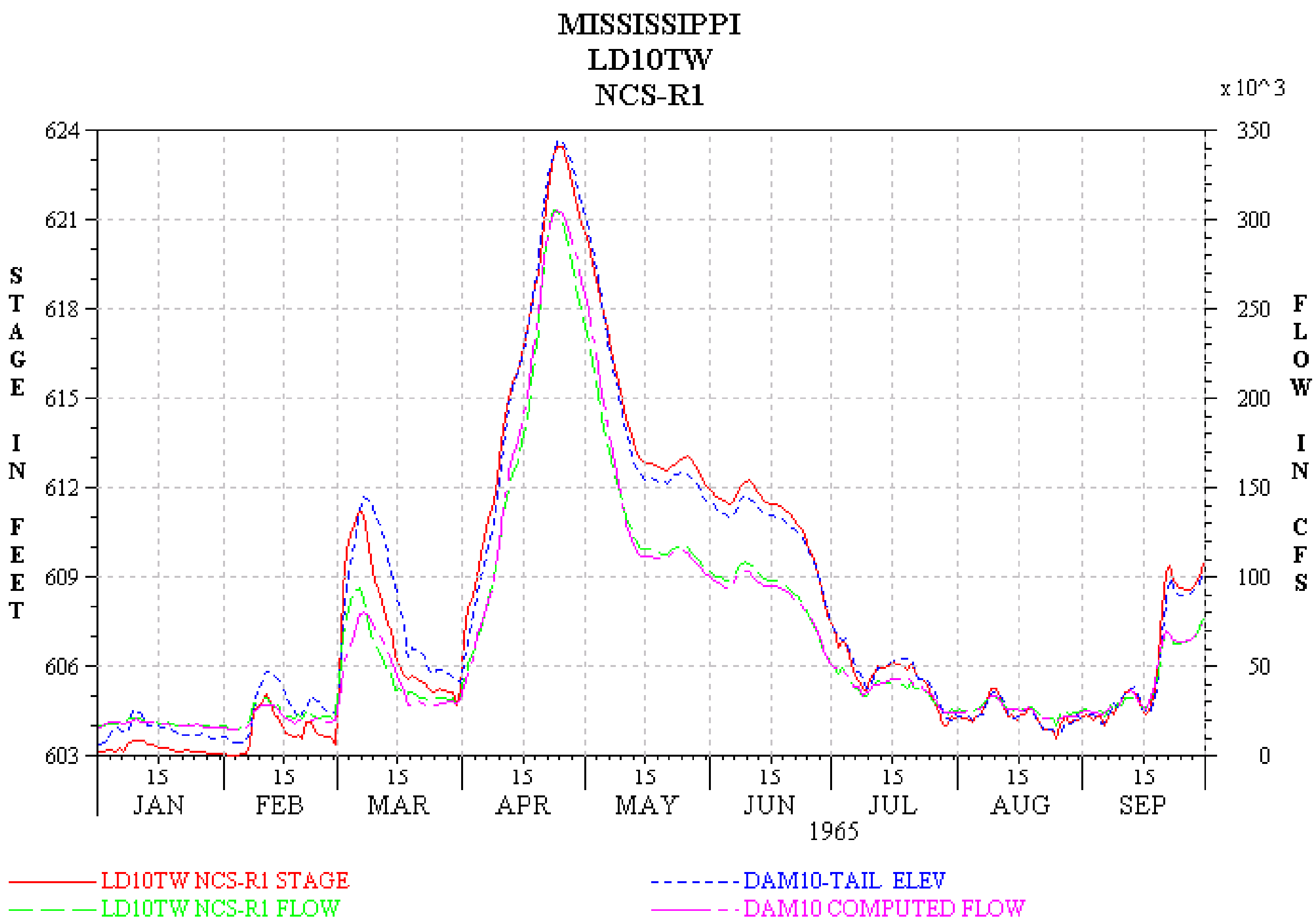
15 SEP
2001
MCGI4 US NCS-R1 STAGE
MCGI4 US NCS-R1 FLOW
MCGI4 ELEV
MCGI4 NCS-F1 FLOW



MISSISSIPPI
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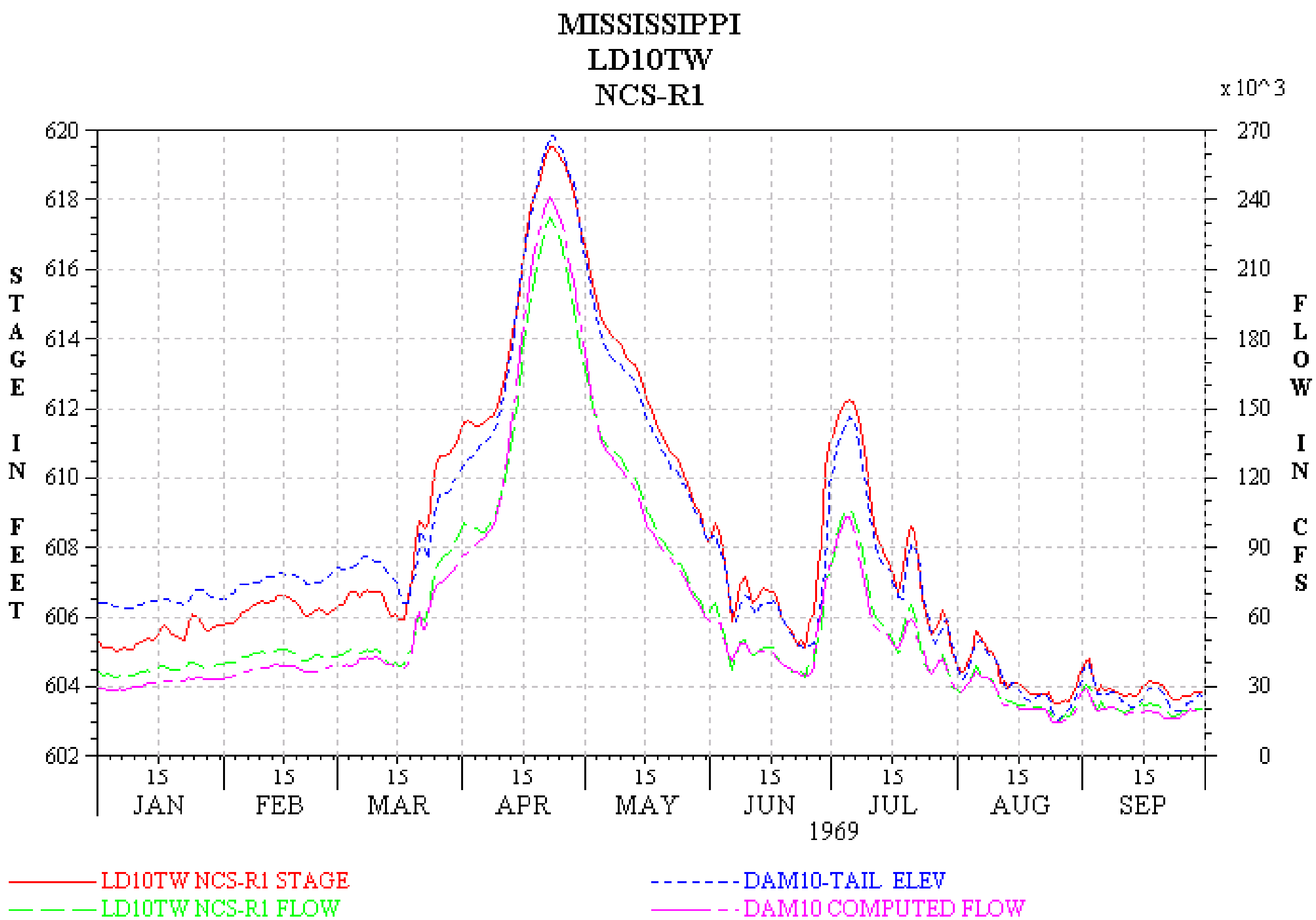
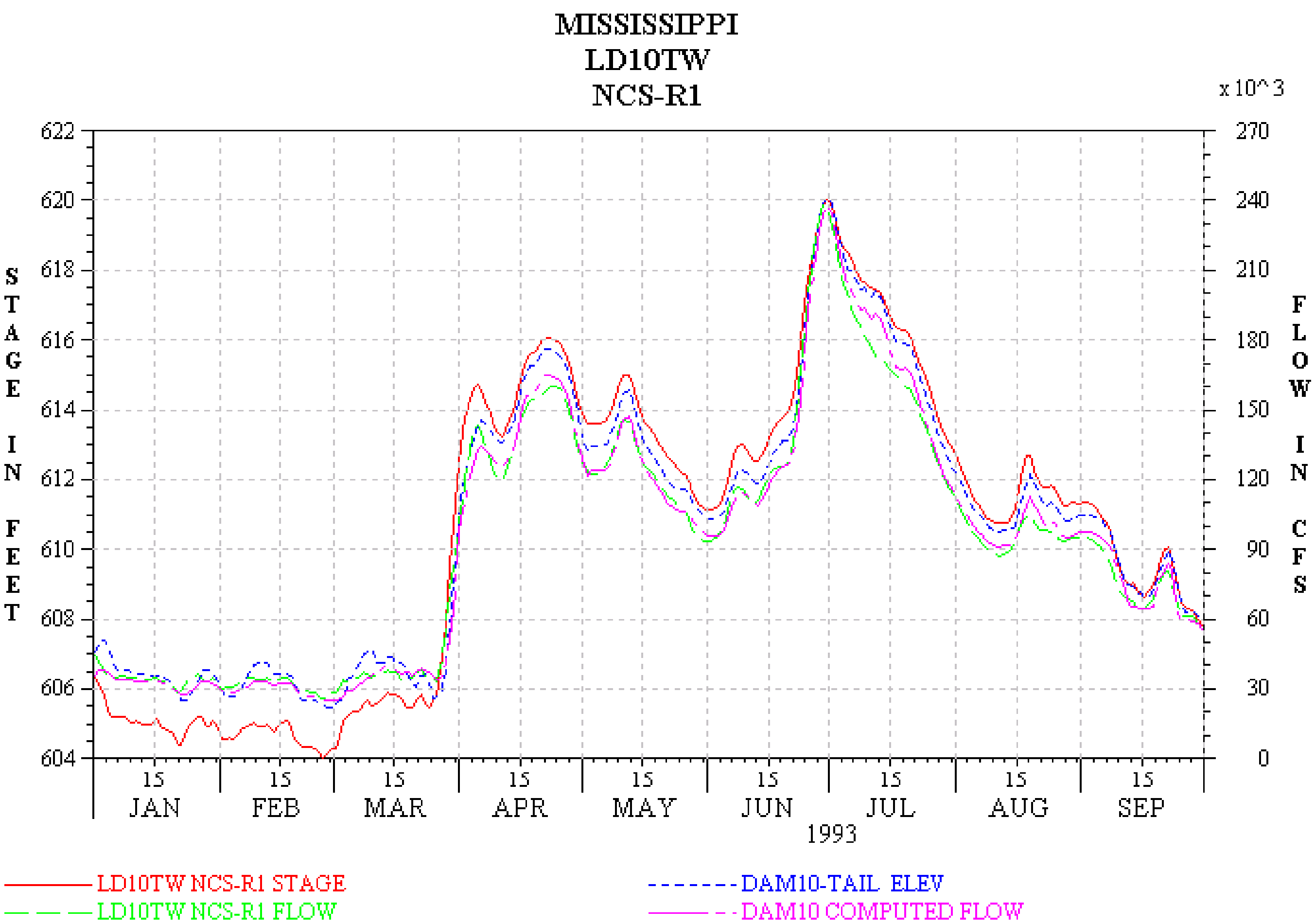
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
624
621
618
615
612
609
606
603
350
300
250
200
150
100
50
0
15
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
1965
LD10TW NCS-R1 STAGE
LD10TW NCS-R1 FLOW
DAM10-TAIL ELEV
DAM10 COMPUTED FLOW



MISSISSIPPI
LD10TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
620
618
616
614
612
610
608
606
604
602
270
240
210
180
150
120
90
60
30
0
15 JAN
15 FEB
15 MAR
15 APR
15 MAY
15 JUN
15 JUL
15 AUG
15 SEP
1969
LD10TW NCS-R1 STAGE
LD10TW NCS-R1 FLOW
DAM10-TAIL ELEV
DAM10 COMPUTED FLOW


MISSISSIPPI
LD10TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
622
620
618
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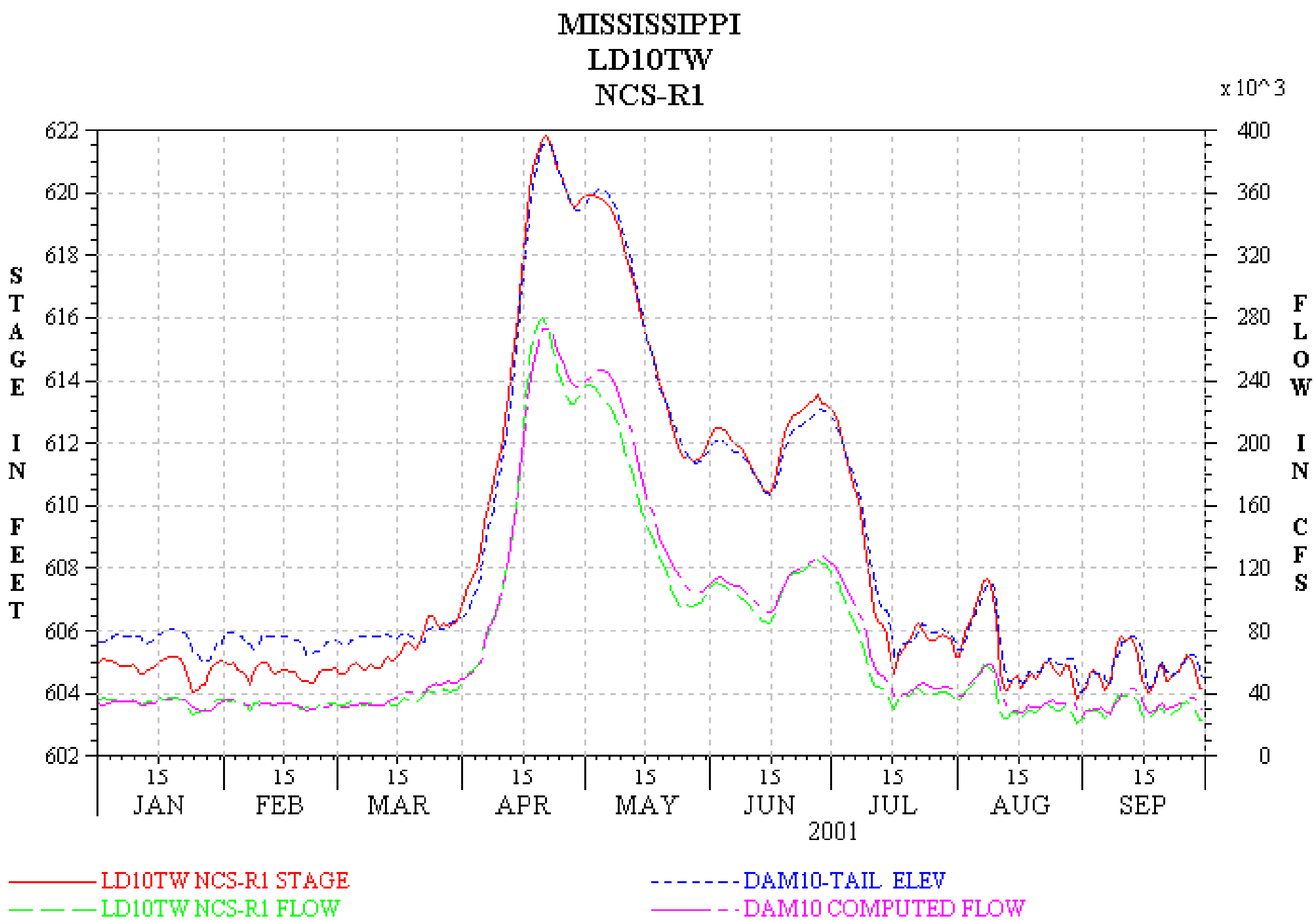
614
612
610
608
606
604
270
240
210
180
150
120
90
60
30
0
JAN FEB MAR APR MAY JUN JUL AUG SEP
1993
LD10TW NCS-R1 STAGE
LD10TW NCS-R1 FLOW
DAM10-TAIL ELEV
DAM10 COMPUTED FLOW



MISSISSIPPI
LD10TW
NCS-R1
x 10^3
STAGE IN FEET
FLOW IN CFS
622
620
618
616
614
612
610
608
606
604
602
400
360
320
280
240
200
160
120
80
40
0
15 JAN
15 FEB
15 MAR
15 APR
15 MAY
15 JUN
15 JUL
15 AUG
15 SEP
2001
LD10TW NCS-R1 STAGE
LD10TW NCS-R1 FLOW
DAM10-TAIL ELEV
DAM10 COMPUTED FLOW

Upper Mississippi River
Flow Frequency Study

Attachment B6
St. Paul District
UNET RESULTS
Mississippi River Computed Elevations – Datum 1929

2003 FLOW FREQUENCY STUDY
FLOOD PROFILES NGVD 1929

Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		1979 Study	100 year Profile 2003 Study minus 1979 Study
Prescott Gage - St. Croix	**811.4**	680.7	684.3	686	688.1	689.6	**691.1**	692.6	694.5		**691.1**	**0**
	811.06	680.6	684.2	685.9	687.9	689.4	**690.9**	692.4	694.2		**690.8**	**0.1**
	810.68	680.4	684	685.7	687.7	689.2	**690.7**	692.1	693.9		**690.5**	**0.2**
	810.28	680.2	683.7	685.4	687.3	688.8	**690.2**	691.6	693.4		**690.3**	**-0.1**
	810.06	680	683.5	685.2	687.1	688.5	**690**	691.3	693.1		**690.1**	**-0.1**
	809.79	679.9	683.3	684.9	686.8	688.3	**689.7**	691	692.7		**689.9**	**-0.2**
	809.68	679.8	683.2	684.8	686.7	688.1	**689.5**	690.8	692.5		**689.8**	**-0.3**
	809.33	679.6	683.1	684.6	686.5	687.9	**689.2**	690.5	692.2		**689.7**	**-0.5**
	808.79	679.4	682.8	684.4	686.2	687.6	**689**	690.2	691.9		**689.5**	**-0.5**
	808.33	679.2	682.6	684.1	686	687.3	**688.7**	690	691.7		**689.3**	**-0.6**
	807.69	678.9	682.2	683.8	685.7	687	**688.4**	689.7	691.4		**689**	**-0.6**
	807	678.6	682	683.5	685.4	686.8	**688.2**	689.5	691.2		**688.7**	**-0.5**
	806.46	678.4	681.8	683.3	685.2	686.7	**688**	689.3	691		**688.4**	**-0.4**
	806	678.3	681.7	683.2	685.1	686.6	**688**	689.3	690.9		**688.2**	**-0.2**
	805.75	678.2	681.6	683.2	685.1	686.5	**687.9**	689.2	690.9		**688.2**	**-0.3**
	805.45	678.1	681.5	683.1	685	686.4	**687.8**	689.2	690.8		**688.1**	**-0.3**
	805	678.1	681.5	683	684.9	686.4	**687.8**	689.1	690.8		**688**	**-0.2**
Big River	**804.8**	678	681.4	683	684.9	686.3	**687.7**	689	690.7		**687.9**	**-0.2**
	804.55	677.8	681.3	682.9	684.8	686.2	**687.6**	689	690.6		**687.9**	**-0.3**
	804.08	677.7	681.2	682.8	684.7	686.1	**687.5**	688.9	690.5		**687.7**	**-0.2**
	803.55	677.6	681.2	682.7	684.6	686	**687.5**	688.8	690.4		**687.6**	**-0.1**
	802.91	677.5	681	682.6	684.5	685.9	**687.3**	688.6	690.3		**687.4**	**-0.1**
	802.46	677.3	680.9	682.5	684.4	685.8	**687.2**	688.6	690.2		**687.3**	**-0.1**
	802.01	677.1	680.8	682.3	684.2	685.7	**687.1**	688.4	690.1		**687.2**	**-0.1**
	801.51	676.9	680.6	682.2	684.1	685.5	**687**	688.3	690		**687.1**	**-0.1**
	800.97	676.7	680.5	682.1	684	685.4	**686.8**	688.2	689.9		**687**	**-0.2**
	800.42	676.5	680.4	682	683.9	685.3	**686.7**	688.1	689.8		**687**	**-0.3**
Diamond Bluff	**799.97**	676.5	680.3	681.9	683.8	685.2	**686.7**	688	689.7		**686.9**	**-0.2**
	799.5	676.4	680.3	681.8	683.7	685.2	**686.6**	687.9	689.7		**686.9**	**-0.3**
	798.98	676.3	680.2	681.8	683.7	685.1	**686.6**	687.9	689.6		**686.8**	**-0.2**
	798.41	676.2	680.2	681.7	683.6	685.1	**686.5**	687.8	689.5		**686.7**	**-0.2**
	798	676.1	680.1	681.6	683.5	685	**686.4**	687.7	689.4		**686.7**	**-0.3**
	797.55	676	680	681.5	683.4	684.8	**686.3**	687.6	689.3		**686.7**	**-0.4**
LD3 HW	**796.91**	675.9	679.9	681.4	683.3	684.7	**686.1**	687.4	689.1		**686.4**	**-0.3**
	796.8	675.6	679.6	681.1	683	684.4	**685.8**	687.1	688.8		**686.2**	**-0.4**

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
LD 3 TW	**796.61**	675.6	679.6	681.1	682.9	684.3	**685.7**	687.1	688.8	**686.1**	**-0.4**
	796.39	675.5	679.5	681	682.8	684.3	**685.7**	687	688.7	**686**	**-0.3**
	796	675.4	679.4	680.9	682.7	684.1	**685.5**	686.8	688.5	**685.8**	**-0.3**
	795.45	675.3	679.3	680.8	682.6	684	**685.4**	686.7	688.4	**685.6**	**-0.2**
	795	675.2	679.2	680.7	682.5	683.9	**685.3**	686.6	688.3	**685.5**	**-0.2**
Cannon River	**794.67**	675.2	679.1	680.6	682.4	683.8	**685.2**	686.5	688.1	**685.3**	**-0.1**
	794.38	675.1	679	680.5	682.3	683.7	**685**	686.3	687.9	**685.2**	**-0.2**
	794.08	675	678.9	680.4	682.2	683.6	**684.9**	686.2	687.8	**685.1**	**-0.2**
	793.83	674.9	678.8	680.3	682.1	683.5	**684.8**	686.1	687.7	**685**	**-0.2**
	793.56	674.9	678.7	680.2	682	683.4	**684.7**	686	687.7	**684.9**	**-0.2**
	793.3	674.8	678.7	680.1	682	683.3	**684.7**	686	687.6	**684.8**	**-0.1**
	793	674.7	678.6	680.1	681.9	683.3	**684.6**	685.9	687.5	**684.7**	**-0.1**
	792.64	674.6	678.6	680	681.8	683.2	**684.5**	685.8	687.5	**684.6**	**-0.1**
	792.26	674.5	678.5	679.9	681.7	683.1	**684.5**	685.8	687.4	**684.5**	**0**
	791.79	674.5	678.4	679.8	681.6	683	**684.3**	685.6	687.3	**684.3**	**0**
	791.53	674.4	678.3	679.8	681.5	682.9	**684.2**	685.5	687.2	**684.2**	**0**
	791.27	674.3	678.2	679.7	681.4	682.7	**684.1**	685.3	687	**684.1**	**0**
Red Wing	**790.97**	674.3	678.2	679.6	681.3	682.6	**683.9**	685.2	686.9	**684**	**-0.1**
	790.6	674.2	678.1	679.5	681.2	682.5	**683.8**	685.1	686.7	**683.7**	**0.1**
	790.56	674.2	678.1	679.4	681.1	682.4	**683.7**	685	686.6	**683.7**	**0**
	790.44	674.1	677.9	679.3	680.9	682.2	**683.5**	684.7	686.3	**683.6**	**-0.1**
	790.3	674	677.8	679.2	680.8	682	**683.3**	684.5	686.1	**683.5**	**-0.2**
	789.99	673.9	677.7	679.1	680.6	681.8	**683.1**	684.3	685.9	**683.3**	**-0.2**
	789.57	673.7	677.5	678.9	680.4	681.6	**682.8**	684	685.6	**683**	**-0.2**
	789	673.5	677.3	678.7	680.2	681.4	**682.6**	683.8	685.5	**682.6**	**0**
	788.54	673.4	677.2	678.6	680.1	681.2	**682.4**	683.7	685.3	**682.4**	**0**
	787.99	673.3	677.1	678.5	680	681.1	**682.3**	683.5	685.2	**682.3**	**0**
	787.73	673.2	677.1	678.4	679.9	681	**682.2**	683.4	685	**682.3**	**-0.1**
	787.47	673.1	677	678.3	679.7	680.8	**682**	683.2	684.9	**682.3**	**-0.3**
	787.09	673.1	676.9	678.2	679.6	680.7	**681.9**	683.1	684.7	**682.2**	**-0.3**
	786.62	673	676.8	678.1	679.5	680.6	**681.7**	683	684.6	**682.2**	**-0.5**
Bay City	**786.19**	672.9	676.7	678.1	679.4	680.5	**681.6**	682.9	684.5	**682.1**	**-0.5**
	785.86	672.9	676.7	678	679.4	680.5	**681.6**	682.8	684.5	**682.1**	**-0.5**
	785.58	672.8	676.7	678	679.3	680.4	**681.5**	682.8	684.4	**682**	**-0.5**
	785.33	672.8	676.7	678	679.3	680.4	**681.5**	682.7	684.4	**682**	**-0.5**

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	785.02	672.8	676.6	677.9	679.3	680.3	**681.5**	682.7	684.4	**682**	**-0.5**
	784.72	672.8	676.6	677.9	679.3	680.3	**681.4**	682.7	684.3	**682**	**-0.6**
	784.47	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	784.24	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	784.02	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	783.65	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	783.3	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	783	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	781.99	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	781.47	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	780.98	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	780.63	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
Rush River	**780.19**	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	779.98	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	779.81	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	779.39	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	779.19	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
Frontanac	**779**	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	778.66	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	778.29	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	778.07	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.3	**682**	**-0.6**
	777.88	672.8	676.6	677.9	679.2	680.3	**681.4**	682.6	684.2	**682**	**-0.6**
	777.49	672.8	676.6	677.9	679.2	680.2	**681.4**	682.6	684.2	**682**	**-0.6**
	777.08	672.8	676.6	677.8	679.2	680.2	**681.4**	682.6	684.2	**682**	**-0.6**
	776.67	672.8	676.5	677.8	679.2	680.2	**681.4**	682.6	684.2	**682**	**-0.6**
	776	672.8	676.5	677.8	679.2	680.2	**681.3**	682.6	684.2	**682**	**-0.7**
	775.19	672.8	676.5	677.8	679.2	680.2	**681.3**	682.6	684.2	**682**	**-0.7**
	774.74	672.8	676.5	677.8	679.2	680.2	**681.3**	682.6	684.2	**682**	**-0.7**
	774.33	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2	**682**	**-0.7**
	774.11	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2	**682**	**-0.7**
	773.83	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2	**682**	**-0.7**
	773.62	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2	**682**	**-0.7**
	773.34	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2	**682**	**-0.7**
	772.83	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2	**682**	**-0.7**
Lake City Gage	**772.56**	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2	**682**	**-0.7**

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		1979 Study	100 year Profile 2003 Study minus 1979 Study
	772.34	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2		**681.9**	**-0.6**
	772.09	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2		**681.9**	**-0.6**
	771.81	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2		**681.9**	**-0.6**
	771.31	672.8	676.5	677.8	679.1	680.2	**681.3**	682.5	684.2		**681.9**	**-0.6**
	770.88	672.8	676.4	677.8	679.1	680.2	**681.3**	682.5	684.2		**681.9**	**-0.6**
	770.53	672.8	676.4	677.8	679.1	680.2	**681.3**	682.5	684.2		**681.9**	**-0.6**
	769.7	672.8	676.4	677.8	679.1	680.2	**681.3**	682.5	684.1		**681.9**	**-0.6**
	768.72	672.7	676.4	677.7	679.1	680.1	**681.3**	682.5	684.1		**681.8**	**-0.5**
Pepin	**767.61**	672.7	676.4	677.7	679.1	680.1	**681.2**	682.5	684.1		**681.8**	**-0.6**
	766.67	672.7	676.3	677.7	679.1	680.1	**681.2**	682.5	684.1		**681.8**	**-0.6**
	766	672.7	676.3	677.7	679.1	680.1	**681.2**	682.4	684.1		**681.7**	**-0.5**
	765.53	672.7	676.3	677.7	679	680.1	**681.2**	682.4	684.1		**681.7**	**-0.5**
	765.1	672.7	676.3	677.7	679	680	**681.1**	682.4	684		**681.7**	**-0.6**
	764.55	672.6	676.2	677.6	678.9	679.9	**681**	682.2	683.9		**681.5**	**-0.5**
	764.09	672.5	676.1	677.5	678.7	679.7	**680.8**	682	683.7		**681.4**	**-0.6**
	763.66	672.4	675.8	677.2	678.5	679.5	**680.5**	681.7	683.4		**681.2**	**-0.7**
Chippewa River	**763.08**	672.2	675.5	676.8	678.1	679.1	**680.1**	681.3	682.9		**680.8**	**-0.7**
	762.57	672	674.7	676.1	677.7	678.7	**679.8**	680.9	682.2		**680.3**	**-0.5**
	762.27	671.8	674.4	675.8	677.3	678.4	**679.5**	680.5	681.9		**680.1**	**-0.6**
	762.06	671.6	674	675.4	677.1	678.2	**679.3**	680.3	681.6		**679.9**	**-0.6**
	761.82	671.4	673.8	675.2	676.9	678	**679.1**	680.1	681.4		**679.7**	**-0.6**
	761.32	671.1	673.5	674.9	676.5	677.6	**678.7**	679.7	681		**679.2**	**-0.5**
	760.99	670.8	673.1	674.5	676.1	677.2	**678.3**	679.4	680.7		**679**	**-0.7**
	760.75	670.6	672.9	674.3	675.9	677	**678.1**	679.1	680.5		**678.8**	**-0.7**
	760.5	670.4	672.6	674	675.6	676.7	**677.8**	678.9	680.3		**678.5**	**-0.7**
Wabasha Gage	**760.4**	670.3	672.5	673.9	675.5	676.6	**677.7**	678.8	680.2		**678.5**	**-0.8**
Hwy 25 Bridge	**760.21**	670.2	672.4	673.8	675.4	676.5	**677.6**	678.7	680.1		**678.3**	**-0.7**
	760.18	670.1	672.4	673.7	675.3	676.4	**677.5**	678.6	680		**678.3**	**-0.8**
Wabasha	**759.92**	670	672.2	673.6	675.2	676.3	**677.4**	678.5	679.9		**678.2**	**-0.8**
	759.68	669.8	672.1	673.4	675.1	676.2	**677.3**	678.4	679.8		**678**	**-0.7**
	759.45	669.8	672	673.4	675	676.1	**677.3**	678.3	679.7		**677.9**	**-0.6**
	759.17	669.6	671.8	673.2	674.9	676	**677.2**	678.2	679.6		**677.7**	**-0.5**
	758.83	669.3	671.6	673.1	674.7	675.9	**677**	678.1	679.5		**677.5**	**-0.5**
	758.29	669	671.3	672.8	674.5	675.7	**676.8**	677.9	679.3		**677.3**	**-0.5**
	758.01	668.8	671.1	672.6	674.3	675.5	**676.7**	677.8	679.2		**677.2**	**-0.5**

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		1979 Study	100 year Profile 2003 Study minus 1979 Study
	757.66	668.6	670.9	672.4	674.2	675.4	676.5	677.6	679		677	-0.5
	757.38	668.4	670.8	672.3	674.1	675.3	676.4	677.5	678.9		676.9	-0.5
Teepeota Point	757.1	668.3	670.7	672.2	673.9	675.1	676.3	677.4	678.8		676.8	-0.5
	756.76	668.1	670.5	672	673.8	675	676.1	677.2	678.7		676.7	-0.6
	756.37	667.9	670.3	671.8	673.6	674.8	675.9	677	678.4		676.6	-0.7
	755.99	667.7	670.1	671.6	673.4	674.6	675.7	676.8	678.3		676.5	-0.8
	755.46	667.5	669.9	671.4	673.2	674.4	675.6	676.7	678.1		676.4	-0.8
	755.18	667.3	669.7	671.2	673	674.3	675.5	676.6	678		676.4	-0.9
	754.95	667.2	669.6	671.2	673	674.2	675.4	676.5	677.9		676.3	-0.9
Buffalo River	754.59	667	669.4	671	672.8	674.1	675.3	676.4	677.8		676.2	-0.9
	754.2	666.8	669.2	670.8	672.7	673.9	675.1	676.2	677.6		676.1	-1
	753.58	666.5	668.9	670.6	672.4	673.7	674.9	676	677.4		676	-1.1
LD 4 HW	752.95	666.4	668.6	670.3	672.1	673.4	674.6	675.7	677.1		675.3	-0.7
LD 4 TW	752.6	665.1	667.9	669.6	671.4	672.7	673.9	675	676.4		674.5	-0.6
	751.87	664.9	667.6	669.2	671	672.2	673.4	674.5	675.8		673.7	-0.3
	751.11	664.6	667.2	668.7	670.5	671.7	672.8	673.9	675.2		672.8	0
	750.79	664.4	666.9	668.4	670.1	671.3	672.4	673.5	674.8		672.4	0
	750.61	664.3	666.8	668.2	669.9	671.1	672.2	673.2	674.5		672.2	0
Zumbro River	750.08	664.1	666.5	667.8	669.5	670.6	671.7	672.7	674		671.7	0
	749.48	663.8	666.1	667.4	669.1	670.2	671.3	672.3	673.5		671.4	-0.1
	749.01	663.6	665.8	667.1	668.7	669.8	671	671.9	673.1		671.2	-0.2
	748.5	663.4	665.5	666.8	668.4	669.5	670.7	671.7	672.9		671	-0.3
	748.15	663.1	665.1	666.4	668	669.2	670.4	671.4	672.6		670.8	-0.4
	747.78	662.8	664.7	666	667.6	668.8	670	671	672.3		670.6	-0.6
	747.37	662.5	664.3	665.6	667.3	668.5	669.7	670.7	672		670.4	-0.7
	747	662.3	664	665.3	666.9	668.2	669.4	670.5	671.8		670.2	-0.8
	746.51	662	663.7	664.9	666.6	667.9	669.2	670.3	671.6		669.9	-0.7
	745.97	661.8	663.4	664.7	666.4	667.7	669	670.1	671.5		669.7	-0.7
	745.5	661.6	663.1	664.5	666.2	667.6	668.9	670	671.4		669.4	-0.5
	744.95	661.4	662.9	664.3	666.1	667.4	668.8	669.9	671.3		669.2	-0.4
	744.45	661.2	662.6	664.1	665.9	667.3	668.6	669.8	671.2		669.1	-0.5
Buffalo City	744	661	662.4	663.9	665.8	667.2	668.5	669.7	671.2		669	-0.5
	743.52	660.8	662.1	663.7	665.6	667.1	668.4	669.6	671.1		668.9	-0.5
	743.03	660.5	661.8	663.4	665.4	666.9	668.3	669.5	671		668.8	-0.5
Whitewater River	742.5	660.3	661.5	663.2	665.3	666.7	668.1	669.4	670.9		668.6	-0.5

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		1979 Study	100 year Profile 2003 Study minus 1979 Study
	742.04	660.1	661.3	663	665.2	666.6	**668**	669.3	670.8		**668.4**	**-0.4**
	741.43	659.9	661	662.8	665	666.5	**667.9**	669.2	670.7		**668.2**	**-0.3**
	740.9	659.7	660.8	662.6	664.8	666.3	**667.8**	669	670.6		**668**	**-0.2**
	740.54	659.6	660.6	662.4	664.6	666.1	**667.6**	668.8	670.4		**667.9**	**-0.3**
	740	659.5	660.3	662.1	664.4	665.9	**667.3**	668.6	670.2		**667.7**	**-0.4**
	739.37	659.4	660	661.8	664.1	665.6	**667**	668.3	669.9		**667.5**	**-0.5**
	738.75	659.4	659.8	661.5	663.8	665.3	**666.7**	668	669.6		**667.3**	**-0.6**
LD 5 Pool	**738.27**	659.4	659.6	661.2	663.4	665	**666.4**	667.7	669.3		**667.1**	**-0.7**
LD 5 TW	**737.9**	655.6	658.5	660.3	662.6	664.1	**665.5**	666.8	668.5		**666.2**	**-0.7**
	737.85	655.5	658.4	660.2	662.5	664	**665.4**	666.7	668.4		**666.2**	**-0.8**
	737.57	655.3	658.2	660	662.3	663.7	**665.1**	666.4	668		**665.9**	**-0.8**
	736.85	655.2	658	659.8	662	663.5	**664.8**	666.1	667.7		**665.2**	**-0.4**
	736.2	655	657.8	659.6	661.8	663.3	**664.6**	665.9	667.4		**664.8**	**-0.2**
	735.69	654.9	657.7	659.5	661.7	663.1	**664.4**	665.7	667.2		**664.7**	**-0.3**
	735.03	654.7	657.5	659.3	661.5	662.9	**664.2**	665.5	667.1		**664.5**	**-0.3**
Waumandee creek	**734.49**	654.5	657.3	659.2	661.4	662.8	**664.1**	665.3	666.9		**664.4**	**-0.3**
	733.84	654.2	657.1	658.9	661.1	662.5	**663.9**	665.1	666.8		**664.2**	**-0.3**
Fountain City	**733.4**	654	656.9	658.8	661	662.4	**663.7**	665	666.7		**664.1**	**-0.4**
	732.99	653.9	656.8	658.7	660.9	662.3	**663.7**	665	666.6		**664**	**-0.3**
	732.67	653.8	656.7	658.6	660.9	662.3	**663.6**	664.9	666.5		**663.9**	**-0.3**
	732.25	653.7	656.6	658.6	660.8	662.2	**663.5**	664.8	666.5		**663.7**	**-0.2**
	731.92	653.6	656.6	658.5	660.8	662.1	**663.5**	664.8	666.4		**663.5**	**0**
	731.33	653.4	656.4	658.4	660.7	662	**663.3**	664.6	666.3		**663.4**	**-0.1**
	730.85	653.2	656.3	658.3	660.6	661.9	**663.2**	664.5	666.2		**663.4**	**-0.2**
	730.76	653.2	656.3	658.3	660.5	661.9	**663.2**	664.5	666.2		**663.3**	**-0.1**
	730.53	653.1	656.2	658.2	660.4	661.8	**663.1**	664.4	666.1		**663.3**	**-0.2**
	730.26	652.9	656	658.1	660.3	661.6	**663**	664.3	665.9		**663.3**	**-0.3**
	729.87	652.7	655.9	657.9	660.1	661.5	**662.8**	664.1	665.8		**663.2**	**-0.4**
	729.42	652.6	655.8	657.9	660	661.4	**662.7**	664	665.6		**663**	**-0.3**
	728.95	652.5	655.7	657.7	659.9	661.2	**662.5**	663.8	665.4		**662.6**	**-0.1**
LD 5A HW	**728.65**	652.4	655.6	657.6	659.7	661	**662.3**	663.6	665.2		**662.4**	**-0.1**
	728.59	652.4	655.6	657.6	659.7	661	**662.2**	663.5	665.1		**662.3**	**-0.1**
	728.52	652.4	655.5	657.5	659.6	660.9	**662.2**	663.4	665		**662.2**	**0**
	728.48	651.6	654.7	656.7	658.8	660.1	**661.4**	662.6	664.2		**662.1**	**-0.7**
LD 5A TW	**728.28**	651.5	654.7	656.7	658.7	660	**661.3**	662.5	664.1		**661.9**	**-0.6**

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	727.89	651.4	654.6	656.6	658.6	659.9	**661.1**	662.3	663.8	**661.4**	**-0.3**
	727.58	651.3	654.5	656.5	658.5	659.7	**660.9**	662	663.5	**661**	**-0.1**
	727.17	651.2	654.4	656.4	658.4	659.5	**660.7**	661.8	663.3	**660.7**	**0**
	726.9	651.1	654.3	656.3	658.3	659.4	**660.5**	661.6	663	**660.5**	**0**
	726.72	651	654.2	656.2	658.2	659.3	**660.4**	661.5	662.9	**660.5**	**-0.1**
	726.46	650.8	654.1	656.1	658	659.2	**660.2**	661.3	662.6	**660.4**	**-0.2**
	726.15	650.7	654	656	657.9	659	**660**	661	662.3	**660.2**	**-0.2**
Hwy 54	**725.83**	650.6	653.8	655.8	657.7	658.7	**659.7**	660.7	661.9	**660**	**-0.3**
	725.78	650.6	653.8	655.8	657.6	658.6	**659.6**	660.5	661.7	**660**	**-0.4**
Winona Gage	**725.7**	650.5	653.7	655.7	657.5	658.5	**659.5**	660.4	661.5	**659.9**	**-0.4**
RR	**725.66**	650.4	653.6	655.6	657.4	658.4	**659.4**	660.3	661.4	**659.9**	**-0.5**
	725.63	650.3	653.5	655.5	657.3	658.3	**659.2**	660.1	661.2	**659.8**	**-0.6**
	725.23	650.2	653.4	655.4	657.1	658.1	**659**	659.9	661	**659.5**	**-0.5**
	724.93	650.1	653.3	655.2	656.9	657.9	**658.7**	659.6	660.7	**659.3**	**-0.6**
	724.68	650	653.2	655.1	656.8	657.8	**658.6**	659.5	660.6	**659.1**	**-0.5**
	724.37	649.9	653.1	655	656.6	657.5	**658.3**	659.2	660.3	**658.8**	**-0.5**
	724.14	649.8	653	654.9	656.4	657.3	**658.1**	659	660.1	**658.6**	**-0.5**
	723.81	649.7	652.8	654.7	656.2	657	**657.9**	658.8	659.9	**658.2**	**-0.3**
	723.49	649.6	652.7	654.6	656	656.9	**657.7**	658.6	659.7	**657.9**	**-0.2**
	723.03	649.5	652.6	654.5	655.9	656.7	**657.6**	658.5	659.6	**657.5**	**0.1**
	722.71	649.4	652.5	654.4	655.8	656.6	**657.5**	658.4	659.6	**657.5**	**0**
	722.44	649.2	652.4	654.3	655.7	656.5	**657.4**	658.3	659.5	**657.4**	**0**
	721.86	649	652.2	654.1	655.5	656.4	**657.3**	658.2	659.4	**657.3**	**0**
	721.51	648.8	652	653.9	655.3	656.2	**657.1**	658	659.3	**657.2**	**-0.1**
	721.03	648.7	651.8	653.7	655.1	656	**656.9**	657.9	659.2	**657.1**	**-0.2**
	720.24	648.4	651.5	653.3	654.8	655.7	**656.6**	657.6	658.9	**656.7**	**-0.1**
	719.51	648.1	651.1	652.9	654.4	655.2	**656.2**	657.2	658.6	**656.4**	**-0.2**
	718.98	647.8	650.8	652.5	654	654.8	**655.8**	656.8	658.3	**656.1**	**-0.3**
	718.54	647.6	650.5	652.2	653.7	654.5	**655.5**	656.6	658	**655.9**	**-0.4**
	718.1	647.4	650.3	652	653.5	654.3	**655.2**	656.3	657.8	**655.7**	**-0.5**
	717.79	647.3	650.2	651.8	653.3	654.1	**655.1**	656.2	657.7	**655.5**	**-0.4**
	717.34	647.1	650	651.6	653.1	653.9	**654.9**	656	657.5	**655.3**	**-0.4**
Trempealeau river	**717.21**	647	649.9	651.5	653	653.8	**654.8**	655.9	657.4	**655.2**	**-0.4**
	716.87	646.8	649.7	651.3	652.8	653.6	**654.5**	655.6	657.1	**655**	**-0.5**
	716.37	646.6	649.4	651	652.5	653.3	**654.2**	655.3	656.8	**654.8**	**-0.6**

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		1979 Study	100 year Profile 2003 Study minus 1979 Study
	715.88	646.4	649.2	650.7	652.2	653	**653.9**	655	656.5		**654.5**	**-0.6**
	715.4	646.3	649	650.5	652	652.7	**653.7**	654.8	656.3		**654.3**	**-0.6**
	715	646.1	648.8	650.3	651.7	652.4	**653.4**	654.5	656		**653.9**	**-0.5**
LD 6 Pool	**714.44**	645.8	648.4	649.9	651.3	652	**652.9**	654	655.5		**653.3**	**-0.4**
	714.31	645.8	648.3	649.8	651.2	651.9	**652.8**	653.9	655.3		**652.8**	**0**
	714.26	644.3	646.8	648.3	649.7	650.4	**651.3**	652.4	653.8		**652.6**	**-1.3**
	714.17	644.3	646.8	648.2	649.7	650.3	**651.2**	652.3	653.7		**652.3**	**-1.1**
LD 6 TW	**714.07**	644.2	646.7	648.2	649.6	650.3	**651.2**	652.2	653.6		**651.9**	**-0.7**
	713.71	644.1	646.5	647.9	649.4	650.1	**651**	652	653.4		**651.6**	**-0.6**
	713.19	643.8	646.2	647.6	649.1	649.8	**650.7**	651.7	653.1		**651.3**	**-0.6**
	712.75	643.7	646	647.4	648.8	649.6	**650.5**	651.5	652.8		**651**	**-0.5**
	712.26	643.4	645.7	647.1	648.5	649.3	**650.1**	651.1	652.5		**650.6**	**-0.5**
	711.72	643.1	645.4	646.8	648.2	649	**649.9**	650.9	652.2		**650.2**	**-0.3**
	711.3	642.9	645.1	646.5	647.9	648.8	**649.6**	650.6	652		**649.9**	**-0.3**
	710.81	642.5	644.8	646.1	647.6	648.4	**649.3**	650.3	651.7		**649.6**	**-0.3**
	710.15	642.1	644.3	645.7	647.1	648	**648.9**	649.9	651.2		**649.1**	**-0.2**
	709.58	641.7	643.8	645.2	646.6	647.6	**648.5**	649.5	650.8		**648.7**	**-0.2**
Black River	**709.08**	641.3	643.4	644.6	646.2	647.2	**648.1**	649.1	650.3		**648.4**	**-0.3**
	708.7	641	643.1	644.3	645.9	646.9	**647.9**	648.8	650.1		**648.3**	**-0.4**
	708	640.7	642.7	644	645.6	646.6	**647.6**	648.6	649.8		**648**	**-0.4**
Dakota Gage	**707.23**	640.5	642.4	643.8	645.3	646.4	**647.4**	648.4	649.6		**647.7**	**-0.3**
	707.13	640.4	642.3	643.7	645.2	646.3	**647.3**	648.3	649.5		**647.7**	**-0.4**
	706.64	640.1	642.1	643.4	645	646.1	**647.1**	648.1	649.3		**647.5**	**-0.4**
	706.22	640	641.9	643.3	644.9	646	**647**	648	649.2		**647.4**	**-0.4**
Drebash, MN	**705.73**	639.7	641.7	643.1	644.7	645.8	**646.8**	647.8	649.1		**647.3**	**-0.5**
	705.09	639.4	641.5	642.9	644.5	645.6	**646.7**	647.7	649		**647.1**	**-0.4**
	704.56	639.1	641.3	642.7	644.4	645.5	**646.6**	647.6	649		**647**	**-0.4**
	704.03	638.9	641.1	642.6	644.3	645.4	**646.5**	647.5	648.9		**646.9**	**-0.4**
	703.92	638.8	641.1	642.6	644.3	645.4	**646.5**	647.5	648.9		**646.9**	**-0.4**
	703.82	638.8	641.1	642.6	644.2	645.4	**646.4**	647.5	648.9		**646.9**	**-0.5**
	703.73	638.8	641	642.6	644.2	645.4	**646.4**	647.5	648.9		**646.9**	**-0.5**
	703.54	638.7	641	642.5	644.2	645.3	**646.4**	647.5	648.9		**646.8**	**-0.4**
	703.25	638.6	640.9	642.5	644.2	645.3	**646.3**	647.4	648.8		**646.8**	**-0.5**
	702.97	638.5	640.8	642.4	644.2	645.2	**646.1**	647.3	648.7		**646.8**	**-0.7**
LD 7 Pool	**702.61**	638.5	640.7	642.3	644.2	645.1	**645.8**	647.2	648.7		**646.7**	**-0.9**

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Location	RIVER MILE	FREQUENCY								1979 Study	100 year Profile 2003 Study minus 1979 Study
		2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		
	702.47	637.3	640	641.6	643.3	644.4	645.5	646.5	648	646.4	-0.9
LD 7 TW	702.32	637.2	640	641.5	643.2	644.3	645.4	646.4	647.9	646.1	-0.7
	702.17	637.2	639.9	641.5	643.1	644.3	645.3	646.4	647.8	645.9	-0.6
	701.93	637.2	639.9	641.5	643.1	644.2	645.3	646.4	647.8	645.8	-0.5
	701.82	637.2	639.9	641.4	643	644.1	645.2	646.3	647.7	645.7	-0.5
	701.76	637.2	639.9	641.4	643	644.1	645.2	646.2	647.7	645.7	-0.5
	701.66	637.1	639.8	641.4	643	644.1	645.2	646.2	647.6	645.7	-0.5
	701.28	637.1	639.8	641.3	642.9	644	645.1	646.1	647.5	645.5	-0.4
	700.85	637	639.7	641.3	642.8	643.9	645	646	647.4	645.3	-0.3
	700.37	637	639.6	641.1	642.7	643.8	644.8	645.9	647.2	645	-0.2
	700.22	636.9	639.6	641.1	642.6	643.7	644.7	645.8	647.1	644.9	-0.2
	700.17	636.9	639.5	641	642.6	643.6	644.7	645.7	647.1	644.9	-0.2
	700.06	636.9	639.5	641	642.5	643.6	644.6	645.6	647	644.9	-0.3
	699.8	636.8	639.4	640.9	642.4	643.4	644.5	645.5	646.9	644.7	-0.2
	699.74	636.8	639.4	640.9	642.4	643.4	644.5	645.5	646.8	644.7	-0.2
	699.36	636.7	639.3	640.8	642.3	643.3	644.3	645.3	646.7	644.5	-0.2
	699.06	636.6	639.2	640.6	642.1	643.1	644.1	645.1	646.4	644.4	-0.3
La Crosse River	698.37	636.5	639	640.4	641.8	642.7	643.7	644.7	646	644	-0.3
State Hwy 61 Bridge	697.52	636.3	638.7	640.1	641.4	642.2	643.2	644.1	645.4	642.9	0.3
	697.47	636.2	638.5	639.9	641.2	642	643	643.9	645.1	642.9	0.1
	697.42	636.2	638.5	639.9	641.1	642	642.9	643.8	645	642.9	0
	697.38	636.1	638.4	639.8	641	641.8	642.7	643.6	644.8	642.9	-0.2
	697.22	636	638.3	639.7	640.9	641.7	642.5	643.4	644.6	642.8	-0.3
	696.94	635.9	638.2	639.5	640.7	641.5	642.3	643.1	644.3	642.6	-0.3
	696.75	635.9	638.1	639.4	640.6	641.4	642.2	643	644.2	642.5	-0.3
	696.56	635.8	638	639.3	640.5	641.2	642	642.8	644	642.4	-0.4
	696.34	635.7	637.8	639.1	640.3	641	641.8	642.6	643.8	642.2	-0.4
	696.2	635.6	637.7	638.9	640.1	640.8	641.6	642.4	643.6	642.1	-0.5
	696.03	635.4	637.5	638.7	639.9	640.6	641.4	642.2	643.4	642	-0.6
	695.61	635.3	637.3	638.5	639.6	640.4	641.2	642	643.2	641.8	-0.6
	695.12	635.1	637.1	638.3	639.4	640.1	640.9	641.8	642.9	641.5	-0.6
	694.74	635	636.9	638.1	639.2	639.9	640.7	641.6	642.8	641.2	-0.5
	694.32	634.8	636.7	637.9	639	639.8	640.6	641.4	642.6	640.9	-0.3
Root River	693.99	634.6	636.5	637.6	638.8	639.5	640.3	641.2	642.4	640.7	-0.4
	693.53	634.3	636.1	637.2	638.4	639.2	640	640.9	642.1	640.4	-0.4

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		1979 Study	100 year Profile 2003 Study minus 1979 Study
	693.24	634	635.8	637	638.1	639	639.8	640.7	641.9		640.2	-0.4
	692.96	633.8	635.6	636.7	637.9	638.8	639.6	640.5	641.7		640	-0.4
	692.64	633.6	635.4	636.5	637.7	638.6	639.5	640.4	641.6		639.7	-0.2
	692.22	633.5	635.2	636.3	637.6	638.5	639.4	640.3	641.5		639.4	0
	691.81	633.3	635	636.1	637.4	638.3	639.2	640.1	641.4		639.1	0.1
	691.42	633.1	634.9	636	637.2	638.1	639.1	640	641.2		639	0.1
	691.3	633	634.8	635.9	637.2	638.1	639	639.9	641.2		639	0
	691	632.9	634.6	635.7	637	637.9	638.9	639.8	641.1		639	-0.1
	690.56	632.7	634.4	635.5	636.9	637.8	638.7	639.7	641		638.9	-0.2
	690.17	632.4	634.2	635.3	636.7	637.6	638.6	639.5	640.8		638.9	-0.3
	689.76	632.1	633.9	635.1	636.5	637.4	638.4	639.4	640.7		638.8	-0.4
	689.35	631.9	633.7	634.9	636.3	637.3	638.3	639.2	640.6		638.7	-0.4
	688.95	631.7	633.5	634.7	636.2	637.2	638.2	639.2	640.5		638.7	-0.5
	688.6	631.6	633.4	634.7	636.1	637.1	638.1	639.1	640.4		638.7	-0.6
Brownsville Gage	688.37	631.5	633.4	634.6	636	637.1	638.1	639.1	640.4		638.6	-0.5
	688.14	631.5	633.3	634.6	636	637	638	639	640.4		638.6	-0.6
	687.57	631.3	633.2	634.5	635.9	636.9	637.9	639	640.3		638.6	-0.7
	687.26	631.2	633.1	634.4	635.8	636.9	637.9	638.9	640.3		638.5	-0.6
	686.83	631.1	633	634.3	635.8	636.8	637.8	638.9	640.2		638.5	-0.7
	686.42	631.1	632.9	634.3	635.7	636.8	637.8	638.8	640.2		638.5	-0.7
	685.83	631	632.8	634.2	635.7	636.7	637.8	638.8	640.2		638.4	-0.6
	685.28	630.9	632.7	634.1	635.6	636.6	637.7	638.7	640.1		638.3	-0.6
	684.79	630.8	632.6	634	635.5	636.6	637.6	638.7	640.1		638.3	-0.7
Coon Creek	684.36	630.7	632.5	633.9	635.4	636.5	637.6	638.6	640		638.3	-0.7
	684.01	630.6	632.5	633.9	635.4	636.5	637.5	638.6	640		638.2	-0.7
	683.56	630.5	632.4	633.8	635.3	636.4	637.5	638.5	639.9		638.2	-0.7
	683.04	630.4	632.3	633.7	635.3	636.3	637.4	638.5	639.9		638.1	-0.7
	682.56	630.4	632.2	633.7	635.2	636.3	637.3	638.4	639.8		638	-0.7
	682.01	630.3	632.1	633.6	635.1	636.2	637.3	638.4	639.8		638	-0.7
	681.6	630.2	632.1	633.5	635.1	636.2	637.2	638.3	639.8		637.9	-0.7
	681.23	630.2	632	633.5	635	636.1	637.2	638.3	639.7		637.9	-0.7
	680.9	630.2	631.9	633.4	635	636.1	637.1	638.2	639.7		637.8	-0.7
	680.49	630.1	631.8	633.3	634.9	636	637.1	638.1	639.6		637.8	-0.7
	680.29	630.1	631.7	633.2	634.8	635.9	637	638.1	639.5		637.7	-0.7
	679.95	630.1	631.6	633.1	634.7	635.8	636.9	638	639.5		637.7	-0.8

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		1979 Study	100 year Profile 2003 Study minus 1979 Study
Genoa, WI	679.69	630.1	631.6	633.1	634.6	635.7	636.8	637.9	639.4		637.6	-0.8
LD 8 hw	679.39	630.1	631.5	633	634.6	635.7	636.8	637.9	639.3		637.6	-0.8
	679.15	628.3	630.7	632.2	633.8	634.9	636	637.1	638.5		637	-1
LD 8 tw	678.94	628.3	630.7	632.2	633.7	634.8	635.9	637	638.5		636.7	-0.8
	678.52	628.1	630.5	632	633.6	634.7	635.8	636.9	638.4		636.6	-0.8
	678.1	628	630.4	631.9	633.4	634.5	635.6	636.7	638.2		636.4	-0.8
	677.74	627.9	630.2	631.7	633.3	634.4	635.5	636.6	638.1		636.2	-0.7
	677.59	627.8	630.2	631.6	633.2	634.3	635.4	636.5	638		636.2	-0.8
	677.07	627.6	630	631.5	633	634.1	635.2	636.3	637.8		636	-0.8
	676.58	627.4	629.8	631.2	632.8	633.9	635	636.1	637.7		635.8	-0.8
	676.15	627.2	629.6	631.1	632.7	633.8	634.9	636	637.5		635.6	-0.7
	675.6	627	629.3	630.9	632.5	633.6	634.7	635.8	637.4		635.4	-0.7
Bad AX River	675.1	626.6	629	630.6	632.3	633.4	634.5	635.7	637.2		635.2	-0.7
	674.75	626.4	628.8	630.4	632.1	633.2	634.4	635.5	637.1		635.1	-0.7
	674.13	626.1	628.5	630.2	631.9	633	634.2	635.4	637		635	-0.8
	673.96	626	628.4	630.1	631.9	633	634.1	635.3	636.9		635	-0.9
MN - IA Border	673.9	626	628.4	630.1	631.8	632.9	634.1	635.3	636.9		635	-0.9
	673.57	625.9	628.3	630	631.8	632.9	634	635.2	636.8		634.9	-0.9
	673.25	625.8	628.2	629.9	631.7	632.8	633.9	635.1	636.8		634.8	-0.9
Victory, WI	672.97	625.7	628.1	629.9	631.6	632.7	633.9	635.1	636.7		634.8	-0.9
	672.4	625.6	628.1	629.8	631.6	632.7	633.8	635	636.7		634.7	-0.9
	671.91	625.5	628	629.8	631.5	632.6	633.8	635	636.6		634.6	-0.8
	671.43	625.5	627.9	629.7	631.5	632.6	633.7	634.9	636.6		634.5	-0.8
Upper Iowa River	671.08	625.3	627.8	629.6	631.3	632.4	633.6	634.8	636.4		634.5	-0.9
	670.61	625.2	627.7	629.5	631.2	632.3	633.5	634.7	636.4		634.4	-0.9
	669.99	625	627.6	629.4	631.1	632.2	633.4	634.6	636.3		634.3	-0.9
	669.53	624.9	627.5	629.3	631	632.1	633.3	634.5	636.2		634.2	-0.9
	669.11	624.8	627.4	629.2	631	632.1	633.2	634.5	636.2		634.2	-1
	668.56	624.7	627.3	629.1	630.9	632	633.2	634.4	636.1		634.1	-0.9
	668.09	624.7	627.3	629.1	630.8	631.9	633.1	634.4	636.1		634	-0.9
De Soto	667.59	624.6	627.2	629	630.8	631.9	633.1	634.3	636		633.9	-0.8
	667.05	624.5	627.1	629	630.7	631.9	633	634.3	636		633.8	-0.8
	666.63	624.4	627.1	629	630.7	631.8	633	634.3	636		633.8	-0.8
	665.97	624.3	627	628.9	630.7	631.8	633	634.2	635.9		633.7	-0.7
	665.5	624.3	627	628.9	630.6	631.7	632.9	634.2	635.9		633.6	-0.7

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	665.04	624.2	626.9	628.8	630.6	631.7	632.9	634.1	635.9	633.5	-0.6
	664.6	624.1	626.9	628.8	630.5	631.6	632.8	634.1	635.8	633.5	-0.7
	664.12	624.1	626.9	628.7	630.5	631.6	632.8	634.1	635.8	633.4	-0.6
	663.63	624	626.8	628.7	630.4	631.5	632.7	634	635.8	633.3	-0.6
State Hwy 82 bridge	663.42	624	626.8	628.7	630.4	631.5	632.7	634	635.7	633.3	-0.6
	663.37	624	626.8	628.7	630.4	631.5	632.7	634	635.7	633.3	-0.6
	663.17	623.9	626.7	628.6	630.3	631.4	632.6	633.9	635.7	633.2	-0.6
Lansing, IA	663	623.9	626.7	628.6	630.3	631.4	632.6	633.9	635.6	633.2	-0.6
	662.89	623.8	626.7	628.5	630.3	631.4	632.6	633.8	635.6	633.2	-0.6
	662.35	623.7	626.6	628.5	630.2	631.3	632.5	633.8	635.6	633.1	-0.6
	662	623.7	626.6	628.5	630.2	631.3	632.5	633.8	635.6	633.1	-0.6
	661.29	623.6	626.5	628.4	630.1	631.2	632.4	633.7	635.5	633	-0.6
	660.64	623.5	626.4	628.3	630.1	631.2	632.4	633.6	635.5	632.9	-0.5
	660.36	623.5	626.4	628.3	630	631.1	632.3	633.6	635.4	632.8	-0.5
	660	623.4	626.4	628.3	630	631.1	632.3	633.6	635.4	632.8	-0.5
	659.89	623.4	626.3	628.3	630	631.1	632.3	633.6	635.4	632.8	-0.5
	659.33	623.3	626.3	628.2	629.9	631	632.2	633.5	635.4	632.7	-0.5
	658.88	623.2	626.3	628.2	629.9	631	632.2	633.5	635.3	632.7	-0.5
	658.43	623.2	626.2	628.2	629.9	631	632.2	633.5	635.3	632.7	-0.5
	658.01	623.1	626.2	628.1	629.8	630.9	632.1	633.4	635.3	632.7	-0.6
	657.8	623.1	626.2	628.1	629.8	630.9	632.1	633.4	635.3	632.6	-0.5
	657.59	623.1	626.2	628.1	629.8	630.9	632.1	633.4	635.3	632.6	-0.5
	657.22	623	626.2	628.1	629.8	630.9	632.1	633.4	635.2	632.6	-0.5
	656.95	623	626.1	628.1	629.8	630.9	632.1	633.4	635.2	632.6	-0.5
	656.61	623	626.1	628.1	629.8	630.8	632.1	633.4	635.2	632.6	-0.5
	656.18	623	626.1	628.1	629.7	630.8	632	633.4	635.2	632.6	-0.6
	655.77	622.9	626.1	628	629.7	630.8	632	633.3	635.2	632.6	-0.6
	655.48	622.9	626.1	628	629.7	630.8	632	633.3	635.2	632.6	-0.6
	655.21	622.9	626.1	628	629.7	630.8	632	633.3	635.2	632.6	-0.6
	654.75	622.8	626.1	628	629.7	630.8	632	633.3	635.2	632.5	-0.5
	654.36	622.8	626	628	629.7	630.7	632	633.3	635.1	632.5	-0.5
	654	622.8	626	628	629.6	630.7	631.9	633.3	635.1	632.5	-0.6
	653.59	622.8	626	628	629.6	630.7	631.9	633.2	635.1	632.5	-0.6
	653.41	622.7	626	627.9	629.6	630.7	631.9	633.2	635.1	632.5	-0.6
	653.22	622.7	626	627.9	629.6	630.7	631.9	633.2	635.1	632.5	-0.6

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	652.73	622.7	626	627.9	629.6	630.7	631.9	633.2	635.1	632.5	-0.6
	652	622.7	626	627.9	629.6	630.6	631.9	633.2	635.1	632.4	-0.5
	651.12	622.6	626	627.9	629.5	630.6	631.8	633.2	635.1	632.4	-0.6
	650.59	622.6	625.9	627.9	629.5	630.6	631.8	633.1	635	632.4	-0.6
	650.05	622.6	625.9	627.9	629.5	630.6	631.8	633.1	635	632.4	-0.6
	649.46	622.6	625.9	627.8	629.5	630.6	631.8	633.1	635	632.3	-0.5
	648.97	622.5	625.9	627.8	629.5	630.5	631.8	633.1	635	632.3	-0.5
	648.54	622.5	625.9	627.8	629.4	630.5	631.7	633.1	635	632.3	-0.6
LD 9 hw	648.09	622.5	625.8	627.8	629.4	630.5	631.7	633	634.9	632.3	-0.6
	647.88	621.7	625	627	628.6	629.7	630.9	632.2	634.1	632	-1.1
LD 9 tw	647.72	621.7	625	626.9	628.6	629.6	630.8	632.2	634.1	631.8	-1
	647.21	621.6	624.9	626.9	628.5	629.6	630.8	632.1	634	631.5	-0.7
	646.69	621.5	624.9	626.8	628.5	629.5	630.7	632	633.9	631.2	-0.5
	646.35	621.5	624.9	626.8	628.4	629.5	630.7	632	633.9	631.2	-0.5
Harpers Ferry	645.89	621.4	624.8	626.7	628.3	629.4	630.6	631.9	633.8	631.1	-0.5
	645.45	621.4	624.8	626.7	628.3	629.3	630.5	631.9	633.7	631	-0.5
	645	621.3	624.7	626.6	628.2	629.3	630.5	631.8	633.7	631	-0.5
	644.52	621.2	624.6	626.6	628.2	629.2	630.4	631.7	633.6	630.9	-0.5
	644	621.1	624.5	626.5	628.1	629.1	630.3	631.6	633.5	630.8	-0.5
	643.47	621	624.4	626.4	628	629	630.2	631.5	633.4	630.7	-0.5
	642.97	620.9	624.4	626.3	627.9	629	630.1	631.4	633.3	630.7	-0.6
	642.48	620.8	624.3	626.3	627.9	628.9	630.1	631.4	633.3	630.6	-0.5
	641.94	620.8	624.3	626.3	627.8	628.9	630	631.3	633.2	630.5	-0.5
	641.39	620.7	624.3	626.2	627.8	628.8	630	631.3	633.2	630.4	-0.4
	640.97	620.7	624.2	626.2	627.7	628.7	629.9	631.2	633.1	630.4	-0.5
	640.49	620.6	624.1	626.1	627.6	628.7	629.8	631.1	633	630.4	-0.6
	640	620.5	624.1	626	627.5	628.6	629.7	631	632.9	630.4	-0.7
	639.51	620.4	624	625.9	627.5	628.5	629.7	631	632.9	630.3	-0.6
	639.01	620.3	623.9	625.9	627.4	628.4	629.6	630.9	632.8	630.2	-0.6
	638.51	620.2	623.9	625.8	627.3	628.4	629.5	630.8	632.7	630.2	-0.7
	638.09	620.2	623.8	625.8	627.3	628.3	629.5	630.8	632.7	630.1	-0.6
Yellow River	637.7	620.1	623.8	625.8	627.2	628.3	629.4	630.7	632.6	630	-0.6
	637.23	620	623.7	625.7	627.2	628.2	629.3	630.6	632.5	629.9	-0.6
	636.77	619.9	623.7	625.6	627.1	628.1	629.2	630.5	632.4	629.9	-0.7
	636.27	619.9	623.7	625.6	627.1	628.1	629.2	630.5	632.4	629.8	-0.6

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	635.91	619.8	623.6	625.5	627	628	629.1	630.4	632.3	629.7	-0.6
	635.63	619.8	623.5	625.5	627	627.9	629.1	630.4	632.3	629.7	-0.6
	635.35	619.7	623.5	625.4	626.9	627.9	629	630.3	632.2	629.6	-0.6
Prarie Du Chien	635.03	619.7	623.4	625.4	626.8	627.8	628.9	630.2	632.1	629.6	-0.7
Federal Hwy 18	634.72	619.6	623.4	625.3	626.8	627.8	628.9	630.2	632.1	629.5	-0.6
	634.69	619.6	623.4	625.3	626.8	627.8	628.9	630.2	632.1	629.5	-0.6
	634.47	619.6	623.4	625.3	626.8	627.7	628.9	630.2	632.1	629.5	-0.6
	634.21	619.5	623.4	625.3	626.7	627.7	628.9	630.1	632	629.4	-0.5
	633.92	619.5	623.3	625.3	626.7	627.7	628.8	630.1	632	629.4	-0.6
Mcgregor	633.6	619.4	623.3	625.2	626.6	627.6	628.7	630	631.9	629.4	-0.7
	633.38	619.4	623.3	625.2	626.6	627.6	628.7	630	631.9	629.3	-0.6
	633.18	619.4	623.2	625.1	626.6	627.5	628.7	630	631.9	629.2	-0.5
	632.92	619.3	623.2	625.1	626.5	627.5	628.6	629.9	631.8	629.1	-0.5
	632.44	619.2	623.1	625	626.4	627.4	628.5	629.8	631.7	628.9	-0.4
	631.99	619.1	623	624.9	626.3	627.3	628.4	629.7	631.7	628.7	-0.3
	631.44	619	622.9	624.8	626.2	627.2	628.3	629.6	631.5	628.5	-0.2
	631.26	618.9	622.8	624.6	626.1	627.1	628.3	629.6	631.4	628.4	-0.1
Wisconsin River	631	618.8	622.6	624.5	626	627	628.2	629.4	631.3	628.3	-0.1
	630.83	618.5	622.1	623.8	625.8	627.1	628.3	629.6	631.2	628.2	0.1
	630.61	618.5	622	623.8	625.7	627	628.2	629.4	631.1	628.1	0.1
	630.32	618.4	622	623.7	625.6	626.9	628.1	629.4	631	628	0.1
	629.86	618.3	621.9	623.6	625.5	626.8	628	629.3	630.9	627.8	0.2
	629.42	618.2	621.7	623.4	625.3	626.6	627.8	629	630.6	627.5	0.3
	628.91	617.9	621.4	623.2	625.1	626.4	627.6	628.8	630.4	627.3	0.3
	628.27	617.7	621.1	622.9	624.8	626.1	627.3	628.5	630.1	627	0.3
	627.76	617.5	621	622.7	624.7	625.9	627.2	628.4	630	626.8	0.4
	627.28	617.3	620.7	622.5	624.4	625.7	626.9	628.2	629.8	626.5	0.4
	626.74	617	620.4	622.2	624.1	625.4	626.6	627.9	629.4	626.3	0.3
	626.03	616.8	620.1	621.9	623.8	625.1	626.4	627.6	629.2	625.9	0.5
	625.52	616.5	619.9	621.6	623.6	624.8	626.1	627.3	628.9	625.7	0.4
	625.06	616.4	619.7	621.5	623.5	624.7	626	627.2	628.8	625.5	0.5
Clayton	624.8	616.2	619.5	621.3	623.2	624.5	625.8	627	628.6	625.4	0.4
	624.11	616.1	619.3	621.1	623	624.3	625.6	626.8	628.3	625	0.6
	623.61	616	619.3	621	623	624.2	625.5	626.7	628.3	624.8	0.7
Bagley	623.15	615.9	619.1	620.8	622.8	624.1	625.3	626.5	628.1	624.6	0.7

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	622.59	615.7	618.9	620.6	622.5	623.8	**625**	626.2	627.8	**624.4**	**0.6**
	622	615.3	618.5	620.2	622.1	623.4	**624.7**	625.8	627.4	**624.1**	**0.6**
	621.53	615	618.2	619.9	621.8	623.1	**624.3**	625.5	627	**623.9**	**0.4**
	621.03	614.8	618	619.6	621.5	622.8	**624.1**	625.3	626.8	**623.7**	**0.4**
	620.52	614.7	617.9	619.5	621.4	622.7	**623.9**	625.1	626.6	**623.5**	**0.4**
	620	614.5	617.7	619.3	621.2	622.5	**623.8**	625	626.5	**623.3**	**0.5**
	619.49	614.3	617.5	619.1	621	622.3	**623.6**	624.8	626.3	**623.2**	**0.4**
	618.93	614.2	617.3	618.9	620.9	622.2	**623.4**	624.6	626.1	**623.1**	**0.3**
	618.69	614.1	617.2	618.8	620.8	622.1	**623.4**	624.5	626.1	**623**	**0.4**
	618.21	614	617.1	618.7	620.7	622	**623.2**	624.4	625.9	**622.9**	**0.3**
	617.76	613.9	617	618.6	620.5	621.8	**623.1**	624.3	625.8	**622.8**	**0.3**
	617.41	613.8	616.9	618.5	620.4	621.7	**623**	624.2	625.7	**622.8**	**0.2**
	617.28	613.8	616.9	618.5	620.4	621.7	**623**	624.2	625.7	**622.7**	**0.3**
	616.92	613.7	616.7	618.3	620.2	621.6	**622.8**	624	625.5	**622.7**	**0.1**
	616.65	613.6	616.7	618.2	620.2	621.5	**622.8**	623.9	625.4	**622.6**	**0.2**
	616.37	613.6	616.6	618.2	620.1	621.5	**622.8**	623.9	625.4	**622.6**	**0.2**
	616.04	613.5	616.6	618.1	620.1	621.4	**622.7**	623.9	625.3	**622.5**	**0.2**
	615.77	613.5	616.5	618.1	620	621.3	**622.6**	623.8	625.3	**622.5**	**0.1**
	615.52	613.5	616.5	618	620	621.3	**622.6**	623.7	625.2	**622.4**	**0.2**
	615.27	613.4	616.4	618	619.9	621.2	**622.5**	623.7	625.1	**622.4**	**0.1**
ld 10 pool	**615.2**	613.4	616.4	617.9	619.8	621.1	**622.4**	623.5	625	**622.4**	**0**
ld 10 tw	**614.8**	612.8	615.8	617.3	619.2	620.5	**621.8**	622.9	624.4		

Upper Mississippi River
Flow Frequency Study

Attachment B7
St. Paul District
UNET RESULTS
Mississippi River Computed Elevations – Datum 1912

2003 FLOW FREQUENCY STUDY
FLOOD PROFILES 1912 ADJ

Location	RIVER	FREQUENCY								1979	100 year Profile 2003 Study minus
	MILE	2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	Study	1979 Study
Prescott Gage - St. Croix	**811.4**	681.2	684.8	686.5	688.6	690.1	**691.6**	693.1	695	**691.6**	**0**
	811.06	681.1	684.7	686.4	688.4	689.9	**691.4**	692.9	694.7	**691.3**	**0.1**
	810.68	680.9	684.5	686.2	688.2	689.7	**691.2**	692.6	694.4	**691**	**0.2**
	810.28	680.7	684.2	685.9	687.8	689.3	**690.7**	692.1	693.9	**690.8**	**-0.1**
	810.06	680.5	684	685.7	687.6	689	**690.5**	691.8	693.6	**690.6**	**-0.1**
	809.79	680.4	683.8	685.4	687.3	688.8	**690.2**	691.5	693.2	**690.4**	**-0.2**
	809.68	680.3	683.7	685.3	687.2	688.6	**690**	691.3	693	**690.3**	**-0.3**
	809.33	680.1	683.6	685.1	687	688.4	**689.7**	691	692.7	**690.2**	**-0.5**
	808.79	679.9	683.3	684.9	686.7	688.1	**689.5**	690.7	692.4	**690**	**-0.5**
	808.33	679.7	683.1	684.6	686.5	687.8	**689.2**	690.5	692.2	**689.8**	**-0.6**
	807.69	679.4	682.7	684.3	686.2	687.5	**688.9**	690.2	691.9	**689.5**	**-0.6**
	807	679.1	682.5	684	685.9	687.3	**688.7**	690	691.7	**689.2**	**-0.5**
	806.46	678.9	682.3	683.8	685.7	687.2	**688.5**	689.8	691.5	**688.9**	**-0.4**
	806	678.8	682.2	683.7	685.6	687.1	**688.5**	689.8	691.4	**688.7**	**-0.2**
	805.75	678.7	682.1	683.7	685.6	687	**688.4**	689.7	691.4	**688.7**	**-0.3**
	805.45	678.6	682	683.6	685.5	686.9	**688.3**	689.7	691.3	**688.6**	**-0.3**
	805	678.6	682	683.5	685.4	686.9	**688.3**	689.6	691.3	**688.5**	**-0.2**
Big River	**804.8**	678.5	681.9	683.5	685.4	686.8	**688.2**	689.5	691.2	**688.4**	**-0.2**
	804.55	678.3	681.8	683.4	685.3	686.7	**688.1**	689.5	691.1	**688.4**	**-0.3**
	804.08	678.2	681.7	683.3	685.2	686.6	**688**	689.4	691	**688.2**	**-0.2**
	803.55	678.1	681.7	683.2	685.1	686.5	**688**	689.3	690.9	**688.1**	**-0.1**
	802.91	678	681.5	683.1	685	686.4	**687.8**	689.1	690.8	**687.9**	**-0.1**
	802.46	677.8	681.4	683	684.9	686.3	**687.7**	689.1	690.7	**687.8**	**-0.1**
	802.01	677.6	681.3	682.8	684.7	686.2	**687.6**	688.9	690.6	**687.7**	**-0.1**
	801.51	677.4	681.1	682.7	684.6	686	**687.5**	688.8	690.5	**687.6**	**-0.1**
	800.97	677.2	681	682.6	684.5	685.9	**687.3**	688.7	690.4	**687.5**	**-0.2**
	800.42	677	680.9	682.5	684.4	685.8	**687.2**	688.6	690.3	**687.5**	**-0.3**
Diamond Bluff	**799.97**	677	680.8	682.4	684.3	685.7	**687.2**	688.5	690.2	**687.4**	**-0.2**
	799.5	676.9	680.8	682.3	684.2	685.7	**687.1**	688.4	690.2	**687.4**	**-0.3**
	798.98	676.8	680.7	682.3	684.2	685.6	**687.1**	688.4	690.1	**687.3**	**-0.2**
	798.41	676.7	680.7	682.2	684.1	685.6	**687**	688.3	690	**687.2**	**-0.2**
	798	676.6	680.6	682.1	684	685.5	**686.9**	688.2	689.9	**687.2**	**-0.3**
	797.55	676.5	680.5	682	683.9	685.3	**686.8**	688.1	689.8	**687.2**	**-0.4**
LD3 HW	**796.91**	676.4	680.4	681.9	683.8	685.2	**686.6**	687.9	689.6	**686.9**	**-0.3**
	796.8	676.1	680.1	681.6	683.5	684.9	**686.3**	687.6	689.3	**686.7**	**-0.4**

2003 FLOW FREQUENCY STUDY
FLOOD PROFILES 1912 ADJ

Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
LD 3 TW	**796.61**	676.1	680.1	681.6	683.4	684.8	**686.2**	687.6	689.3	**686.6**	**-0.4**
	796.39	676	680	681.5	683.3	684.8	**686.2**	687.5	689.2	**686.5**	**-0.3**
	796	675.9	679.9	681.4	683.2	684.6	**686**	687.3	689	**686.3**	**-0.3**
	795.45	675.8	679.8	681.3	683.1	684.5	**685.9**	687.2	688.9	**686.1**	**-0.2**
	795	675.7	679.7	681.2	683	684.4	**685.8**	687.1	688.8	**686**	**-0.2**
Cannon River	**794.67**	675.7	679.6	681.1	682.9	684.3	**685.7**	687	688.6	**685.8**	**-0.1**
	794.38	675.6	679.5	681	682.8	684.2	**685.5**	686.8	688.4	**685.7**	**-0.2**
	794.08	675.5	679.4	680.9	682.7	684.1	**685.4**	686.7	688.3	**685.6**	**-0.2**
	793.83	675.4	679.3	680.8	682.6	684	**685.3**	686.6	688.2	**685.5**	**-0.2**
	793.56	675.4	679.2	680.7	682.5	683.9	**685.2**	686.5	688.2	**685.4**	**-0.2**
	793.3	675.3	679.2	680.6	682.5	683.8	**685.2**	686.5	688.1	**685.3**	**-0.1**
	793	675.2	679.1	680.6	682.4	683.8	**685.1**	686.4	688	**685.2**	**-0.1**
	792.64	675.1	679.1	680.5	682.3	683.7	**685**	686.3	688	**685.1**	**-0.1**
	792.26	675	679	680.4	682.2	683.6	**685**	686.3	687.9	**685**	**0**
	791.79	675	678.9	680.3	682.1	683.5	**684.8**	686.1	687.8	**684.8**	**0**
	791.53	674.9	678.8	680.3	682	683.4	**684.7**	686	687.7	**684.7**	**0**
	791.27	674.8	678.7	680.2	681.9	683.2	**684.6**	685.8	687.5	**684.6**	**0**
Red Wing	**790.97**	674.8	678.7	680.1	681.8	683.1	**684.4**	685.7	687.4	**684.5**	**-0.1**
	790.6	674.7	678.6	680	681.7	683	**684.3**	685.6	687.2	**684.2**	**0.1**
	790.56	674.7	678.6	679.9	681.6	682.9	**684.2**	685.5	687.1	**684.2**	**0**
	790.44	674.6	678.4	679.8	681.4	682.7	**684**	685.2	686.8	**684.1**	**-0.1**
	790.3	674.5	678.3	679.7	681.3	682.5	**683.8**	685	686.6	**684**	**-0.2**
	789.99	674.4	678.2	679.6	681.1	682.3	**683.6**	684.8	686.4	**683.8**	**-0.2**
	789.57	674.2	678	679.4	680.9	682.1	**683.3**	684.5	686.1	**683.5**	**-0.2**
	789	674	677.8	679.2	680.7	681.9	**683.1**	684.3	686	**683.1**	**0**
	788.54	673.9	677.7	679.1	680.6	681.7	**682.9**	684.2	685.8	**682.9**	**0**
	787.99	673.8	677.6	679	680.5	681.6	**682.8**	684	685.7	**682.8**	**0**
	787.73	673.7	677.6	678.9	680.4	681.5	**682.7**	683.9	685.5	**682.8**	**-0.1**
	787.47	673.6	677.5	678.8	680.2	681.3	**682.5**	683.7	685.4	**682.8**	**-0.3**
	787.09	673.6	677.4	678.7	680.1	681.2	**682.4**	683.6	685.2	**682.7**	**-0.3**
	786.62	673.5	677.3	678.6	680	681.1	**682.2**	683.5	685.1	**682.7**	**-0.5**
Bay City	**786.19**	673.4	677.2	678.6	679.9	681	**682.1**	683.4	685	**682.6**	**-0.5**
	785.86	673.4	677.2	678.5	679.9	681	**682.1**	683.3	685	**682.6**	**-0.5**
	785.58	673.3	677.2	678.5	679.8	680.9	**682**	683.3	684.9	**682.5**	**-0.5**
	785.33	673.3	677.2	678.5	679.8	680.9	**682**	683.2	684.9	**682.5**	**-0.5**

2003 FLOW FREQUENCY STUDY
FLOOD PROFILES 1912 ADJ

Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	785.02	673.3	677.1	678.4	679.8	680.8	682	683.2	684.9	682.5	-0.5
	784.72	673.3	677.1	678.4	679.8	680.8	681.9	683.2	684.8	682.5	-0.6
	784.47	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	784.24	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	784.02	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	783.65	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	783.3	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	783	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	781.99	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	781.47	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	780.98	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	780.63	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
Rush River	780.19	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	779.98	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	779.81	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	779.39	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	779.19	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
Frontanac	779	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	778.66	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	778.29	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	778.07	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.8	682.5	-0.6
	777.88	673.3	677.1	678.4	679.7	680.8	681.9	683.1	684.7	682.5	-0.6
	777.49	673.3	677.1	678.4	679.7	680.7	681.9	683.1	684.7	682.5	-0.6
	777.08	673.3	677.1	678.3	679.7	680.7	681.9	683.1	684.7	682.5	-0.6
	776.67	673.3	677	678.3	679.7	680.7	681.9	683.1	684.7	682.5	-0.6
	776	673.3	677	678.3	679.7	680.7	681.8	683.1	684.7	682.5	-0.7
	775.19	673.3	677	678.3	679.7	680.7	681.8	683.1	684.7	682.5	-0.7
	774.74	673.3	677	678.3	679.7	680.7	681.8	683.1	684.7	682.5	-0.7
	774.33	673.3	677	678.3	679.6	680.7	681.8	683	684.7	682.5	-0.7
	774.11	673.3	677	678.3	679.6	680.7	681.8	683	684.7	682.5	-0.7
	773.83	673.3	677	678.3	679.6	680.7	681.8	683	684.7	682.5	-0.7
	773.62	673.3	677	678.3	679.6	680.7	681.8	683	684.7	682.5	-0.7
	773.34	673.3	677	678.3	679.6	680.7	681.8	683	684.7	682.5	-0.7
	772.83	673.3	677	678.3	679.6	680.7	681.8	683	684.7	682.5	-0.7
Lake City Gage	772.56	673.3	677	678.3	679.6	680.7	681.8	683	684.7	682.5	-0.7

2003 FLOW FREQUENCY STUDY
FLOOD PROFILES 1912 ADJ

Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	772.34	673.3	677	678.3	679.6	680.7	**681.8**	683	684.7	**682.4**	**-0.6**
	772.09	673.3	677	678.3	679.6	680.7	**681.8**	683	684.7	**682.4**	**-0.6**
	771.81	673.3	677	678.3	679.6	680.7	**681.8**	683	684.7	**682.4**	**-0.6**
	771.31	673.3	677	678.3	679.6	680.7	**681.8**	683	684.7	**682.4**	**-0.6**
	770.88	673.3	676.9	678.3	679.6	680.7	**681.8**	683	684.7	**682.4**	**-0.6**
	770.53	673.3	676.9	678.3	679.6	680.7	**681.8**	683	684.7	**682.4**	**-0.6**
	769.7	673.3	676.9	678.3	679.6	680.7	**681.8**	683	684.6	**682.4**	**-0.6**
	768.72	673.2	676.9	678.2	679.6	680.6	**681.8**	683	684.6	**682.3**	**-0.5**
Pepin	**767.61**	673.2	676.9	678.2	679.6	680.6	**681.7**	683	684.6	**682.3**	**-0.6**
	766.67	673.2	676.8	678.2	679.6	680.6	**681.7**	683	684.6	**682.3**	**-0.6**
	766	673.2	676.8	678.2	679.6	680.6	**681.7**	682.9	684.6	**682.2**	**-0.5**
	765.53	673.2	676.8	678.2	679.5	680.6	**681.7**	682.9	684.6	**682.2**	**-0.5**
	765.1	673.2	676.8	678.2	679.5	680.5	**681.6**	682.9	684.5	**682.2**	**-0.6**
	764.55	673.1	676.7	678.1	679.4	680.4	**681.5**	682.7	684.4	**682**	**-0.5**
	764.09	673	676.6	678	679.2	680.2	**681.3**	682.5	684.2	**681.9**	**-0.6**
	763.66	672.9	676.3	677.7	679	680	**681**	682.2	683.9	**681.7**	**-0.7**
Chippewa River	**763.08**	672.7	676	677.3	678.6	679.6	**680.6**	681.8	683.4	**681.3**	**-0.7**
	762.57	672.5	675.2	676.6	678.2	679.2	**680.3**	681.4	682.7	**680.8**	**-0.5**
	762.27	672.3	674.9	676.3	677.8	678.9	**680**	681	682.4	**680.6**	**-0.6**
	762.06	672.1	674.5	675.9	677.6	678.7	**679.8**	680.8	682.1	**680.4**	**-0.6**
	761.82	671.9	674.3	675.7	677.4	678.5	**679.6**	680.6	681.9	**680.2**	**-0.6**
	761.32	671.6	674	675.4	677	678.1	**679.2**	680.2	681.5	**679.7**	**-0.5**
	760.99	671.3	673.6	675	676.6	677.7	**678.8**	679.9	681.2	**679.5**	**-0.7**
	760.75	671.1	673.4	674.8	676.4	677.5	**678.6**	679.6	681	**679.3**	**-0.7**
	760.5	670.9	673.1	674.5	676.1	677.2	**678.3**	679.4	680.8	**679**	**-0.7**
Wabasha Gage	**760.4**	670.8	673	674.4	676	677.1	**678.2**	679.3	680.7	**679**	**-0.8**
Hwy 25 Bridge	**760.21**	670.7	672.9	674.3	675.9	677	**678.1**	679.2	680.6	**678.8**	**-0.7**
	760.18	670.6	672.9	674.2	675.8	676.9	**678**	679.1	680.5	**678.8**	**-0.8**
Wabasha	**759.92**	670.5	672.7	674.1	675.7	676.8	**677.9**	679	680.4	**678.7**	**-0.8**
	759.68	670.3	672.6	673.9	675.6	676.7	**677.8**	678.9	680.3	**678.5**	**-0.7**
	759.45	670.3	672.5	673.9	675.5	676.6	**677.8**	678.8	680.2	**678.4**	**-0.6**
	759.17	670.1	672.3	673.7	675.4	676.5	**677.7**	678.7	680.1	**678.2**	**-0.5**
	758.83	669.8	672.1	673.6	675.2	676.4	**677.5**	678.6	680	**678**	**-0.5**
	758.29	669.5	671.8	673.3	675	676.2	**677.3**	678.4	679.8	**677.8**	**-0.5**
	758.01	669.3	671.6	673.1	674.8	676	**677.2**	678.3	679.7	**677.7**	**-0.5**

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Location	RIVER MILE	FREQUENCY								1979 Study	100 year Profile 2003 Study minus 1979 Study
		2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		
	757.66	669.1	671.4	672.9	674.7	675.9	**677**	678.1	679.5	**677.5**	**-0.5**
	757.38	668.9	671.3	672.8	674.6	675.8	**676.9**	678	679.4	**677.4**	**-0.5**
Teepeota Point	**757.1**	668.8	671.2	672.7	674.4	675.6	**676.8**	677.9	679.3	**677.3**	**-0.5**
	756.76	668.6	671	672.5	674.3	675.5	**676.6**	677.7	679.2	**677.2**	**-0.6**
	756.37	668.4	670.8	672.3	674.1	675.3	**676.4**	677.5	678.9	**677.1**	**-0.7**
	755.99	668.2	670.6	672.1	673.9	675.1	**676.2**	677.3	678.8	**677**	**-0.8**
	755.46	668	670.4	671.9	673.7	674.9	**676.1**	677.2	678.6	**676.9**	**-0.8**
	755.18	667.8	670.2	671.7	673.5	674.8	**676**	677.1	678.5	**676.9**	**-0.9**
	754.95	667.7	670.1	671.7	673.5	674.7	**675.9**	677	678.4	**676.8**	**-0.9**
Buffalo River	**754.59**	667.5	669.9	671.5	673.3	674.6	**675.8**	676.9	678.3	**676.7**	**-0.9**
	754.2	667.3	669.7	671.3	673.2	674.4	**675.6**	676.7	678.1	**676.6**	**-1**
	753.58	667	669.4	671.1	672.9	674.2	**675.4**	676.5	677.9	**676.5**	**-1.1**
LD 4 HW	**752.95**	666.9	669.1	670.8	672.6	673.9	**675.1**	676.2	677.6	**675.8**	**-0.7**
LD 4 TW	**752.6**	665.6	668.4	670.1	671.9	673.2	**674.4**	675.5	676.9	**675**	**-0.6**
	751.87	665.4	668.1	669.7	671.5	672.7	**673.9**	675	676.3	**674.2**	**-0.3**
	751.11	665.1	667.7	669.2	671	672.2	**673.3**	674.4	675.7	**673.3**	**0**
	750.79	664.9	667.4	668.9	670.6	671.8	**672.9**	674	675.3	**672.9**	**0**
	750.61	664.8	667.3	668.7	670.4	671.6	**672.7**	673.7	675	**672.7**	**0**
Zumbro River	**750.08**	664.6	667	668.3	670	671.1	**672.2**	673.2	674.5	**672.2**	**0**
	749.48	664.3	666.6	667.9	669.6	670.7	**671.8**	672.8	674	**671.9**	**-0.1**
	749.01	664.1	666.3	667.6	669.2	670.3	**671.5**	672.4	673.6	**671.7**	**-0.2**
	748.5	663.9	666	667.3	668.9	670	**671.2**	672.2	673.4	**671.5**	**-0.3**
	748.15	663.6	665.6	666.9	668.5	669.7	**670.9**	671.9	673.1	**671.3**	**-0.4**
	747.78	663.3	665.2	666.5	668.1	669.3	**670.5**	671.5	672.8	**671.1**	**-0.6**
	747.37	663	664.8	666.1	667.8	669	**670.2**	671.2	672.5	**670.9**	**-0.7**
	747	662.8	664.5	665.8	667.4	668.7	**669.9**	671	672.3	**670.7**	**-0.8**
	746.51	662.5	664.2	665.4	667.1	668.4	**669.7**	670.8	672.1	**670.4**	**-0.7**
	745.97	662.3	663.9	665.2	666.9	668.2	**669.5**	670.6	672	**670.2**	**-0.7**
	745.5	662.1	663.6	665	666.7	668.1	**669.4**	670.5	671.9	**669.9**	**-0.5**
	744.95	661.9	663.4	664.8	666.6	667.9	**669.3**	670.4	671.8	**669.7**	**-0.4**
	744.45	661.7	663.1	664.6	666.4	667.8	**669.1**	670.3	671.7	**669.6**	**-0.5**
Buffalo City	**744**	661.5	662.9	664.4	666.3	667.7	**669**	670.2	671.7	**669.5**	**-0.5**
	743.52	661.3	662.6	664.2	666.1	667.6	**668.9**	670.1	671.6	**669.4**	**-0.5**
	743.03	661	662.3	663.9	665.9	667.4	**668.8**	670	671.5	**669.3**	**-0.5**
Whitewater River	**742.5**	660.8	662	663.7	665.8	667.2	**668.6**	669.9	671.4	**669.1**	**-0.5**

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	742.04	660.6	661.8	663.5	665.7	667.1	**668.5**	669.8	671.3	**668.9**	**-0.4**
	741.43	660.4	661.5	663.3	665.5	667	**668.4**	669.7	671.2	**668.7**	**-0.3**
	740.9	660.2	661.3	663.1	665.3	666.8	**668.3**	669.5	671.1	**668.5**	**-0.2**
	740.54	660.1	661.1	662.9	665.1	666.6	**668.1**	669.3	670.9	**668.4**	**-0.3**
	740	660	660.8	662.6	664.9	666.4	**667.8**	669.1	670.7	**668.2**	**-0.4**
	739.37	659.9	660.5	662.3	664.6	666.1	**667.5**	668.8	670.4	**668**	**-0.5**
	738.75	659.9	660.3	662	664.3	665.8	**667.2**	668.5	670.1	**667.8**	**-0.6**
LD 5 Pool	**738.27**	659.9	660.1	661.7	663.9	665.5	**666.9**	668.2	669.8	**667.6**	**-0.7**
LD 5 TW	**737.9**	656.1	659	660.8	663.1	664.6	**666**	667.3	669	**666.7**	**-0.7**
	737.85	656	658.9	660.7	663	664.5	**665.9**	667.2	668.9	**666.7**	**-0.8**
	737.57	655.8	658.7	660.5	662.8	664.2	**665.6**	666.9	668.5	**666.4**	**-0.8**
	736.85	655.7	658.5	660.3	662.5	664	**665.3**	666.6	668.2	**665.7**	**-0.4**
	736.2	655.5	658.3	660.1	662.3	663.8	**665.1**	666.4	667.9	**665.3**	**-0.2**
	735.69	655.4	658.2	660	662.2	663.6	**664.9**	666.2	667.7	**665.2**	**-0.3**
	735.03	655.2	658	659.8	662	663.4	**664.7**	666	667.6	**665**	**-0.3**
Waumandee creek	**734.49**	655	657.8	659.7	661.9	663.3	**664.6**	665.8	667.4	**664.9**	**-0.3**
	733.84	654.7	657.6	659.4	661.6	663	**664.4**	665.6	667.3	**664.7**	**-0.3**
Fountain City	**733.4**	654.5	657.4	659.3	661.5	662.9	**664.2**	665.5	667.2	**664.6**	**-0.4**
	732.99	654.4	657.3	659.2	661.4	662.8	**664.2**	665.5	667.1	**664.5**	**-0.3**
	732.67	654.3	657.2	659.1	661.4	662.8	**664.1**	665.4	667	**664.4**	**-0.3**
	732.25	654.2	657.1	659.1	661.3	662.7	**664**	665.3	667	**664.2**	**-0.2**
	731.92	654.1	657.1	659	661.3	662.6	**664**	665.3	666.9	**664**	**0**
	731.33	653.9	656.9	658.9	661.2	662.5	**663.8**	665.1	666.8	**663.9**	**-0.1**
	730.85	653.7	656.8	658.8	661.1	662.4	**663.7**	665	666.7	**663.9**	**-0.2**
	730.76	653.7	656.8	658.8	661	662.4	**663.7**	665	666.7	**663.8**	**-0.1**
	730.53	653.6	656.7	658.7	660.9	662.3	**663.6**	664.9	666.6	**663.8**	**-0.2**
	730.26	653.4	656.5	658.6	660.8	662.1	**663.5**	664.8	666.4	**663.8**	**-0.3**
	729.87	653.2	656.4	658.4	660.6	662	**663.3**	664.6	666.3	**663.7**	**-0.4**
	729.42	653.1	656.3	658.4	660.5	661.9	**663.2**	664.5	666.1	**663.5**	**-0.3**
	728.95	653	656.2	658.2	660.4	661.7	**663**	664.3	665.9	**663.1**	**-0.1**
LD 5A HW	**728.65**	652.9	656.1	658.1	660.2	661.5	**662.8**	664.1	665.7	**662.9**	**-0.1**
	728.59	652.9	656.1	658.1	660.2	661.5	**662.7**	664	665.6	**662.8**	**-0.1**
	728.52	652.9	656	658	660.1	661.4	**662.7**	663.9	665.5	**662.7**	**0**
	728.48	652.1	655.2	657.2	659.3	660.6	**661.9**	663.1	664.7	**662.6**	**-0.7**
LD 5A TW	**728.28**	652	655.2	657.2	659.2	660.5	**661.8**	663	664.6	**662.4**	**-0.6**

	2003 FLOW FREQUENCY STUDY FLOOD PROFILES 1912 ADJ										
Location	RIVER MILE	FREQUENCY								1979 Study	100 year Profile 2003 Study minus 1979 Study
		2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		
	727.89	651.9	655.1	657.1	659.1	660.4	**661.6**	662.8	664.3	**661.9**	**-0.3**
	727.58	651.8	655	657	659	660.2	**661.4**	662.5	664	**661.5**	**-0.1**
	727.17	651.7	654.9	656.9	658.9	660	**661.2**	662.3	663.8	**661.2**	**0**
	726.9	651.6	654.8	656.8	658.8	659.9	**661**	662.1	663.5	**661**	**0**
	726.72	651.5	654.7	656.7	658.7	659.8	**660.9**	662	663.4	**661**	**-0.1**
	726.46	651.3	654.6	656.6	658.5	659.7	**660.7**	661.8	663.1	**660.9**	**-0.2**
	726.15	651.2	654.5	656.5	658.4	659.5	**660.5**	661.5	662.8	**660.7**	**-0.2**
Hwy 54	**725.83**	651.1	654.3	656.3	658.2	659.2	**660.2**	661.2	662.4	**660.5**	**-0.3**
	725.78	651.1	654.3	656.3	658.1	659.1	**660.1**	661	662.2	**660.5**	**-0.4**
Winona Gage	**725.7**	651	654.2	656.2	658	659	**660**	660.9	662	**660.4**	**-0.4**
RR	**725.66**	650.9	654.1	656.1	657.9	658.9	**659.9**	660.8	661.9	**660.4**	**-0.5**
	725.63	650.8	654	656	657.8	658.8	**659.7**	660.6	661.7	**660.3**	**-0.6**
	725.23	650.7	653.9	655.9	657.6	658.6	**659.5**	660.4	661.5	**660**	**-0.5**
	724.93	650.6	653.8	655.7	657.4	658.4	**659.2**	660.1	661.2	**659.8**	**-0.6**
	724.68	650.5	653.7	655.6	657.3	658.3	**659.1**	660	661.1	**659.6**	**-0.5**
	724.37	650.4	653.6	655.5	657.1	658	**658.8**	659.7	660.8	**659.3**	**-0.5**
	724.14	650.3	653.5	655.4	656.9	657.8	**658.6**	659.5	660.6	**659.1**	**-0.5**
	723.81	650.2	653.3	655.2	656.7	657.5	**658.4**	659.3	660.4	**658.7**	**-0.3**
	723.49	650.1	653.2	655.1	656.5	657.4	**658.2**	659.1	660.2	**658.4**	**-0.2**
	723.03	650	653.1	655	656.4	657.2	**658.1**	659	660.1	**658**	**0.1**
	722.71	649.9	653	654.9	656.3	657.1	**658**	658.9	660.1	**658**	**0**
	722.44	649.7	652.9	654.8	656.2	657	**657.9**	658.8	660	**657.9**	**0**
	721.86	649.5	652.7	654.6	656	656.9	**657.8**	658.7	659.9	**657.8**	**0**
	721.51	649.3	652.5	654.4	655.8	656.7	**657.6**	658.5	659.8	**657.7**	**-0.1**
	721.03	649.2	652.3	654.2	655.6	656.5	**657.4**	658.4	659.7	**657.6**	**-0.2**
	720.24	648.9	652	653.8	655.3	656.2	**657.1**	658.1	659.4	**657.2**	**-0.1**
	719.51	648.6	651.6	653.4	654.9	655.7	**656.7**	657.7	659.1	**656.9**	**-0.2**
	718.98	648.3	651.3	653	654.5	655.3	**656.3**	657.3	658.8	**656.6**	**-0.3**
	718.54	648.1	651	652.7	654.2	655	**656**	657.1	658.5	**656.4**	**-0.4**
	718.1	647.9	650.8	652.5	654	654.8	**655.7**	656.8	658.3	**656.2**	**-0.5**
	717.79	647.8	650.7	652.3	653.8	654.6	**655.6**	656.7	658.2	**656**	**-0.4**
	717.34	647.6	650.5	652.1	653.6	654.4	**655.4**	656.5	658	**655.8**	**-0.4**
Trempealeau river	**717.21**	647.5	650.4	652	653.5	654.3	**655.3**	656.4	657.9	**655.7**	**-0.4**
	716.87	647.3	650.2	651.8	653.3	654.1	**655**	656.1	657.6	**655.5**	**-0.5**
	716.37	647.1	649.9	651.5	653	653.8	**654.7**	655.8	657.3	**655.3**	**-0.6**

	2003 FLOW FREQUENCY STUDY FLOOD PROFILES 1912 ADJ										
Location	RIVER MILE	FREQUENCY								1979 Study	100 year Profile 2003 Study minus 1979 Study
		2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year		
	715.88	646.9	649.7	651.2	652.7	653.5	**654.4**	655.5	657	**655**	**-0.6**
	715.4	646.8	649.5	651	652.5	653.2	**654.2**	655.3	656.8	**654.8**	**-0.6**
	715	646.6	649.3	650.8	652.2	652.9	**653.9**	655	656.5	**654.4**	**-0.5**
LD 6 Pool	**714.44**	646.3	648.9	650.4	651.8	652.5	**653.4**	654.5	656	**653.8**	**-0.4**
	714.31	646.3	648.8	650.3	651.7	652.4	**653.3**	654.4	655.8	**653.3**	**0**
	714.26	644.8	647.3	648.8	650.2	650.9	**651.8**	652.9	654.3	**653.1**	**-1.3**
	714.17	644.8	647.3	648.7	650.2	650.8	**651.7**	652.8	654.2	**652.8**	**-1.1**
LD 6 TW	**714.07**	644.7	647.2	648.7	650.1	650.8	**651.7**	652.7	654.1	**652.4**	**-0.7**
	713.71	644.6	647	648.4	649.9	650.6	**651.5**	652.5	653.9	**652.1**	**-0.6**
	713.19	644.3	646.7	648.1	649.6	650.3	**651.2**	652.2	653.6	**651.8**	**-0.6**
	712.75	644.2	646.5	647.9	649.3	650.1	**651**	652	653.3	**651.5**	**-0.5**
	712.26	643.9	646.2	647.6	649	649.8	**650.6**	651.6	653	**651.1**	**-0.5**
	711.72	643.6	645.9	647.3	648.7	649.5	**650.4**	651.4	652.7	**650.7**	**-0.3**
	711.3	643.4	645.6	647	648.4	649.3	**650.1**	651.1	652.5	**650.4**	**-0.3**
	710.81	643	645.3	646.6	648.1	648.9	**649.8**	650.8	652.2	**650.1**	**-0.3**
	710.15	642.6	644.8	646.2	647.6	648.5	**649.4**	650.4	651.7	**649.6**	**-0.2**
	709.58	642.2	644.3	645.7	647.1	648.1	**649**	650	651.3	**649.2**	**-0.2**
Black River	**709.08**	641.8	643.9	645.1	646.7	647.7	**648.6**	649.6	650.8	**648.9**	**-0.3**
	708.7	641.5	643.6	644.8	646.4	647.4	**648.4**	649.3	650.6	**648.8**	**-0.4**
	708	641.2	643.2	644.5	646.1	647.1	**648.1**	649.1	650.3	**648.5**	**-0.4**
Dakota Gage	**707.23**	641	642.9	644.3	645.8	646.9	**647.9**	648.9	650.1	**648.2**	**-0.3**
	707.13	640.9	642.8	644.2	645.7	646.8	**647.8**	648.8	650	**648.2**	**-0.4**
	706.64	640.6	642.6	643.9	645.5	646.6	**647.6**	648.6	649.8	**648**	**-0.4**
	706.22	640.5	642.4	643.8	645.4	646.5	**647.5**	648.5	649.7	**647.9**	**-0.4**
Drebash, MN	**705.73**	640.2	642.2	643.6	645.2	646.3	**647.3**	648.3	649.6	**647.8**	**-0.5**
	705.09	639.9	642	643.4	645	646.1	**647.2**	648.2	649.5	**647.6**	**-0.4**
	704.56	639.6	641.8	643.2	644.9	646	**647.1**	648.1	649.5	**647.5**	**-0.4**
	704.03	639.4	641.6	643.1	644.8	645.9	**647**	648	649.4	**647.4**	**-0.4**
	703.92	639.3	641.6	643.1	644.8	645.9	**647**	648	649.4	**647.4**	**-0.4**
	703.82	639.3	641.6	643.1	644.7	645.9	**646.9**	648	649.4	**647.4**	**-0.5**
	703.73	639.3	641.5	643.1	644.7	645.9	**646.9**	648	649.4	**647.4**	**-0.5**
	703.54	639.2	641.5	643	644.7	645.8	**646.9**	648	649.4	**647.3**	**-0.4**
	703.25	639.1	641.4	643	644.7	645.8	**646.8**	647.9	649.3	**647.3**	**-0.5**
	702.97	639	641.3	642.9	644.7	645.7	**646.6**	647.8	649.2	**647.3**	**-0.7**
LD 7 Pool	**702.61**	639	641.2	642.8	644.7	645.6	**646.3**	647.7	649.2	**647.2**	**-0.9**

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Location	RIVER MILE	FREQUENCY									1979 Study	100 year Profile 2003 Study minus 1979 Study
		2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year			
	702.47	637.8	640.5	642.1	643.8	644.9	646	647	648.5		646.9	-0.9
LD 7 TW	702.32	637.7	640.5	642	643.7	644.8	645.9	646.9	648.4		646.6	-0.7
	702.17	637.7	640.4	642	643.6	644.8	645.8	646.9	648.3		646.4	-0.6
	701.93	637.7	640.4	642	643.6	644.7	645.8	646.9	648.3		646.3	-0.5
	701.82	637.7	640.4	641.9	643.5	644.6	645.7	646.8	648.2		646.2	-0.5
	701.76	637.7	640.4	641.9	643.5	644.6	645.7	646.7	648.2		646.2	-0.5
	701.66	637.6	640.3	641.9	643.5	644.6	645.7	646.7	648.1		646.2	-0.5
	701.28	637.6	640.3	641.8	643.4	644.5	645.6	646.6	648		646	-0.4
	700.85	637.5	640.2	641.8	643.3	644.4	645.5	646.5	647.9		645.8	-0.3
	700.37	637.5	640.1	641.6	643.2	644.3	645.3	646.4	647.7		645.5	-0.2
	700.22	637.4	640.1	641.6	643.1	644.2	645.2	646.3	647.6		645.4	-0.2
	700.17	637.4	640	641.5	643.1	644.1	645.2	646.2	647.6		645.4	-0.2
	700.06	637.4	640	641.5	643	644.1	645.1	646.1	647.5		645.4	-0.3
	699.8	637.3	639.9	641.4	642.9	643.9	645	646	647.4		645.2	-0.2
	699.74	637.3	639.9	641.4	642.9	643.9	645	646	647.3		645.2	-0.2
	699.36	637.2	639.8	641.3	642.8	643.8	644.8	645.8	647.2		645	-0.2
	699.06	637.1	639.7	641.1	642.6	643.6	644.6	645.6	646.9		644.9	-0.3
La Crosse River	698.37	637	639.5	640.9	642.3	643.2	644.2	645.2	646.5		644.5	-0.3
State Hwy 61 Bridge	697.52	636.8	639.2	640.6	641.9	642.7	643.7	644.6	645.9		643.4	0.3
	697.47	636.7	639	640.4	641.7	642.5	643.5	644.4	645.6		643.4	0.1
	697.42	636.7	639	640.4	641.6	642.5	643.4	644.3	645.5		643.4	0
	697.38	636.6	638.9	640.3	641.5	642.3	643.2	644.1	645.3		643.4	-0.2
	697.22	636.5	638.8	640.2	641.4	642.2	643	643.9	645.1		643.3	-0.3
	696.94	636.4	638.7	640	641.2	642	642.8	643.6	644.8		643.1	-0.3
	696.75	636.4	638.6	639.9	641.1	641.9	642.7	643.5	644.7		643	-0.3
	696.56	636.3	638.5	639.8	641	641.7	642.5	643.3	644.5		642.9	-0.4
	696.34	636.2	638.3	639.6	640.8	641.5	642.3	643.1	644.3		642.7	-0.4
	696.2	636.1	638.2	639.4	640.6	641.3	642.1	642.9	644.1		642.6	-0.5
	696.03	635.9	638	639.2	640.4	641.1	641.9	642.7	643.9		642.5	-0.6
	695.61	635.8	637.8	639	640.1	640.9	641.7	642.5	643.7		642.3	-0.6
	695.12	635.6	637.6	638.8	639.9	640.6	641.4	642.3	643.4		642	-0.6
	694.74	635.5	637.4	638.6	639.7	640.4	641.2	642.1	643.3		641.7	-0.5
	694.32	635.3	637.2	638.4	639.5	640.3	641.1	641.9	643.1		641.4	-0.3
Root River	693.99	635.1	637	638.1	639.3	640	640.8	641.7	642.9		641.2	-0.4
	693.53	634.8	636.6	637.7	638.9	639.7	640.5	641.4	642.6		640.9	-0.4

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	693.24	634.5	636.3	637.5	638.6	639.5	**640.3**	641.2	642.4	**640.7**	**-0.4**
	692.96	634.3	636.1	637.2	638.4	639.3	**640.1**	641	642.2	**640.5**	**-0.4**
	692.64	634.1	635.9	637	638.2	639.1	**640**	640.9	642.1	**640.2**	**-0.2**
	692.22	634	635.7	636.8	638.1	639	**639.9**	640.8	642	**639.9**	**0**
	691.81	633.8	635.5	636.6	637.9	638.8	**639.7**	640.6	641.9	**639.6**	**0.1**
	691.42	633.6	635.4	636.5	637.7	638.6	**639.6**	640.5	641.7	**639.5**	**0.1**
	691.3	633.5	635.3	636.4	637.7	638.6	**639.5**	640.4	641.7	**639.5**	**0**
	691	633.4	635.1	636.2	637.5	638.4	**639.4**	640.3	641.6	**639.5**	**-0.1**
	690.56	633.2	634.9	636	637.4	638.3	**639.2**	640.2	641.5	**639.4**	**-0.2**
	690.17	632.9	634.7	635.8	637.2	638.1	**639.1**	640	641.3	**639.4**	**-0.3**
	689.76	632.6	634.4	635.6	637	637.9	**638.9**	639.9	641.2	**639.3**	**-0.4**
	689.35	632.4	634.2	635.4	636.8	637.8	**638.8**	639.7	641.1	**639.2**	**-0.4**
	688.95	632.2	634	635.2	636.7	637.7	**638.7**	639.7	641	**639.2**	**-0.5**
	688.6	632.1	633.9	635.2	636.6	637.6	**638.6**	639.6	640.9	**639.2**	**-0.6**
Brownsville Gage	**688.37**	632	633.9	635.1	636.5	637.6	**638.6**	639.6	640.9	**639.1**	**-0.5**
	688.14	632	633.8	635.1	636.5	637.5	**638.5**	639.5	640.9	**639.1**	**-0.6**
	687.57	631.8	633.7	635	636.4	637.4	**638.4**	639.5	640.8	**639.1**	**-0.7**
	687.26	631.7	633.6	634.9	636.3	637.4	**638.4**	639.4	640.8	**639**	**-0.6**
	686.83	631.6	633.5	634.8	636.3	637.3	**638.3**	639.4	640.7	**639**	**-0.7**
	686.42	631.6	633.4	634.8	636.2	637.3	**638.3**	639.3	640.7	**639**	**-0.7**
	685.83	631.5	633.3	634.7	636.2	637.2	**638.3**	639.3	640.7	**638.9**	**-0.6**
	685.28	631.4	633.2	634.6	636.1	637.1	**638.2**	639.2	640.6	**638.8**	**-0.6**
	684.79	631.3	633.1	634.5	636	637.1	**638.1**	639.2	640.6	**638.8**	**-0.7**
Coon Creek	**684.36**	631.2	633	634.4	635.9	637	**638.1**	639.1	640.5	**638.8**	**-0.7**
	684.01	631.1	633	634.4	635.9	637	**638**	639.1	640.5	**638.7**	**-0.7**
	683.56	631	632.9	634.3	635.8	636.9	**638**	639	640.4	**638.7**	**-0.7**
	683.04	630.9	632.8	634.2	635.8	636.8	**637.9**	639	640.4	**638.6**	**-0.7**
	682.56	630.9	632.7	634.2	635.7	636.8	**637.8**	638.9	640.3	**638.5**	**-0.7**
	682.01	630.8	632.6	634.1	635.6	636.7	**637.8**	638.9	640.3	**638.5**	**-0.7**
	681.6	630.7	632.6	634	635.6	636.7	**637.7**	638.8	640.3	**638.4**	**-0.7**
	681.23	630.7	632.5	634	635.5	636.6	**637.7**	638.8	640.2	**638.4**	**-0.7**
	680.9	630.7	632.4	633.9	635.5	636.6	**637.6**	638.7	640.2	**638.3**	**-0.7**
	680.49	630.6	632.3	633.8	635.4	636.5	**637.6**	638.6	640.1	**638.3**	**-0.7**
	680.29	630.6	632.2	633.7	635.3	636.4	**637.5**	638.6	640	**638.2**	**-0.7**
	679.95	630.6	632.1	633.6	635.2	636.3	**637.4**	638.5	640	**638.2**	**-0.8**

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
Genoa, WI	**679.69**	630.6	632.1	633.6	635.1	636.2	**637.3**	638.4	639.9	**638.1**	**-0.8**
LD 8 hw	**679.39**	630.6	632	633.5	635.1	636.2	**637.3**	638.4	639.8	**638.1**	**-0.8**
	679.15	628.8	631.2	632.7	634.3	635.4	**636.5**	637.6	639	**637.5**	**-1**
LD 8 tw	**678.94**	628.8	631.2	632.7	634.2	635.3	**636.4**	637.5	639	**637.2**	**-0.8**
	678.52	628.6	631	632.5	634.1	635.2	**636.3**	637.4	638.9	**637.1**	**-0.8**
	678.1	628.5	630.9	632.4	633.9	635	**636.1**	637.2	638.7	**636.9**	**-0.8**
	677.74	628.4	630.7	632.2	633.8	634.9	**636**	637.1	638.6	**636.7**	**-0.7**
	677.59	628.3	630.7	632.1	633.7	634.8	**635.9**	637	638.5	**636.7**	**-0.8**
	677.07	628.1	630.5	632	633.5	634.6	**635.7**	636.8	638.3	**636.5**	**-0.8**
	676.58	627.9	630.3	631.7	633.3	634.4	**635.5**	636.6	638.2	**636.3**	**-0.8**
	676.15	627.7	630.1	631.6	633.2	634.3	**635.4**	636.5	638	**636.1**	**-0.7**
	675.6	627.5	629.8	631.4	633	634.1	**635.2**	636.3	637.9	**635.9**	**-0.7**
Bad AX River	**675.1**	627.1	629.5	631.1	632.8	633.9	**635**	636.2	637.7	**635.7**	**-0.7**
	674.75	626.9	629.3	630.9	632.6	633.7	**634.9**	636	637.6	**635.6**	**-0.7**
	674.13	626.6	629	630.7	632.4	633.5	**634.7**	635.9	637.5	**635.5**	**-0.8**
	673.96	626.5	628.9	630.6	632.4	633.5	**634.6**	635.8	637.4	**635.5**	**-0.9**
MN - IA Border	**673.9**	626.5	628.9	630.6	632.3	633.4	**634.6**	635.8	637.4	**635.5**	**-0.9**
	673.57	626.4	628.8	630.5	632.3	633.4	**634.5**	635.7	637.3	**635.4**	**-0.9**
	673.25	626.3	628.7	630.4	632.2	633.3	**634.4**	635.6	637.3	**635.3**	**-0.9**
Victory, WI	**672.97**	626.2	628.6	630.4	632.1	633.2	**634.4**	635.6	637.2	**635.3**	**-0.9**
	672.4	626.1	628.6	630.3	632.1	633.2	**634.3**	635.5	637.2	**635.2**	**-0.9**
	671.91	626	628.5	630.3	632	633.1	**634.3**	635.5	637.1	**635.1**	**-0.8**
	671.43	626	628.4	630.2	632	633.1	**634.2**	635.4	637.1	**635**	**-0.8**
Upper Iowa River	**671.08**	625.8	628.3	630.1	631.8	632.9	**634.1**	635.3	636.9	**635**	**-0.9**
	670.61	625.7	628.2	630	631.7	632.8	**634**	635.2	636.9	**634.9**	**-0.9**
	669.99	625.5	628.1	629.9	631.6	632.7	**633.9**	635.1	636.8	**634.8**	**-0.9**
	669.53	625.4	628	629.8	631.5	632.6	**633.8**	635	636.7	**634.7**	**-0.9**
	669.11	625.3	627.9	629.7	631.5	632.6	**633.7**	635	636.7	**634.7**	**-1**
	668.56	625.2	627.8	629.6	631.4	632.5	**633.7**	634.9	636.6	**634.6**	**-0.9**
	668.09	625.2	627.8	629.6	631.3	632.4	**633.6**	634.9	636.6	**634.5**	**-0.9**
De Soto	**667.59**	625.1	627.7	629.5	631.3	632.4	**633.6**	634.8	636.5	**634.4**	**-0.8**
	667.05	625	627.6	629.5	631.2	632.4	**633.5**	634.8	636.5	**634.3**	**-0.8**
	666.63	624.9	627.6	629.5	631.2	632.3	**633.5**	634.8	636.5	**634.3**	**-0.8**
	665.97	624.8	627.5	629.4	631.2	632.3	**633.5**	634.7	636.4	**634.2**	**-0.7**
	665.5	624.8	627.5	629.4	631.1	632.2	**633.4**	634.7	636.4	**634.1**	**-0.7**

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Location	RIVER MILE	FREQUENCY									1979 Study	100 year Profile 2003 Study minus 1979 Study
		2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year			
	665.04	624.7	627.4	629.3	631.1	632.2	**633.4**	634.6	636.4		**634**	**-0.6**
	664.6	624.6	627.4	629.3	631	632.1	**633.3**	634.6	636.3		**634**	**-0.7**
	664.12	624.6	627.4	629.2	631	632.1	**633.3**	634.6	636.3		**633.9**	**-0.6**
	663.63	624.5	627.3	629.2	630.9	632	**633.2**	634.5	636.3		**633.8**	**-0.6**
State Hwy 82 bridge	**663.42**	624.5	627.3	629.2	630.9	632	**633.2**	634.5	636.2		**633.8**	**-0.6**
	663.37	624.5	627.3	629.2	630.9	632	**633.2**	634.5	636.2		**633.8**	**-0.6**
	663.17	624.4	627.2	629.1	630.8	631.9	**633.1**	634.4	636.2		**633.7**	**-0.6**
Lansing, IA	**663**	624.4	627.2	629.1	630.8	631.9	**633.1**	634.4	636.1		**633.7**	**-0.6**
	662.89	624.3	627.2	629	630.8	631.9	**633.1**	634.3	636.1		**633.7**	**-0.6**
	662.35	624.2	627.1	629	630.7	631.8	**633**	634.3	636.1		**633.6**	**-0.6**
	662	624.2	627.1	629	630.7	631.8	**633**	634.3	636.1		**633.6**	**-0.6**
	661.29	624.1	627	628.9	630.6	631.7	**632.9**	634.2	636		**633.5**	**-0.6**
	660.64	624	626.9	628.8	630.6	631.7	**632.9**	634.1	636		**633.4**	**-0.5**
	660.36	624	626.9	628.8	630.5	631.6	**632.8**	634.1	635.9		**633.3**	**-0.5**
	660	623.9	626.9	628.8	630.5	631.6	**632.8**	634.1	635.9		**633.3**	**-0.5**
	659.89	623.9	626.8	628.8	630.5	631.6	**632.8**	634.1	635.9		**633.3**	**-0.5**
	659.33	623.8	626.8	628.7	630.4	631.5	**632.7**	634	635.9		**633.2**	**-0.5**
	658.88	623.7	626.8	628.7	630.4	631.5	**632.7**	634	635.8		**633.2**	**-0.5**
	658.43	623.7	626.7	628.7	630.4	631.5	**632.7**	634	635.8		**633.2**	**-0.5**
	658.01	623.6	626.7	628.6	630.3	631.4	**632.6**	633.9	635.8		**633.2**	**-0.6**
	657.8	623.6	626.7	628.6	630.3	631.4	**632.6**	633.9	635.8		**633.1**	**-0.5**
	657.59	623.6	626.7	628.6	630.3	631.4	**632.6**	633.9	635.8		**633.1**	**-0.5**
	657.22	623.5	626.7	628.6	630.3	631.4	**632.6**	633.9	635.7		**633.1**	**-0.5**
	656.95	623.5	626.6	628.6	630.3	631.4	**632.6**	633.9	635.7		**633.1**	**-0.5**
	656.61	623.5	626.6	628.6	630.3	631.3	**632.6**	633.9	635.7		**633.1**	**-0.5**
	656.18	623.5	626.6	628.6	630.2	631.3	**632.5**	633.9	635.7		**633.1**	**-0.6**
	655.77	623.4	626.6	628.5	630.2	631.3	**632.5**	633.8	635.7		**633.1**	**-0.6**
	655.48	623.4	626.6	628.5	630.2	631.3	**632.5**	633.8	635.7		**633.1**	**-0.6**
	655.21	623.4	626.6	628.5	630.2	631.3	**632.5**	633.8	635.7		**633.1**	**-0.6**
	654.75	623.3	626.6	628.5	630.2	631.3	**632.5**	633.8	635.7		**633**	**-0.5**
	654.36	623.3	626.5	628.5	630.2	631.2	**632.5**	633.8	635.6		**633**	**-0.5**
	654	623.3	626.5	628.5	630.1	631.2	**632.4**	633.8	635.6		**633**	**-0.6**
	653.59	623.3	626.5	628.5	630.1	631.2	**632.4**	633.7	635.6		**633**	**-0.6**
	653.41	623.2	626.5	628.4	630.1	631.2	**632.4**	633.7	635.6		**633**	**-0.6**
	653.22	623.2	626.5	628.4	630.1	631.2	**632.4**	633.7	635.6		**633**	**-0.6**

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Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	652.73	623.2	626.5	628.4	630.1	631.2	**632.4**	633.7	635.6	**633**	**-0.6**
	652	623.2	626.5	628.4	630.1	631.1	**632.4**	633.7	635.6	**632.9**	**-0.5**
	651.12	623.1	626.5	628.4	630	631.1	**632.3**	633.7	635.6	**632.9**	**-0.6**
	650.59	623.1	626.4	628.4	630	631.1	**632.3**	633.6	635.5	**632.9**	**-0.6**
	650.05	623.1	626.4	628.4	630	631.1	**632.3**	633.6	635.5	**632.9**	**-0.6**
	649.46	623.1	626.4	628.3	630	631.1	**632.3**	633.6	635.5	**632.8**	**-0.5**
	648.97	623	626.4	628.3	630	631	**632.3**	633.6	635.5	**632.8**	**-0.5**
	648.54	623	626.4	628.3	629.9	631	**632.2**	633.6	635.5	**632.8**	**-0.6**
LD 9 hw	**648.09**	623	626.3	628.3	629.9	631	**632.2**	633.5	635.4	**632.8**	**-0.6**
	647.88	622.2	625.5	627.5	629.1	630.2	**631.4**	632.7	634.6	**632.5**	**-1.1**
LD 9 tw	**647.72**	622.2	625.5	627.4	629.1	630.1	**631.3**	632.7	634.6	**632.3**	**-1**
	647.21	622.1	625.4	627.4	629	630.1	**631.3**	632.6	634.5	**632**	**-0.7**
	646.69	622	625.4	627.3	629	630	**631.2**	632.5	634.4	**631.7**	**-0.5**
	646.35	622	625.4	627.3	628.9	630	**631.2**	632.5	634.4	**631.7**	**-0.5**
Harpers Ferry	**645.89**	621.9	625.3	627.2	628.8	629.9	**631.1**	632.4	634.3	**631.6**	**-0.5**
	645.45	621.9	625.3	627.2	628.8	629.8	**631**	632.4	634.2	**631.5**	**-0.5**
	645	621.8	625.2	627.1	628.7	629.8	**631**	632.3	634.2	**631.5**	**-0.5**
	644.52	621.7	625.1	627.1	628.7	629.7	**630.9**	632.2	634.1	**631.4**	**-0.5**
	644	621.6	625	627	628.6	629.6	**630.8**	632.1	634	**631.3**	**-0.5**
	643.47	621.5	624.9	626.9	628.5	629.5	**630.7**	632	633.9	**631.2**	**-0.5**
	642.97	621.4	624.9	626.8	628.4	629.5	**630.6**	631.9	633.8	**631.2**	**-0.6**
	642.48	621.3	624.8	626.8	628.4	629.4	**630.6**	631.9	633.8	**631.1**	**-0.5**
	641.94	621.3	624.8	626.8	628.3	629.4	**630.5**	631.8	633.7	**631**	**-0.5**
	641.39	621.2	624.8	626.7	628.3	629.3	**630.5**	631.8	633.7	**630.9**	**-0.4**
	640.97	621.2	624.7	626.7	628.2	629.2	**630.4**	631.7	633.6	**630.9**	**-0.5**
	640.49	621.1	624.6	626.6	628.1	629.2	**630.3**	631.6	633.5	**630.9**	**-0.6**
	640	621	624.6	626.5	628	629.1	**630.2**	631.5	633.4	**630.9**	**-0.7**
	639.51	620.9	624.5	626.4	628	629	**630.2**	631.5	633.4	**630.8**	**-0.6**
	639.01	620.8	624.4	626.4	627.9	628.9	**630.1**	631.4	633.3	**630.7**	**-0.6**
	638.51	620.7	624.4	626.3	627.8	628.9	**630**	631.3	633.2	**630.7**	**-0.7**
	638.09	620.7	624.3	626.3	627.8	628.8	**630**	631.3	633.2	**630.6**	**-0.6**
Yellow River	**637.7**	620.6	624.3	626.3	627.7	628.8	**629.9**	631.2	633.1	**630.5**	**-0.6**
	637.23	620.5	624.2	626.2	627.7	628.7	**629.8**	631.1	633	**630.4**	**-0.6**
	636.77	620.4	624.2	626.1	627.6	628.6	**629.7**	631	632.9	**630.4**	**-0.7**
	636.27	620.4	624.2	626.1	627.6	628.6	**629.7**	631	632.9	**630.3**	**-0.6**

		2003 FLOW FREQUENCY STUDY FLOOD PROFILES 1912 ADJ										
Location	RIVER MILE	FREQUENCY									1979 Study	100 year Profile 2003 Study minus 1979 Study
		2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year			
	635.91	620.3	624.1	626	627.5	628.5	**629.6**	630.9	632.8		**630.2**	**-0.6**
	635.63	620.3	624	626	627.5	628.4	**629.6**	630.9	632.8		**630.2**	**-0.6**
	635.35	620.2	624	625.9	627.4	628.4	**629.5**	630.8	632.7		**630.1**	**-0.6**
Prarie Du Chien	**635.03**	620.2	623.9	625.9	627.3	628.3	**629.4**	630.7	632.6		**630.1**	**-0.7**
Federal Hwy 18	**634.72**	620.1	623.9	625.8	627.3	628.3	**629.4**	630.7	632.6		**630**	**-0.6**
	634.69	620.1	623.9	625.8	627.3	628.3	**629.4**	630.7	632.6		**630**	**-0.6**
	634.47	620.1	623.9	625.8	627.3	628.2	**629.4**	630.7	632.6		**630**	**-0.6**
	634.21	620	623.9	625.8	627.2	628.2	**629.4**	630.6	632.5		**629.9**	**-0.5**
	633.92	620	623.8	625.8	627.2	628.2	**629.3**	630.6	632.5		**629.9**	**-0.6**
Mcgregor	**633.6**	619.9	623.8	625.7	627.1	628.1	**629.2**	630.5	632.4		**629.9**	**-0.7**
	633.38	619.9	623.8	625.7	627.1	628.1	**629.2**	630.5	632.4		**629.8**	**-0.6**
	633.18	619.9	623.7	625.6	627.1	628	**629.2**	630.5	632.4		**629.7**	**-0.5**
	632.92	619.8	623.7	625.6	627	628	**629.1**	630.4	632.3		**629.6**	**-0.5**
	632.44	619.7	623.6	625.5	626.9	627.9	**629**	630.3	632.2		**629.4**	**-0.4**
	631.99	619.6	623.5	625.4	626.8	627.8	**628.9**	630.2	632.2		**629.2**	**-0.3**
	631.44	619.5	623.4	625.3	626.7	627.7	**628.8**	630.1	632		**629**	**-0.2**
	631.26	619.4	623.3	625.1	626.6	627.6	**628.8**	630.1	631.9		**628.9**	**-0.1**
Wisconsin River	**631**	619.3	623.1	625	626.5	627.5	**628.7**	629.9	631.8		**628.8**	**-0.1**
	630.83	619	622.6	624.3	626.3	627.6	**628.8**	630.1	631.7		**628.7**	**0.1**
	630.61	619	622.5	624.3	626.2	627.5	**628.7**	629.9	631.6		**628.6**	**0.1**
	630.32	618.9	622.5	624.2	626.1	627.4	**628.6**	629.9	631.5		**628.5**	**0.1**
	629.86	618.8	622.4	624.1	626	627.3	**628.5**	629.8	631.4		**628.3**	**0.2**
	629.42	618.7	622.2	623.9	625.8	627.1	**628.3**	629.5	631.1		**628**	**0.3**
	628.91	618.4	621.9	623.7	625.6	626.9	**628.1**	629.3	630.9		**627.8**	**0.3**
	628.27	618.2	621.6	623.4	625.3	626.6	**627.8**	629	630.6		**627.5**	**0.3**
	627.76	618	621.5	623.2	625.2	626.4	**627.7**	628.9	630.5		**627.3**	**0.4**
	627.28	617.8	621.2	623	624.9	626.2	**627.4**	628.7	630.3		**627**	**0.4**
	626.74	617.5	620.9	622.7	624.6	625.9	**627.1**	628.4	629.9		**626.8**	**0.3**
	626.03	617.3	620.6	622.4	624.3	625.6	**626.9**	628.1	629.7		**626.4**	**0.5**
	625.52	617	620.4	622.1	624.1	625.3	**626.6**	627.8	629.4		**626.2**	**0.4**
	625.06	616.9	620.2	622	624	625.2	**626.5**	627.7	629.3		**626**	**0.5**
Clayton	**624.8**	616.7	620	621.8	623.7	625	**626.3**	627.5	629.1		**625.9**	**0.4**
	624.11	616.6	619.8	621.6	623.5	624.8	**626.1**	627.3	628.8		**625.5**	**0.6**
	623.61	616.5	619.8	621.5	623.5	624.7	**626**	627.2	628.8		**625.3**	**0.7**
Bagley	**623.15**	616.4	619.6	621.3	623.3	624.6	**625.8**	627	628.6		**625.1**	**0.7**

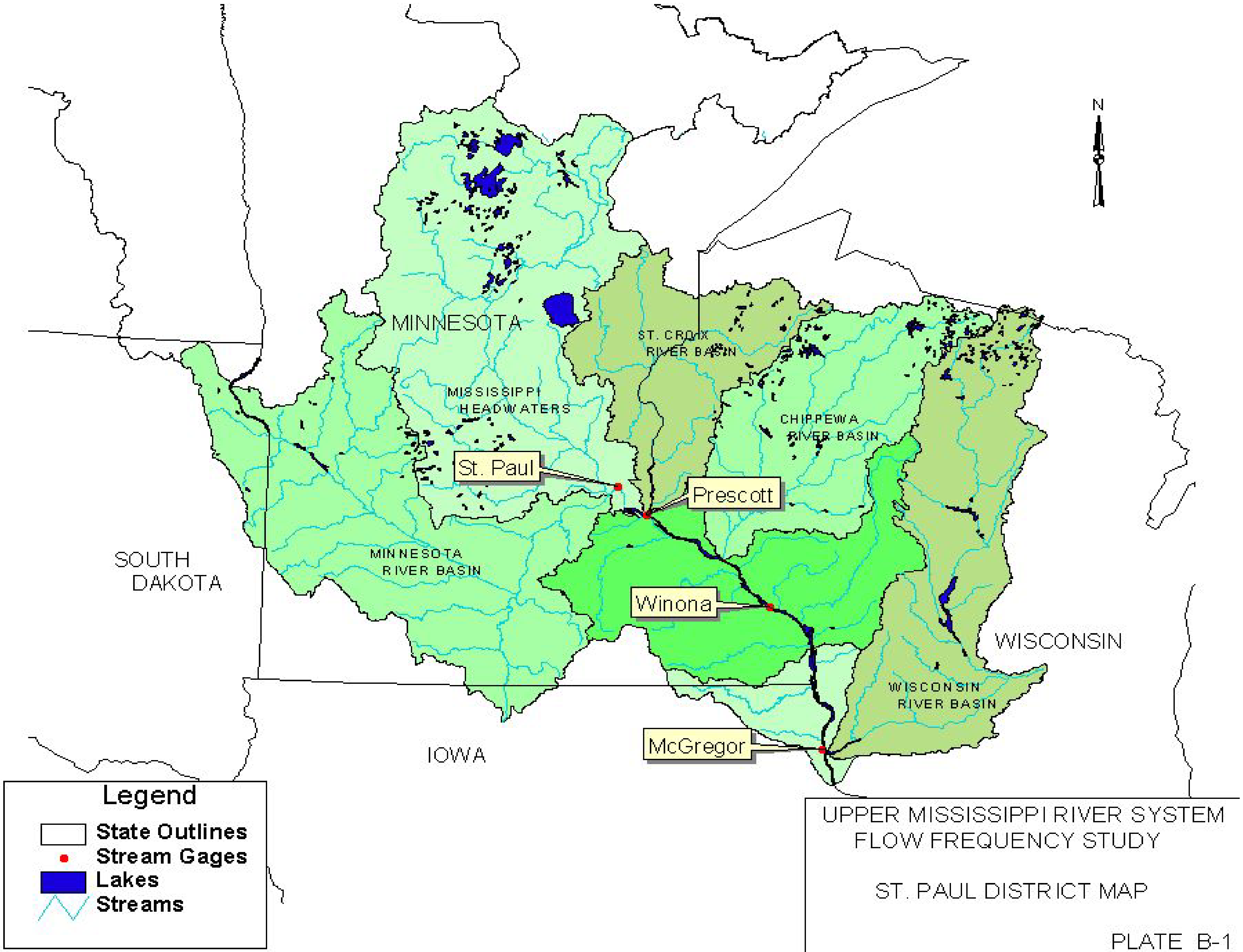
2003 FLOW FREQUENCY STUDY
FLOOD PROFILES 1912 ADJ

Location	RIVER MILE	FREQUENCY 2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year	1979 Study	100 year Profile 2003 Study minus 1979 Study
	622.59	616.2	619.4	621.1	623	624.3	**625.5**	626.7	628.3	**624.9**	**0.6**
	622	615.8	619	620.7	622.6	623.9	**625.2**	626.3	627.9	**624.6**	**0.6**
	621.53	615.5	618.7	620.4	622.3	623.6	**624.8**	626	627.5	**624.4**	**0.4**
	621.03	615.3	618.5	620.1	622	623.3	**624.6**	625.8	627.3	**624.2**	**0.4**
	620.52	615.2	618.4	620	621.9	623.2	**624.4**	625.6	627.1	**624**	**0.4**
	620	615	618.2	619.8	621.7	623	**624.3**	625.5	627	**623.8**	**0.5**
	619.49	614.8	618	619.6	621.5	622.8	**624.1**	625.3	626.8	**623.7**	**0.4**
	618.93	614.7	617.8	619.4	621.4	622.7	**623.9**	625.1	626.6	**623.6**	**0.3**
	618.69	614.6	617.7	619.3	621.3	622.6	**623.9**	625	626.6	**623.5**	**0.4**
	618.21	614.5	617.6	619.2	621.2	622.5	**623.7**	624.9	626.4	**623.4**	**0.3**
	617.76	614.4	617.5	619.1	621	622.3	**623.6**	624.8	626.3	**623.3**	**0.3**
	617.41	614.3	617.4	619	620.9	622.2	**623.5**	624.7	626.2	**623.3**	**0.2**
	617.28	614.3	617.4	619	620.9	622.2	**623.5**	624.7	626.2	**623.2**	**0.3**
	616.92	614.2	617.2	618.8	620.7	622.1	**623.3**	624.5	626	**623.2**	**0.1**
	616.65	614.1	617.2	618.7	620.7	622	**623.3**	624.4	625.9	**623.1**	**0.2**
	616.37	614.1	617.1	618.7	620.6	622	**623.3**	624.4	625.9	**623.1**	**0.2**
	616.04	614	617.1	618.6	620.6	621.9	**623.2**	624.4	625.8	**623**	**0.2**
	615.77	614	617	618.6	620.5	621.8	**623.1**	624.3	625.8	**623**	**0.1**
	615.52	614	617	618.5	620.5	621.8	**623.1**	624.2	625.7	**622.9**	**0.2**
	615.27	613.9	616.9	618.5	620.4	621.7	**623**	624.2	625.6	**622.9**	**0.1**
ld 10 pool	**615.2**	613.9	616.9	618.4	620.3	621.6	**622.9**	624	625.5	**622.9**	**0**
ld 10 tw	**614.8**	613.3	616.3	617.8	619.7	621	**622.3**	623.4	624.9		

Upper Mississippi River
Flow Frequency Study

PLATES

St. Paul District



UPPER MISSISSIPPI RIVER SYSTEM
FLOW FREQUENCY STUDY

ST. PAUL DISTRICT MAP

PLATE B-1

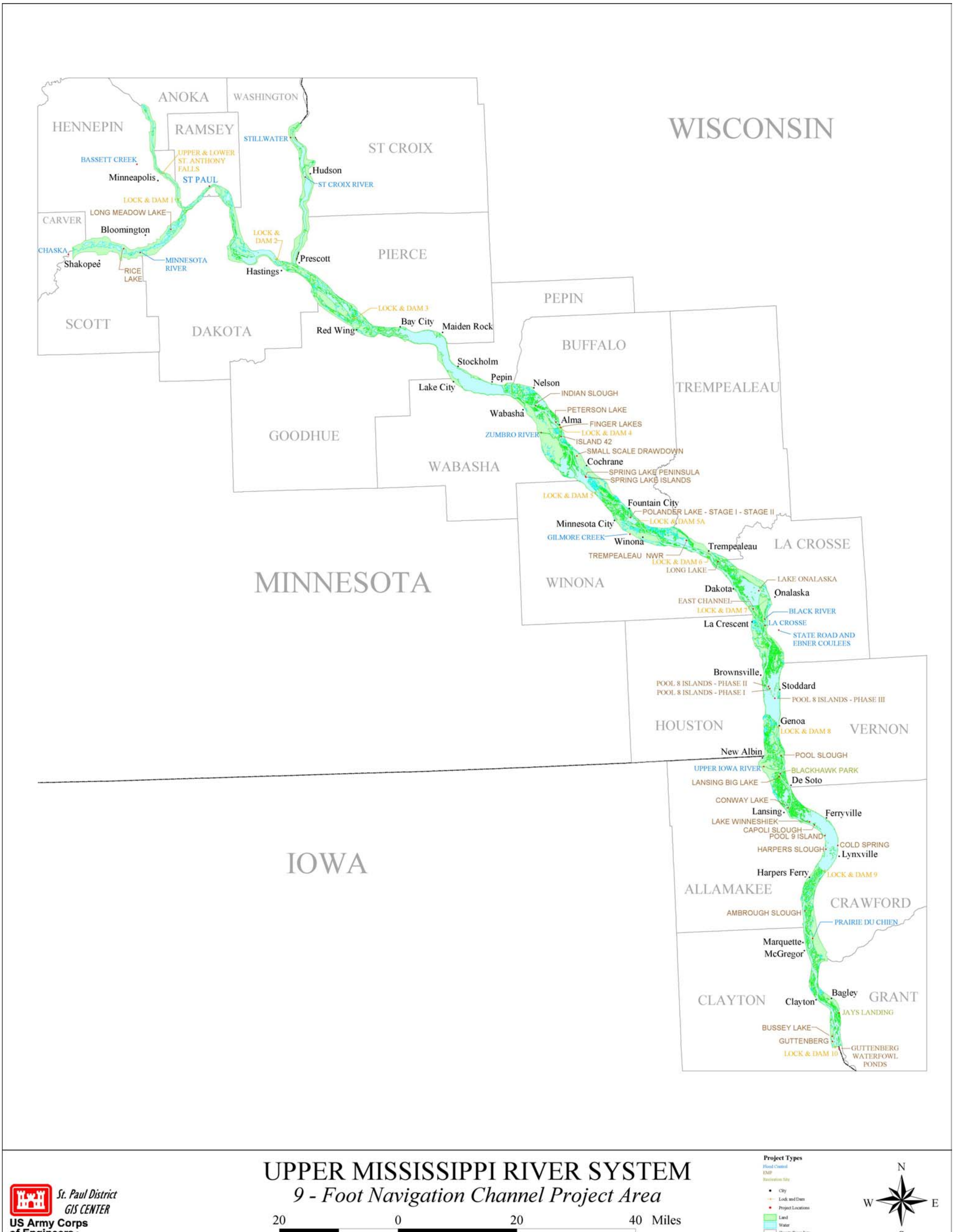
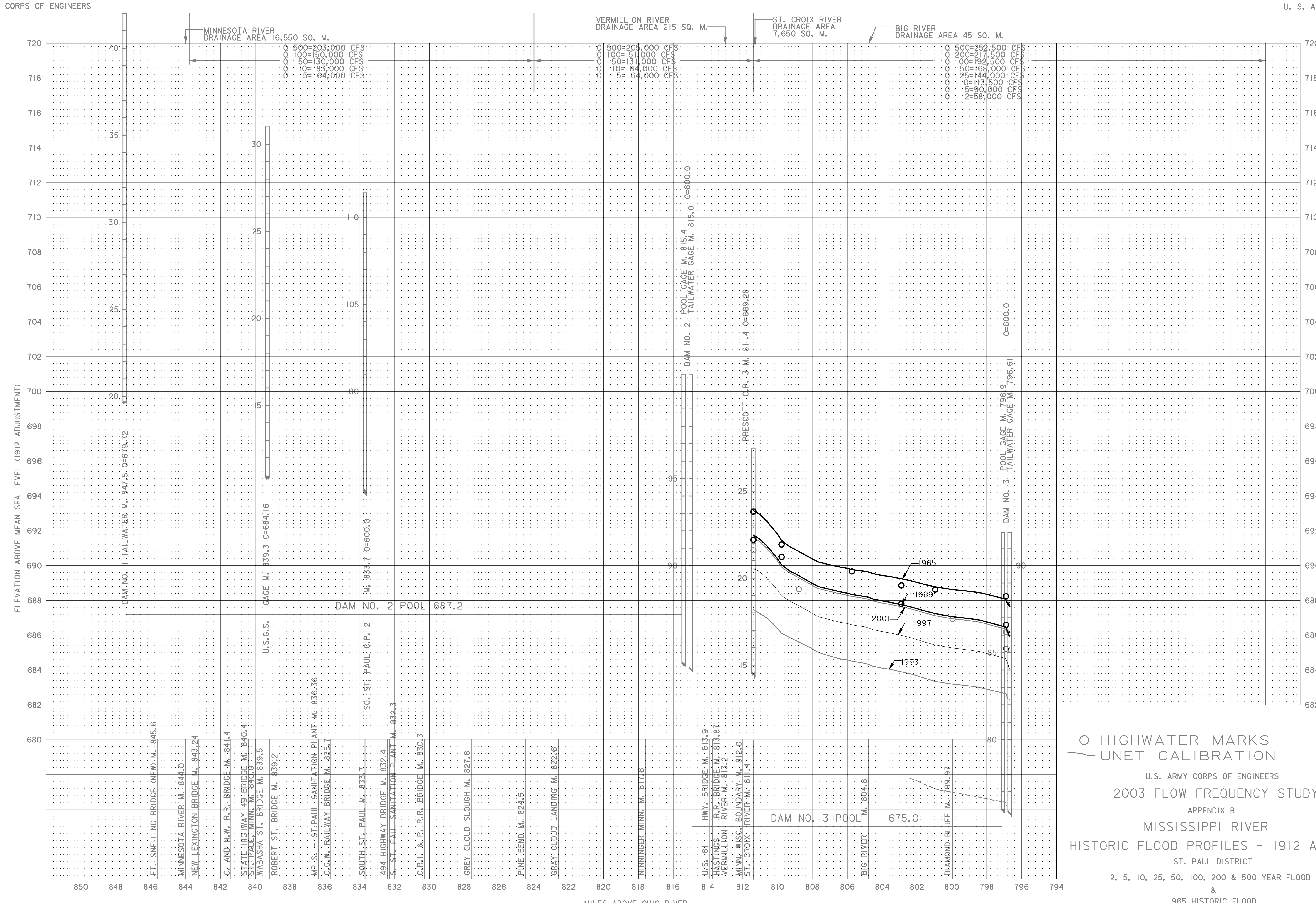

WISCONSIN
MINNESOTA
IOWA
ANOKA
WASHINGTON
HENNEPIN
RAMSEY
ST CROIX
CARVER
PIERCE
SCOTT
DAKOTA
PEPIN
BUFFALO
TREMPEALEAU
GOODHUE
WABASHA
WINONA
LA CROSSE
HOUSTON
VERNON
ALLAMAKEE
CRAWFORD
CLAYTON
GRANT
BASSETT CREEK
UPPER & LOWER ST. ANTHONY FALLS
Minneapolis
ST PAUL
STILLWATER
Hudson
ST CROIX RIVER
LOCK & DAM 1
LONG MEADOW LAKE
Bloomington
CHASKA
Shakopee
RICE LAKE
MINNESOTA RIVER
LOCK & DAM 2
Prescott
Hastings
LOCK & DAM 3
Red Wing
Bay City
Maiden Rock
Stockholm
Pepin
Lake City
Nelson
INDIAN SLOUGH
PETERSON LAKE
Wabasha
Alma
FINGER LAKES
LOCK & DAM 4
ZUMBRO RIVER
ISLAND 42
SMALL SCALE DRAWDOWN
Cochrane
SPRING LAKE PENINSULA
SPRING LAKE ISLANDS
LOCK & DAM 5
Fountain City
POLANDER LAKE - STAGE I - STAGE II
LOCK & DAM 5A
Minnesota City
GILMORE CREEK
Winona
Trempealeau
TREMPEALEAU NWR
LOCK & DAM 6
LONG LAKE
LAKE ONALASKA
Dakota
Onalaska
EAST CHANNEL
LOCK & DAM 7
BLACK RIVER
La Crescent
LA CROSSE
STATE ROAD AND EBNER COULEES
Brownsville
Stoddard
POOL 8 ISLANDS - PHASE II
POOL 8 ISLANDS - PHASE I
POOL 8 ISLANDS - PHASE III
Genoa
LOCK & DAM 8
New Albin
POOL SLOUGH
UPPER IOWA RIVER
BLACKHAWK PARK
LANSING BIG LAKE
De Soto
CONWAY LAKE
Lansing
Ferryville
LAKE WINNESHIEK
CAPOLI SLOUGH
POOL 9 ISLAND
COLD SPRING
HARPERS SLOUGH
Lynxville
Harpers Ferry
LOCK & DAM 9
AMBROUGH SLOUGH
PRAIRIE DU CHIEN
Marquette
McGregor
Bagley
Clayton
JAYS LANDING
BUSSEY LAKE
GUTTENBERG
GUTTENBERG WATERFOWL PONDS
LOCK & DAM 10
St. Paul District
GIS CENTER
US Army Corps of Engineers
UPPER MISSISSIPPI RIVER SYSTEM
9 - Foot Navigation Channel Project Area
20
0
20
40
Miles
Project Types
N
W
E
S

PLATE # 2



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

MISSISSIPPI RIVER

HISTORIC FLOOD PROFILES - 1912 ADJ

ST. PAUL DISTRICT

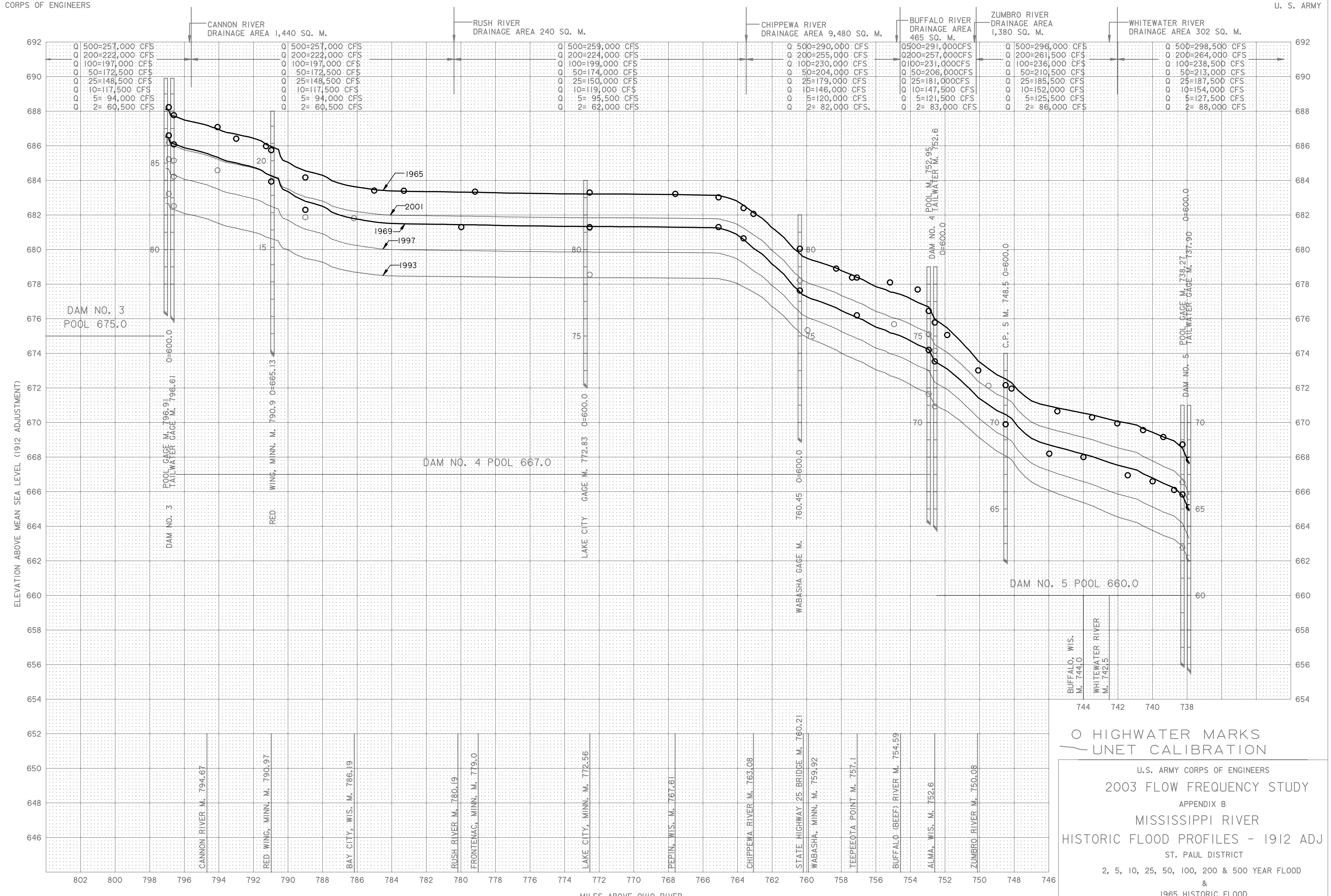
2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD

&

1965 HISTORIC FLOOD

RIVER MILES 796.8 TO 847.5

PLATE # 3



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

MISSISSIPPI RIVER

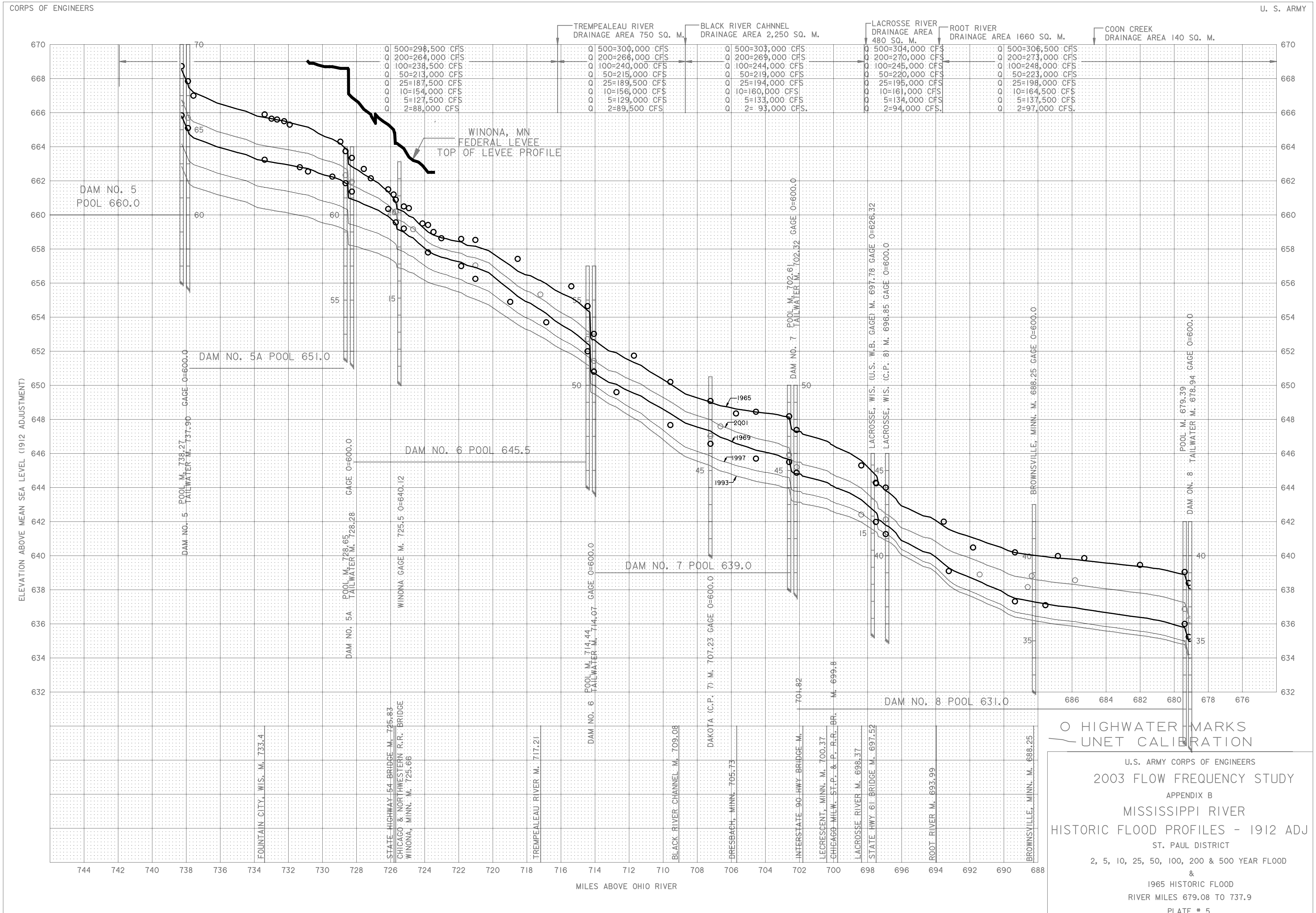
HISTORIC FLOOD PROFILES - 1912 ADJ

ST. PAUL DISTRICT

2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD

RIVER MILES 737.9 TO 796.7

PLATE # 4



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

MISSISSIPPI RIVER

HISTORIC FLOOD PROFILES - 1912 ADJ

ST. PAUL DISTRICT

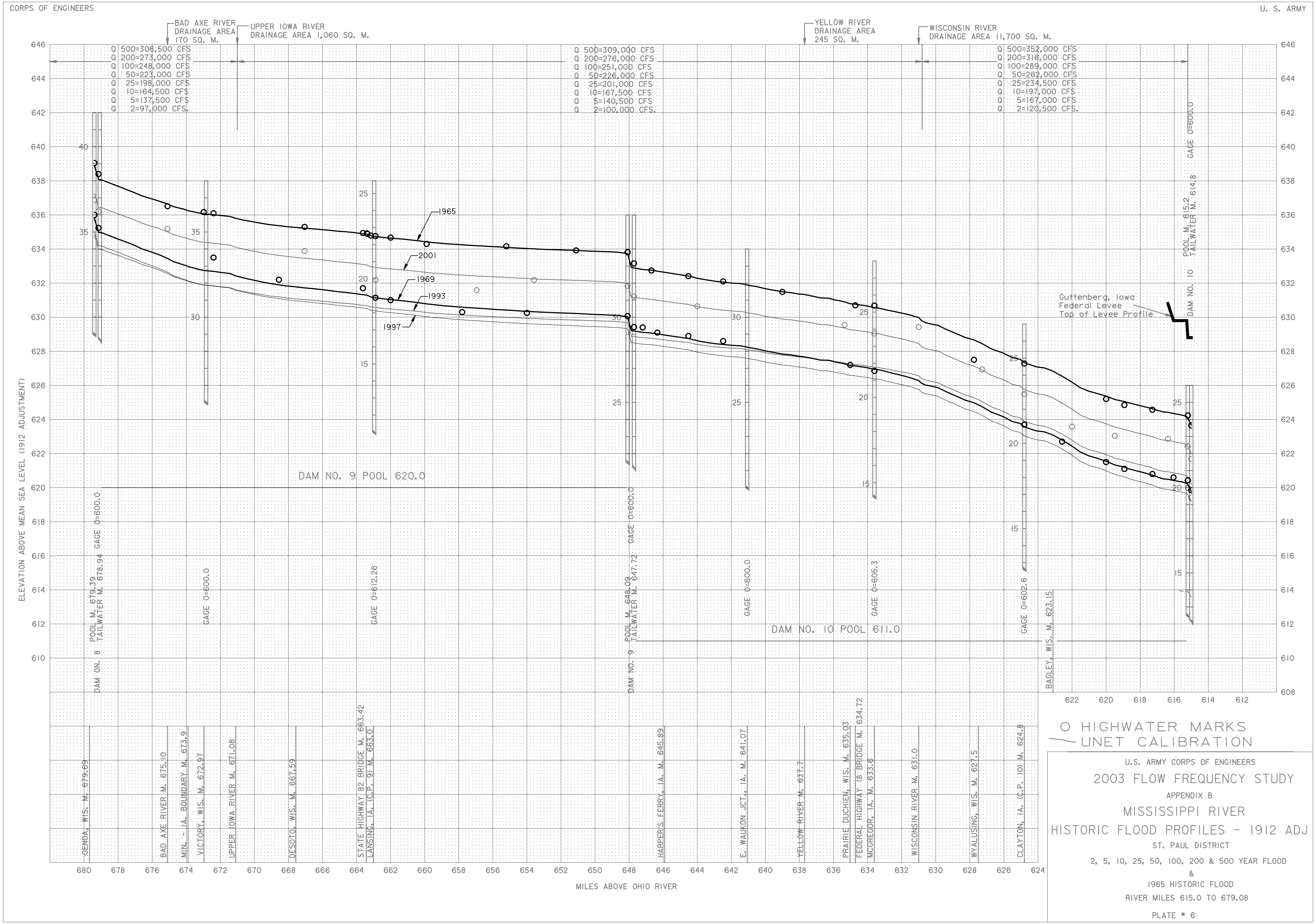
2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD

&

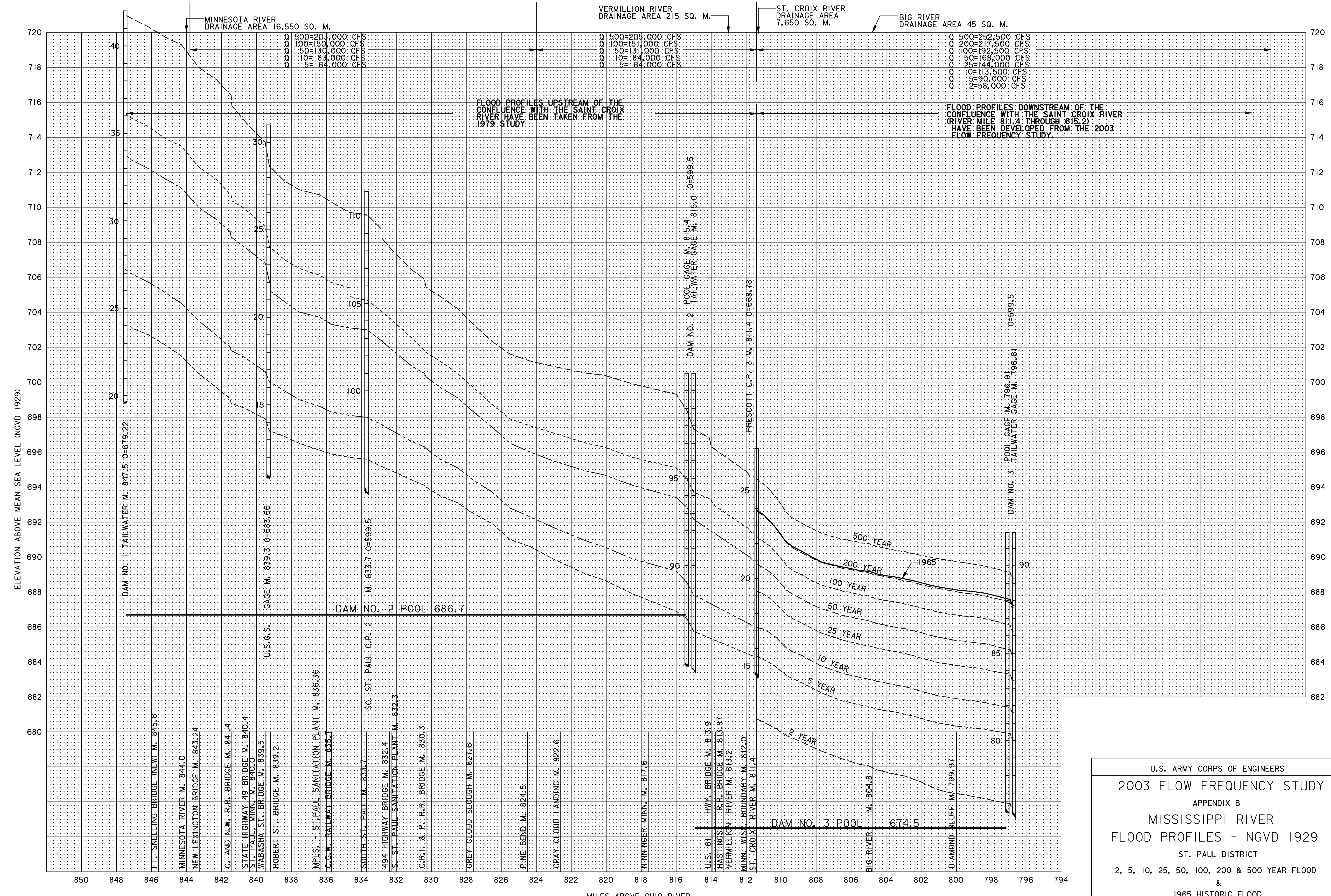
1965 HISTORIC FLOOD

RIVER MILES 679.08 TO 737.9

PLATE # 5



CORPS OF ENGINEERS
U. S. ARMY
BAD AXE RIVER DRAINAGE AREA 170 SQ. M.
UPPER IOWA RIVER DRAINAGE AREA 1,060 SQ. M.
YELLOW RIVER DRAINAGE AREA 245 SQ. M.
WISCONSIN RIVER DRAINAGE AREA 11,700 SQ. M.
Q 500=306,500 CFS
Q 200=273,000 CFS
Q 100=248,000 CFS
Q 50=223,000 CFS
Q 25=198,000 CFS
Q 10=164,500 CFS
Q 5=137,500 CFS
Q 2=97,000 CFS.
Q 500=309,000 CFS
Q 200=276,000 CFS
Q 100=251,000 CFS
Q 50=226,000 CFS
Q 25=201,000 CFS
Q 10=167,500 CFS
Q 5=140,500 CFS
Q 2=100,000 CFS.
Q 500=352,000 CFS
Q 200=316,000 CFS
Q 100=289,000 CFS
Q 50=262,000 CFS
Q 25=234,500 CFS
Q 10=197,000 CFS
Q 5=167,000 CFS
Q 2=120,500 CFS.
1965
2001
1969
1993
1997
Guttenberg, Iowa Federal Levee Top of Levee Profile
DAM NO. 9 POOL 620.0
DAM NO. 10 POOL 611.0
ELEVATION ABOVE MEAN SEA LEVEL (1912 ADJUSTMENT)
MILES ABOVE OHIO RIVER
DAM ON. 8 POOL M. 679.39 TAILWATER M. 678.94 GAGE 0=600.0
GAGE 0=600.0
GAGE 0=612.26
DAM NO. 9 POOL M. 648.09 TAILWATER M. 647.72 GAGE 0=600.0
GAGE 0=600.0
GAGE 0=605.3
GAGE 0=602.6
BAGLEY, WIS. M. 623.15
DAM NO. 10 POOL M. 615.2 TAILWATER M. 614.8 GAGE 0=600.0
GENOA, WIS. M. 679.69
BAD AXE RIVER M. 675.10
MIN. - IA. BOUNDARY M. 673.9
VICTORY, WIS. M. 672.97
UPPER IOWA RIVER M. 671.08
DESOTO, WIS. M. 667.59
STATE HIGHWAY 82 BRIDGE M. 663.42
LANSING, IA. (C.P. 9) M. 663.0
HARPER'S FERRY, IA. M. 645.89
E. WAUKON JCT., IA. M. 641.07
YELLOW RIVER M. 637.7
PRAIRIE DUCHIEN, WIS. M. 635.03
FEDERAL HIGHWAY 18 BRIDGE M. 634.72
MCGREGOR, IA. M. 633.6
WISCONSIN RIVER M. 631.0
WYALUSING, WIS. M. 627.5
CLAYTON, IA. (C.P. 10) M. 624.8
O HIGHWATER MARKS
— UNET CALIBRATION
U.S. ARMY CORPS OF ENGINEERS
2003 FLOW FREQUENCY STUDY
APPENDIX B
MISSISSIPPI RIVER
HISTORIC FLOOD PROFILES - 1912 ADJ
ST. PAUL DISTRICT
2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD
RIVER MILES 615.0 TO 679.08
PLATE # 6



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

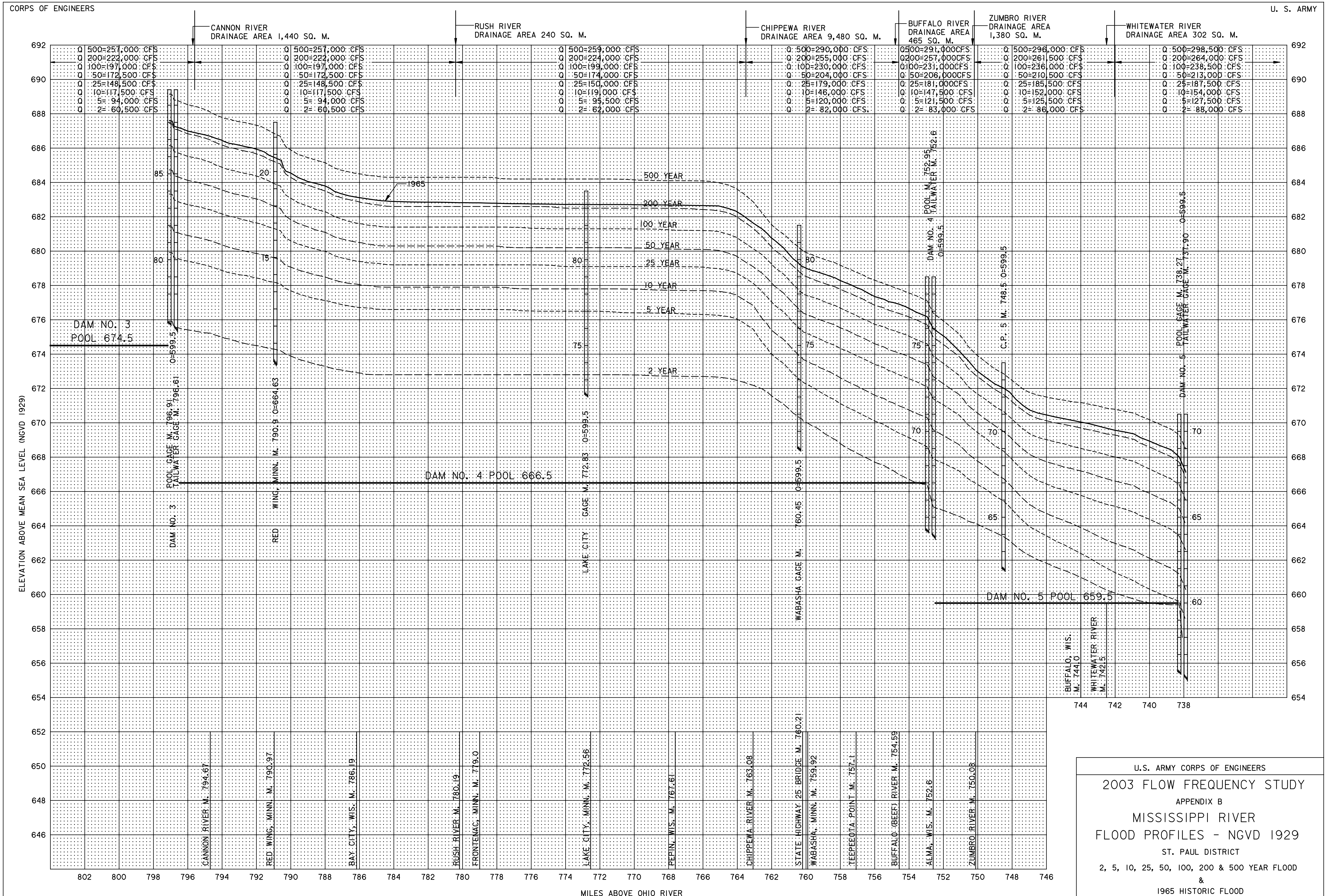
MISSISSIPPI RIVER
FLOOD PROFILES - NGVD 1929

ST. PAUL DISTRICT

2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD

RIVER MILES 796.8 TO 847.5

PLATE # 7



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

MISSISSIPPI RIVER

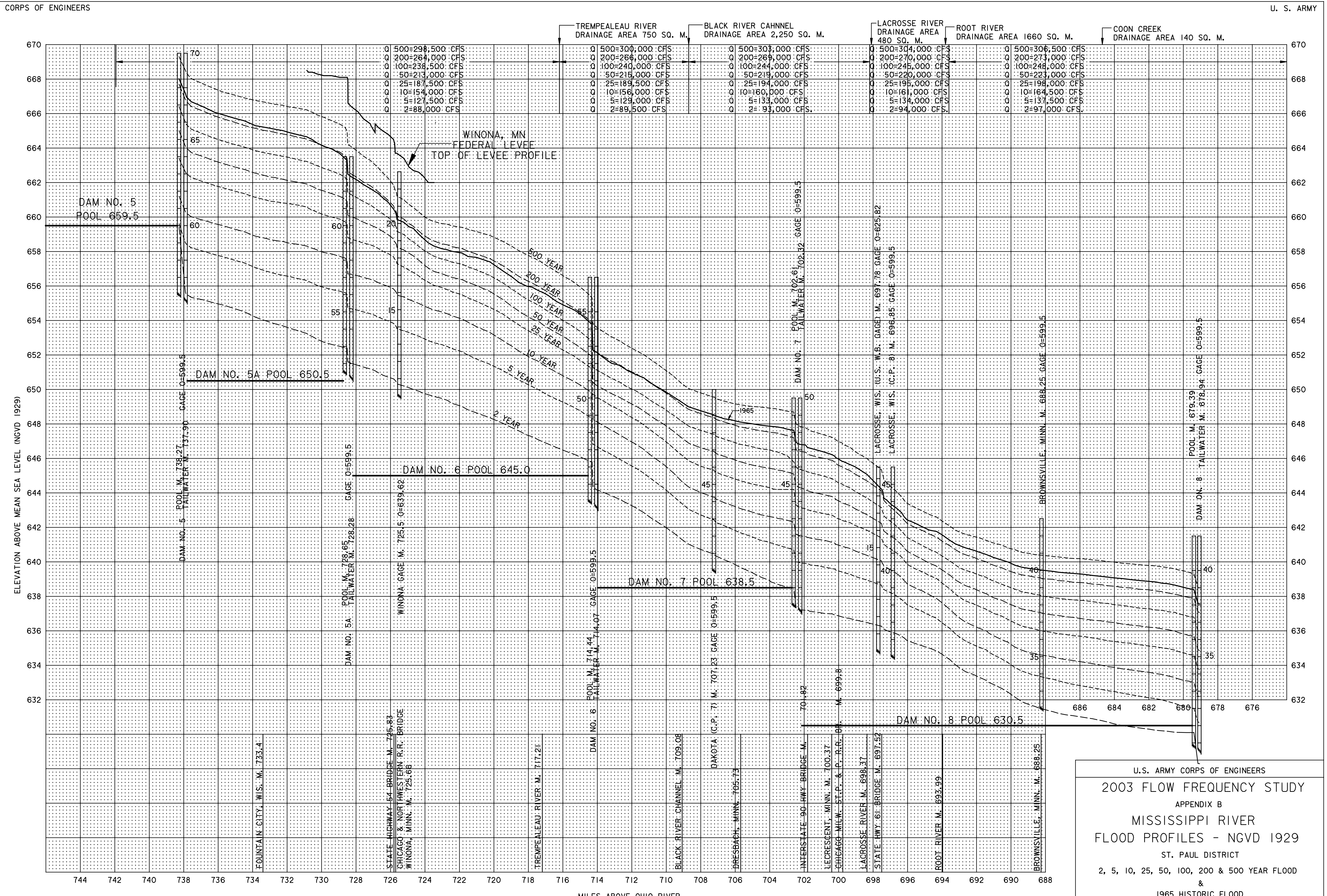
FLOOD PROFILES - NGVD 1929

ST. PAUL DISTRICT

2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD

RIVER MILES 737.9 TO 796.7

PLATE # 8



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

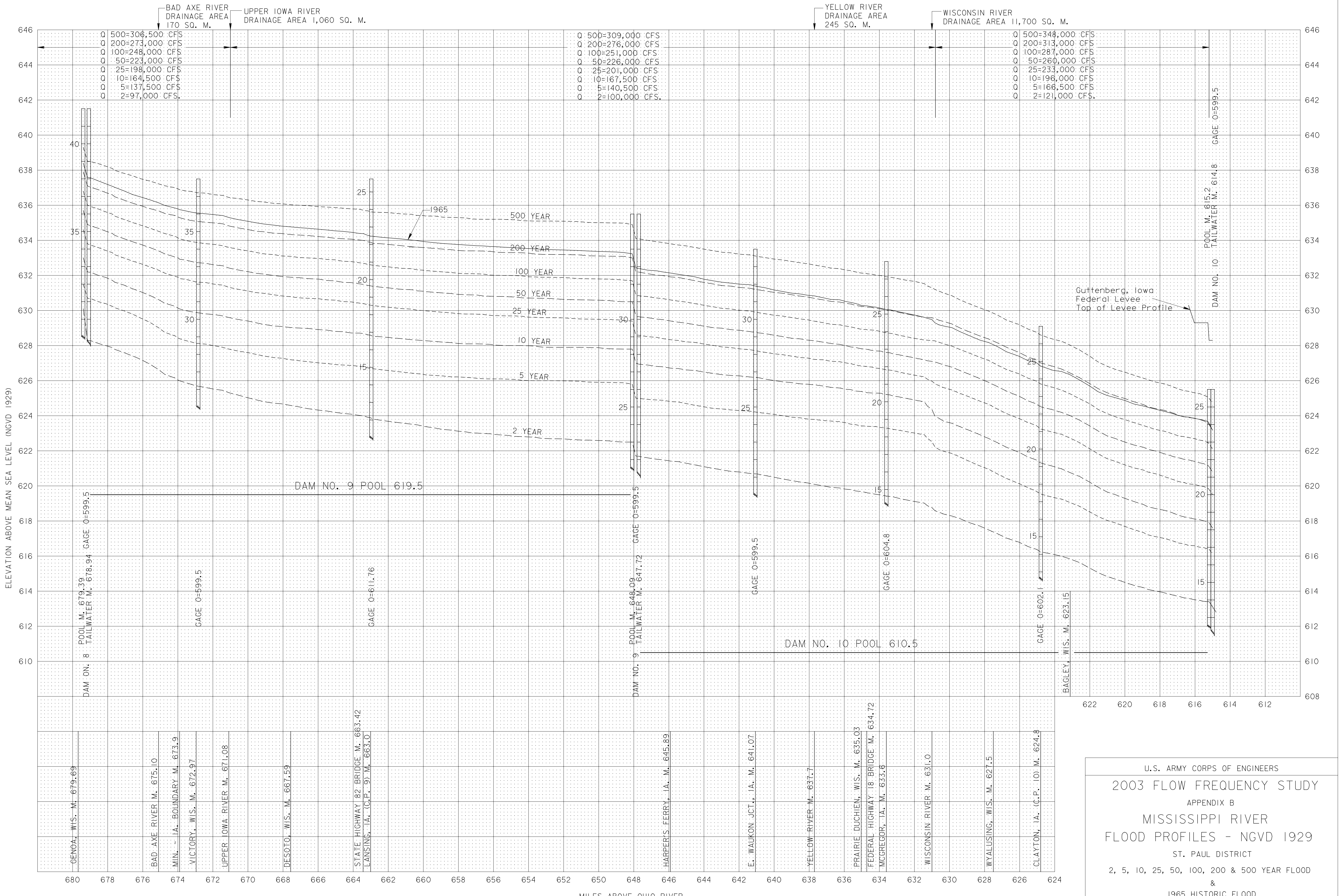
MISSISSIPPI RIVER
FLOOD PROFILES - NGVD 1929

ST. PAUL DISTRICT

2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD

RIVER MILES 679.08 TO 737.9

PLATE # 9



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

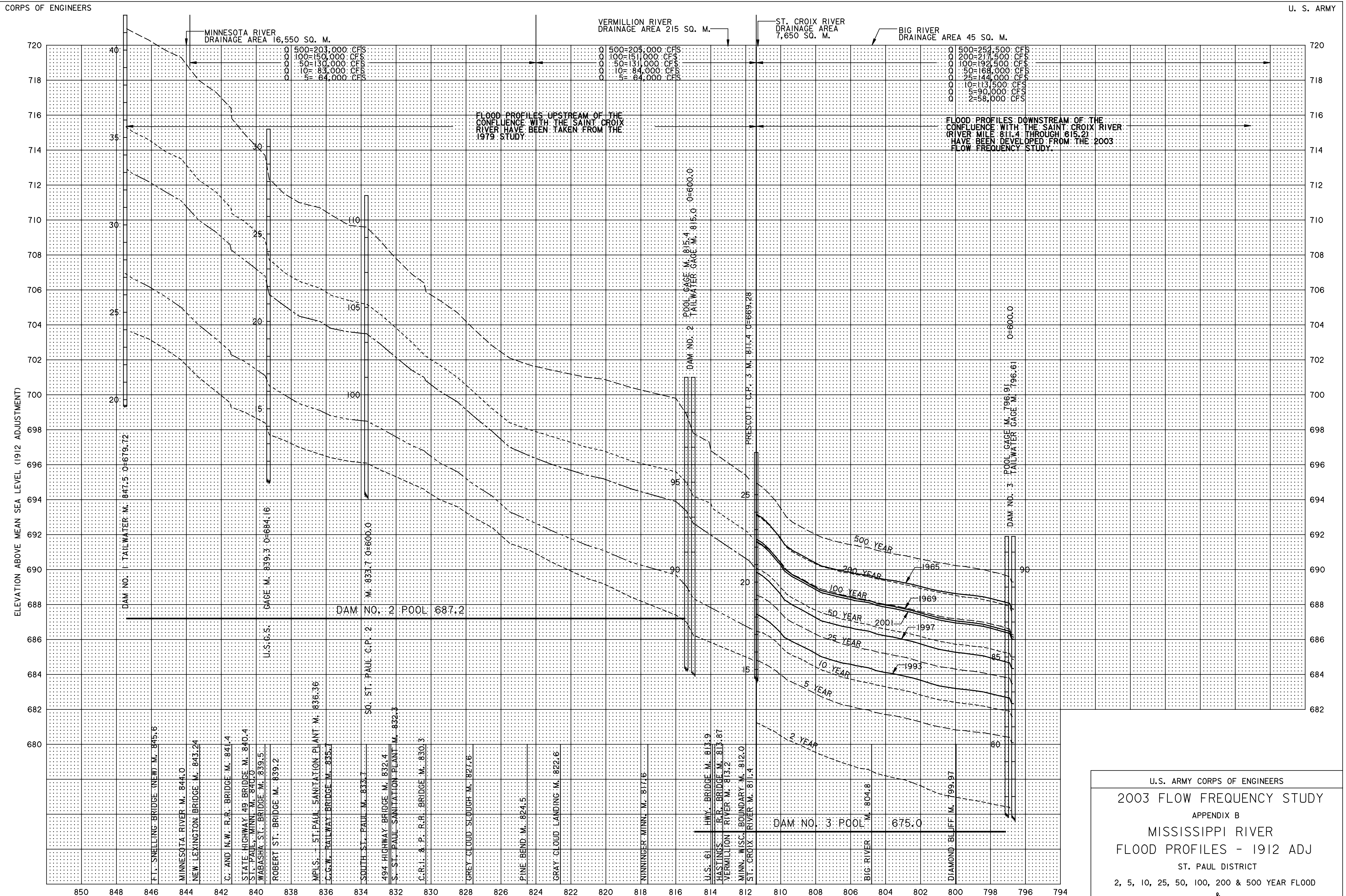
MISSISSIPPI RIVER FLOOD PROFILES - NGVD 1929

ST. PAUL DISTRICT

2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD

RIVER MILES 615.0 TO 679.08

PLATE # 10



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

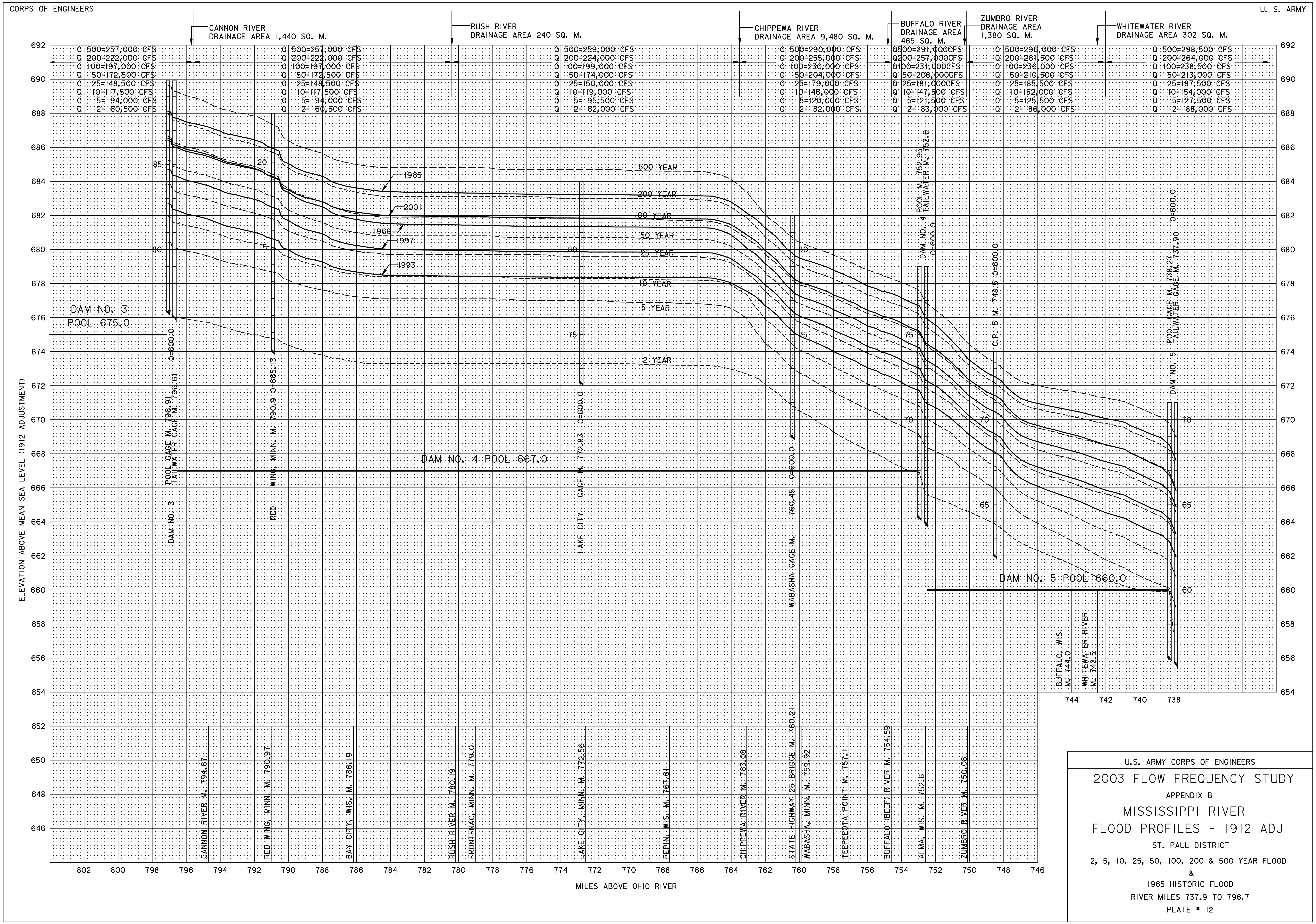
MISSISSIPPI RIVER
FLOOD PROFILES - 1912 ADJ

ST. PAUL DISTRICT

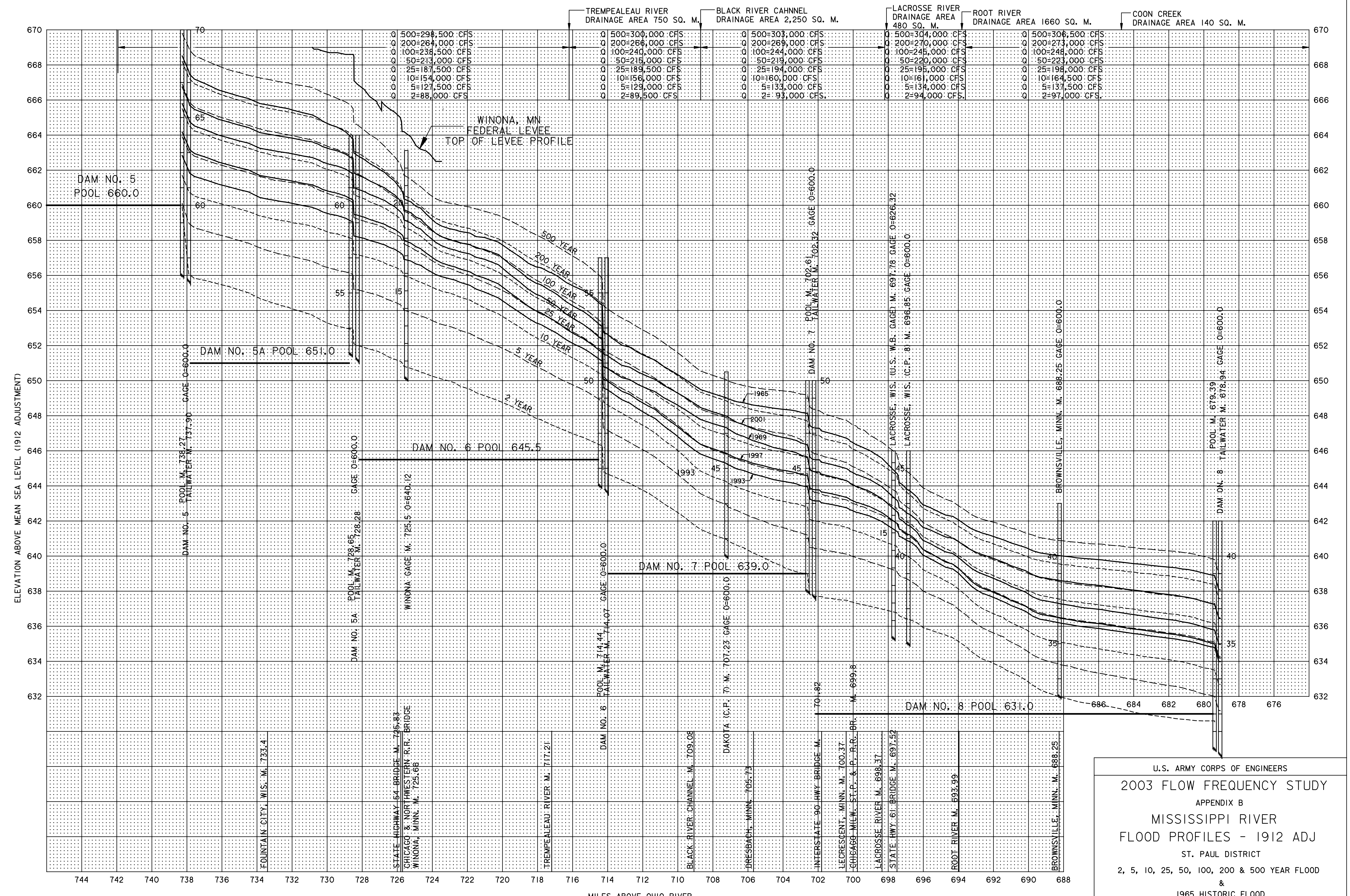
2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD

RIVER MILES 796.8 TO 847.5

PLATE # 11



CORPS OF ENGINEERS
U. S. ARMY
CANNON RIVER DRAINAGE AREA 1,440 SQ. M.
RUSH RIVER DRAINAGE AREA 240 SQ. M.
CHIPPEWA RIVER DRAINAGE AREA 9,480 SQ. M.
BUFFALO RIVER DRAINAGE AREA 465 SQ. M.
ZUMBRO RIVER DRAINAGE AREA 1,380 SQ. M.
WHITEWATER RIVER DRAINAGE AREA 302 SQ. M.
Q 500=257,000 CFS
Q 200=222,000 CFS
Q 100=197,000 CFS
Q 50=172,500 CFS
Q 25=148,500 CFS
Q 10=117,500 CFS
Q 5= 94,000 CFS
Q 2= 60,500 CFS
Q 500=257,000 CFS
Q 200=222,000 CFS
Q 100=197,000 CFS
Q 50=172,500 CFS
Q 25=148,500 CFS
Q 10=117,500 CFS
Q 5= 94,000 CFS
Q 2= 60,500 CFS
Q 500=259,000 CFS
Q 200=224,000 CFS
Q 100=199,000 CFS
Q 50=174,000 CFS
Q 25=150,000 CFS
Q 10=119,000 CFS
Q 5= 95,500 CFS
Q 2= 62,000 CFS
Q 500=290,000 CFS
Q 200=255,000 CFS
Q 100=230,000 CFS
Q 50=204,000 CFS
Q 25=179,000 CFS
Q 10=146,000 CFS
Q 5=120,000 CFS
Q 2= 82,000 CFS
Q500=291,000CFS
Q200=257,000CFS
Q100=231,000CFS
Q 50=206,000CFS
Q 25=181,000CFS
Q 10=147,500 CFS
Q 5=121,500 CFS
Q 2= 83,000 CFS
Q 500=296,000 CFS
Q 200=261,500 CFS
Q 100=236,000 CFS
Q 50=210,500 CFS
Q 25=185,500 CFS
Q 10=152,000 CFS
Q 5=125,500 CFS
Q 2= 86,000 CFS
Q 500=298,500 CFS
Q 200=264,000 CFS
Q 100=238,500 CFS
Q 50=213,000 CFS
Q 25=187,500 CFS
Q 10=154,000 CFS
Q 5=127,500 CFS
Q 2= 88,000 CFS
500 YEAR
200 YEAR
100 YEAR
50 YEAR
25 YEAR
10 YEAR
5 YEAR
2 YEAR
1965
2001
1969
1997
1993
DAM NO. 3
POOL 675.0
DAM NO. 4 POOL 667.0
DAM NO. 5 POOL 660.0
DAM NO. 3 POOL GAGE M. 796.91 TAILWATER GAGE M. 796.61 0=600.0
RED WING, MINN. M. 790.9 0=665.13
LAKE CITY GAGE M. 772.83 0=600.0
WABASHA GAGE M. 760.45 0=600.0
DAM NO. 4 POOL M. 752.95 TAILWATER M. 752.6 0=600.0
C.P. 5 M. 748.5 0=600.0
DAM NO. 5 POOL GAGE M. 738.27 TAILWATER GAGE M. 737.90 0=600.0
BUFFALO, WIS. M. 744.0
WHITEWATER RIVER M. 742.5
CANNON RIVER M. 794.67
RED WING, MINN. M. 790.97
BAY CITY, WIS. M. 786.19
RUSH RIVER M. 780.19
FRONTENAC, MINN. M. 779.0
LAKE CITY, MINN. M. 772.56
PEPIN, WIS. M. 767.61
CHIPPEWA RIVER M. 763.08
STATE HIGHWAY 25 BRIDGE M. 760.21
WABASHA, MINN. M. 759.92
TEEPEEOTA POINT M. 757.1
BUFFALO (BEEF) RIVER M. 754.59
ALMA, WIS. M. 752.6
ZUMBRO RIVER M. 750.08
ELEVATION ABOVE MEAN SEA LEVEL (1912 ADJUSTMENT)
MILES ABOVE OHIO RIVER
692
690
688
686
684
682
680
678
676
674
672
670
668
666
664
662
660
658
656
654
652
650
648
646
802
800
798
796
794
792
790
788
786
784
782
780
778
776
774
772
770
768
766
764
762
760
758
756
754
752
750
748
746
744
742
740
738
U.S. ARMY CORPS OF ENGINEERS
2003 FLOW FREQUENCY STUDY
APPENDIX B
MISSISSIPPI RIVER
FLOOD PROFILES - 1912 ADJ
ST. PAUL DISTRICT
2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD
RIVER MILES 737.9 TO 796.7
PLATE # 12



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

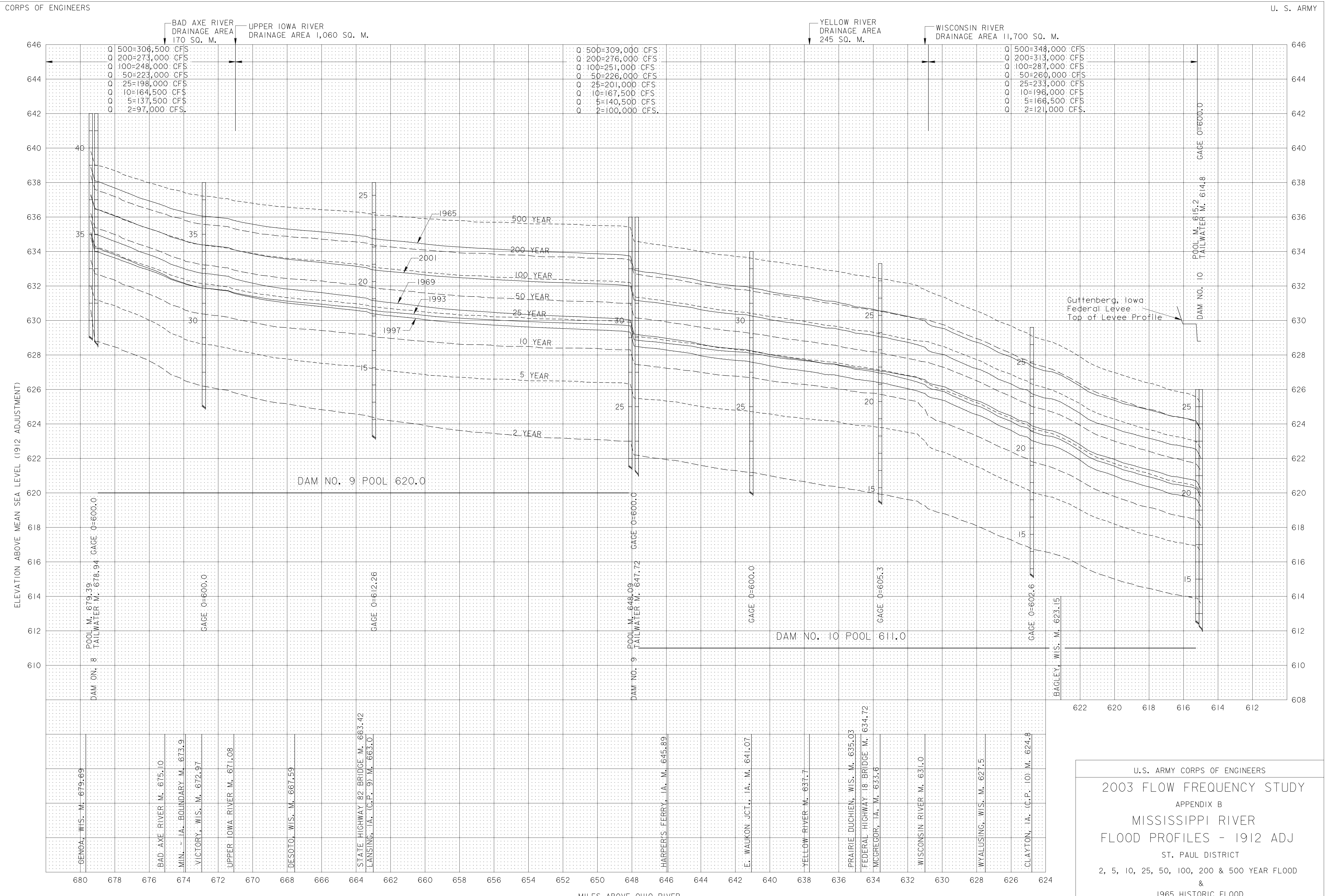
MISSISSIPPI RIVER
FLOOD PROFILES - 1912 ADJ

ST. PAUL DISTRICT

2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD

RIVER MILES 679.08 TO 737.9

PLATE # 13



U.S. ARMY CORPS OF ENGINEERS

2003 FLOW FREQUENCY STUDY

APPENDIX B

MISSISSIPPI RIVER
FLOOD PROFILES - 1912 ADJ

ST. PAUL DISTRICT

2, 5, 10, 25, 50, 100, 200 & 500 YEAR FLOOD
&
1965 HISTORIC FLOOD

RIVER MILES 615.0 TO 679.08

PLATE # 14