5.15 MISSISSIPPI RIVER IMPACTS

The changes in the operating criteria making up each of the alternatives presented in this chapter provide different release patterns from Gavins Point Dam. Some of these differences are more pronounced than others. In some cases, they are dramatic enough to show up on the annual hydrograph for Hermann, Missouri, which is the last location modeled on the Missouri River. These flows join those from the Upper Mississippi River to make up the flow that passes St. Louis, Missouri. Because of these differences and the concerns regarding impacts on the Mississippi River, an analysis was conducted of potential impacts to the Mississippi River, including impacts to the endangered pallid sturgeon. Prior studies and analyses of annual hydrographs indicated that continued evaluations of Mississippi River water intakes, saltwater intrusion, and flood damage were not warranted. Impacts on these resource categories were determined to be indistinguishable. For the submitted alternatives addressed in this chapter, Mississippi River resource evaluations were conducted for hydraulics and hydrology, navigation, and channel improvement features. Details on methods employed in these studies and previous evaluations are included in the Mississippi River Studies technical report (Corps, 1998l).

5.15.1 Hydraulic Impacts to the Mississippi River

The availability of daily flow data on the Missouri River allowed the use of a more sophisticated UNET unsteady flow routing method to determine the Mississippi River stages and flows as compared to a more crude method used for the DEIS, in which only monthly Missouri River flows were available. The existing UNET code was modified to allow a controlled diversion of the Mississippi River flow into the Atchafalaya River through the Old River Complex, and the existing UNET models of the Mississippi and Atchafalaya Rivers were adapted to the needs of the Study. Simulations were completed using the flows at Hermann, Missouri, for the alternatives as the only changeable variable. The periods of the simulation were 1930 through 1995 for the Middle Mississippi River and 1935 through 1995 for the Lower Mississippi/ Atchafalaya River system. Results from these simulations were used to conduct the impact analyses for the other categories listed above.

This portion of the RDEIS discusses the results of the hydraulic analyses performed to determine the impact of the Missouri River Mainstem Reservoir System operating alternatives on the stages and flows on the Mississippi River. Discussions are limited to the CWCP and the MLDDA, ARNRC, MRBA, MODC, BIOP, and FWS30 alternatives. The discussion is also limited to the gaging stations at St. Louis, Missouri, and Cairo, Illinois, which were used to evaluate the economic impact to Mississippi River navigation. A brief discussion of the Missouri River flow at Hermann is also included.

Hermann, Missouri

The only variable that differentiated the numerical model runs on the Mississippi River for each alternative was the flow at Hermann. The differences in flow patterns at Hermann that occur among the alternatives should, therefore, be reflected at downstream gaging stations along the Mississippi River. Figure 5.15-1 shows the average monthly flow on the Missouri River at Hermann for the CWCP and the submitted alternatives. The alternatives that do not have a Gavins Point Dam spring rise (MLDDA, MRBA, and MODC) mimic the CWCP between January and September. Differences begin to emerge in the fall months, with the MLDDA alternative having slightly higher flows and the MODC and MRBA alternatives having higher flows in October and lower flows in November. The spring rise alternatives (ARNRC, BIOP, and FWS30) begin to diverge from the CWCP in late spring. Higher flows at Hermann occur with these alternatives in April, May, and June, followed by sharply lower flows in July and August during the period of low summer releases from Gavins Point Dam. The fall months are once again higher than the CWCP as the remainder of the flood storage is evacuated. Mean monthly stages at Mississippi River gaging stations for the submitted alternatives should reveal similar patterns of increase or decrease in mean monthly stages when compared to the CWCP.

St. Louis, Missouri

Figure 5.15-2 shows the computed mean stage for each month at St. Louis for the CWCP and the alternatives. The pattern of flow change seen at Hermann is replicated here, as expected, with minor changes in the fall months with the MLDDA, MRBA, and MODC alternatives and more significant changes, particularly in July and August, with the ARNRC, BIOP, and FWS30 alternatives.

Figures 5.15-1 and 5.15-2 provide a glimpse of how the alternatives compare to the CWCP and with each other, but the impact of the alternatives to flooding, which begins at 30 feet on the St. Louis gage, and to navigation, which begins when the St. Louis gage falls below 2.0 feet, must be analyzed on an event-by-event basis using the daily stage hydrographs.

Figure 5.15-3 displays the annual maximum stage, in feet above the 30-foot flood stage, attained at St. Louis under each alternative. By focusing on the feet above flood stage, critical periods for increased flood risk are identified. The greatest increase in the annual maximum stage during flooding conditions was 0.9 foot, which occurred in 1965 under the FWS30 and BIOP alternatives. The ARNRC alternative was 0.6 foot higher in 1965, followed by the MLDDA alternative at 0.4 foot higher and the MRBA and MODC alternatives, each at 0.3 foot higher. The greatest decrease in the annual maximum stage during flooding conditions was 0.6 foot, which occurred in 1969 under the ARNRC alternative.

Figure 5.15-4 shows the minimum stage attained at St. Louis each year for each alternative. The stage at which navigation on the Middle Mississippi River begins to be affected is 2.0 feet. Under the CWCP, stages below 2.0 feet occur in all but 11 years out of the 66 years modeled (1930 to 1995). The 11 years in which the stage does not fall below 2.0 feet all occur between 1973 and 1995. In the last 13 years (between 1983 and 1995), there were only four years in which the stage fell below 2.0 feet. As shown in Figure 5.15-4, the greatest decrease in the annual minimum stage was 3.9 feet, which occurred in 1975 under the ARNRC alternative, while the greatest increase in the annual minimum stage was 1.1 foot in 1994, also under the ARNRC alternative. In general, during the most severe low-flow periods, when stages fall below -2.0 feet at the St. Louis gage, none of the alternatives result in a stage that is more than 0.5 foot lower than the CWCP.

Figure 5.15-5 shows the annual stage duration curves at St. Louis for the CWCP and the alternatives. The duration curves show the percent of time a given stage is equaled or exceeded. For example, under the CWCP, the stage of 2.0 feet (the stage at which navigation impact begins) is exceeded about 77 percent of the time, meaning the river remains below 2.0 feet about 23 percent (100 - 77) of the time. An increase in the exceedance duration figure, therefore, means that the river spends more time above that stage and less time below that stage, and conversely, a decrease in the exceedance duration figure means that the river spends less time above that stage and more time below that stage. Figure 5.15-5 shows virtually no difference in the annual stage duration at St. Louis for the CWCP and the alternatives. The greatest change in the annual exceedance duration at any given stage was a decrease of 1.18 percent at the stage of 0.0 foot under FWS30, compared to CWCP. The 1.18 percent is equivalent to 4.3 days per year.

Figures 5.15-6 through 5.15-17 show stage exceedance duration curves at St. Louis for each month of the year. Although the annual stage duration curves (Figure 5.15-5) showed no significant variation between the CWCP and the alternatives, monthly stage duration curves reveal significant differences during certain months. During the month of June when the Gavins Point Dam spring rise would have worked its way downstream to St. Louis, there are 1 to 3 percent increases in the exceedance durations for the ARNRC, BIOP, and FWS30 alternatives. However, the increases are limited to stages in the 9 to 23 feet range, which has little impact on either flood control or navigation. Significant decreases in exceedance duration at low stages occur during July and August under the ARNRC, BIOP, and FWS30 alternatives. These changes include a 10 percent decrease under the ARNRC alternative at the 2.0-foot stage and a 9 percent decrease with the BIOP and FWS30 alternatives at the 2.0-foot stage. Significant increases in exceedance duration, on the order of 5 percent, occur at low stages under the ARNRC, BIOP, and FWS30 alternatives during October as a result of floodwater being evacuated in the fall. Significant decreases in exceedance duration at low stages occur in November under the MRBA, MODC, and FWS30 alternatives, including a 10 percent decrease at the -1.0-foot stage for the MODC alternative.

Cairo, Illinois

Unlike the Middle Mississippi, which typically crests in April or May and reaches the lowest levels in December and January, the Lower Mississippi at Cairo, Illinois, typically crests in March or April and reaches its lowest levels in September or October. By December or January, the Cairo gage is usually on a rise. A change in the Missouri River flow, therefore, affects the Lower Mississippi somewhat differently than it does the Middle Mississippi, particularly during the low-flow periods.

Figure 5.15-18 shows the computed mean stage for each month at Cairo for the CWCP and the alternatives. The pattern of flow change at Hermann is replicated here as it was at St. Louis, although the impact on stage at Cairo is a fraction of that at St. Louis due to attenuation, the introduction of the Ohio River flow, and the fact that the river is much larger at Cairo than at St. Louis.

Figure 5.15-19 shows the annual maximum stage, in feet above the 40-foot flood stage, attained at Cairo under each alternative. The greatest increase in the annual maximum stage from what it was for the CWCP among the six alternatives was 0.7 foot under the FWS30 alternative in 1968. The ARNRC and BIOP alternatives resulted in a 0.4-foot increase in maximum stage in 1968. The greatest decrease in the annual maximum stage while in flood was 0.6 foot, which occurred in 1938 under the MLDDA alternative.

Figure 5.15-20 shows the minimum stage attained at Cairo each year under each alternative. The stage at which the navigation on the Lower Mississippi begins to be affected is 11.8 feet, which, under the CWCP, occurs in about 60 percent of the 61-year (1935-1995) study period. The greatest decrease in the annual minimum stage was 2.1 feet, which occurred in 1970 under the BIOP and FWS30 alternatives; however, the reduction occurred when the stage was well above the 11.8-foot triggering stage for navigation impacts. The greatest decrease in the annual minimum stage while the river was below the 11.8-foot triggering stage was 1.6 feet, which occurred in 1976 under the ARNRC alternative. The BIOP and FWS30 alternatives resulted in a 1.3-foot reduction in stage in 1976. Other years when an alternative had a significant negative impact on minimum stages at Cairo include 1936, which had a 1.5-foot decrease for the MLDDA, ARNRC, MRBA, and MODC alternatives, and 1988, which had a 1.5-foot decrease with the ARNRC alternative. The greatest increase in the annual minimum stage was 3.4 feet in 1939 under the ARNRC alternative, which had a tremendous impact on the Lower Mississippi navigation.

Figure 5.15-21 shows the annual stage duration curve at Cairo for the CWCP and the alternatives. The duration figures are given in percent of time a given stage is equaled or exceeded. The figure demonstrates that there is no appreciable difference between the annual stage duration curves for the CWCP and the alternatives at the Cairo gage on the Mississippi River. Monthly stage duration curves, though not presented, would likely show differences between the alternatives similar to those seen at St. Louis, but on a smaller scale.

5.15.2 Navigation

A primary concern regarding changes in the Water Control Plan for the Missouri River Mainstem Reservoir System is the potential effect on Mississippi River navigation. Reduced Missouri River flows increase the probability of low-water navigation conditions in the Mississippi River system south of Lock and Dam 27 upstream from St. Louis and where the Missouri River enters the Mississippi River. With low water, the maximum tow size and draft are restricted below efficient levels at various locations on the Middle and Lower Mississippi River. Conversely, increased flows from the Missouri River decrease the probability of low-water navigation restrictions and decrease the total transportation costs of using these river reaches.

A navigation economic analysis was conducted to estimate the implications for navigation on the Mississippi River system of the different water control plans for the Mainstem Reservoir System. This analysis was broken down into shallow draft and deep draft analyses by reach on the Middle Mississippi (from St. Louis to Cairo, Illinois) and on the Lower Mississippi (from Cairo to the Mouth of Passes, Louisiana).

Increased navigation costs begin on the Middle Mississippi when the stage at St. Louis drops to 2.0 feet, which translates to a discharge of 90 kcfs or less. Various changes in tow size and draft must occur to continue to navigate between 2.0 feet and -4.5 feet (44 kcfs), when navigation must be suspended. Similarly, there are no restrictions on the Lower Mississippi when the gage reading at Cairo is above 11.8 feet (189 kcfs). Tow size and draft restrictions are required between 11.8 feet and 3.5 feet (80.5 kcfs) at the gage, and navigation is suspended below 3.5 feet at Cairo.

Table 5.15-1 presents the average annual Mississippi River lost navigation efficiency costs.

Table 5.15-1. Average annual Mississippi River lost navigation efficiency average annual costs ($millions).

Missouri River Alternative	Cairo	St. Louis	Both Reaches	Difference from CWCP Scenario
CWCP	18.77	26.50	45.27	0
MLDDA	14.60	24.24	38.84	(6.43)
ARNRC	15.68	23.71	39.39	(5.88)
MRBA	17.99	26.04	44.03	(1.24)
MODC	17.89	28.72	46.61	1.34
BIOP	14.96	22.99	37.95	(7.32)
FWS30	15.98	24.92	40.90	(4.37)

The total average navigation cost resulting from lost efficiency due to low flows on the Mississippi River for the CWCP is $45.27 million. The MODC alternative increased the annual lost efficiency by $1.34 million and the BIOP alternative had the most favorable impact by decreasing the annual lost efficiency by $7.32 million. A contributing factor to the favorable impact of the BIOP alternative is the conservation of water during the split summer Missouri River navigation season. The split navigation season allows for higher releases in October and November, which is coincident with the low-flow period on the Mississippi. All of the alternatives except the MODC alternative provided improvements in Mississippi River navigation efficiency.

5.15.3 Mississippi River Channel Improvement Features - Mouth of the Missouri River to Gulf of Mexico

The low water reference plane (LWRP) on the Mississippi River is used to establish the crown elevation for dikes and other river engineering works. It is also used by navigation interests to obtain a general idea of the depth of water available at critical locations on the river. The LWRP profile along the Mississippi River is developed from LWRP stages computed at individual gaging stations based on the 97 percent exceedance flow for a specified period of record (typically from 1954 to the time of computation) being applied to a series of rating curves from a more recent period (typically the past 10 years). The LWRP was most recently recomputed in 1992 using the 1954 to 1991 period of record flows and 1982 to 1991 rating curves. Current LWRP stages for the Mississippi River downstream of St. Louis are shown in Table 5.15-2.

To assess the impacts of the alternatives on the Mississippi River LWRP, the original LWRP computation procedure was modified to produce reasonable estimates of the impacts on the Mississippi River LWRP resulting from the change in the Missouri River flow. The current analysis consisted of four steps, as described below.

1. Compute the 97 percent exceedance flow at each of the 10 Mississippi River discharge-gaging stations, listed in Table 5.15-2, for the CWCP and the alternatives using the 1954 through 1991 period of record. Table 5.15-3 contains the 97 percent exceedance flows at each gaging station for each alternative computed from model-routed flows.

2. Use the 1988 (low-water year) observed discharge measurements to develop low-water rating curves at each of the 10 gaging stations by drawing a best-fit curve through measured points. Then raise or lower the curve to match the point defined by the existing LWRP stage and the 97 percent exceedance discharge from the CWCP. The use of the single rating curve (1988) deviates from the actual method used in computing the LWRP. The actual method involves developing a set of 10 rating curves (one for each year from 1982 through 1991), converting the 97 percent exceedance flow to stages, and then taking the average of the 10 stages to determine the LWRP. A single rating curve was used in this study for the sake of expediency.

3. Draw a line tangent to each of the rating curves at a point defined by the existing LWRP stage and the 97 percent exceedance discharge from

Table 5.15-2. Current Mississippi River LWRP stages (feet).

Gaging Station	Current LWRP
St. Louis	-3.5
Chester	-0.6
Thebes	4.8
Cairo	9.9
Memphis	-6.7
Helena	-2.2
Arkansas City	-1.1
Vicksburg	2.4
Natchez	7.3
Red River Landing	12.3

Table 5.15-3. 97 percent exceedance flow (kcfs).

Alt	St. Louis	Chester	Thebes	Cairo	Memphis	Helena	Arkansas City	Vicksburg	Natchez	Red River Landing
CWCP	56.4	59.2	60.1	138.9	147.7	151.2	170.0	176.7	173.9	130.0
MLDDA	56.1	58.7	59.6	137.6	147.0	150.4	169.1	175.6	173.1	129.6
ARNRC	56.5	59.3	60.0	136.2	145.5	149.3	167.9	173.7	172.3	128.6
MRBA	54.4	56.8	57.7	136.7	146.0	149.2	167.3	172.8	170.3	127.8
MODC	53.8	56.0	56.8	134.9	145.9	148.7	166.9	171.8	169.8	127.8
BIOP	55.5	58.2	59.2	135.0	144.6	147.7	167.1	172.9	172.4	128.3
FWS30	55.1	57.7	58.5	135.0	144.6	148.0	166.9	172.5	171.5	127.8

the CWCP alternative. This tangent line defines the slope of the curve at the LWRP stage. The slopes, shown below, were rounded off and grouped by Corps District reaches for simplicity and consistency of results:

St. Louis District (St. Louis, Chester, Thebes)	5.5 kcfs/foot
Memphis District (Cairo, Memphis, Helena)	13 kcfs/foot
Vicksburg District (Arkansas City, Vicksburg, Natchez)	14 kcfs/foot
New Orleans District (Red River Landing)	18 kcfs/foot

4. Compute the impact on the LWRP by applying the slope to the difference in the 97 percent exceedance flows (between CWCP and other alternatives). Table 5.15-4 shows the computed differences in the LWRP, with the positive values indicating the raising of the LWRP and the negative values indicating the lowering of the LWRP. Table 5.15-5 shows the adjusted LWRP stages.

Table 5.15-4 shows that all alternatives have a negative impact by lowering the LWRP, typically by 0.2 to 0.5 foot along the Middle Mississippi and 0.2 to 0.3 foot along the Lower Mississippi. The worst case scenario occurs under the MODC alternative, which lowers the LWRP by as much as 0.6 feet along the Middle Mississippi and by as much as 0.3 feet along the Lower Mississippi. The lowering of the LWRP will require the training dikes on the Mississippi River to be extended farther into the river at a substantial cost.

Table 5.15-6 presents the cost associated with Mississippi River channel improvement feature modifications resulting from the respective alternatives. A previous study by the St. Louis District determined that, for each 0.1 foot of reduction in existing the LWRP, the cost of new construction of training structures for the Middle and Lower Mississippi River reaches would be $5 million. This cost is associated with maintaining a 9-foot navigation channel in the Mississippi River. This does not include environmental impacts that may accrue from changing channel improvement features.

Table 5.15-4. Change in Mississippi River LWRP relative to the CWCP (feet).

Alt.	St. Louis	Chester	Thebes	Cairo	Memphis	Helena	Arkansas City	Vicksburg	Natchez	Red River Landing
CWCP	0	0	0	0	0	0	0	0	0	0
MLDDA	-0.05	-0.08	-0.09	-0.10	-0.06	-0.06	-0.06	-0.07	-0.06	-0.02
ARNRC	0.03	0.03	-0.01	-0.21	-0.17	-0.15	-0.15	-0.21	-0.11	-0.08
MRBA	-0.35	-0.43	-0.44	-0.17	-0.13	-0.16	-0.19	-0.28	-0.25	-0.13
MODC	-0.46	-0.57	-0.60	-0.31	-0.14	-0.19	-0.22	-0.35	-0.29	-0.12
BIOP	-0.17	-0.17	-0.16	-0.30	-0.25	-0.27	-0.20	-0.27	-0.11	-0.09
FWS30	-0.24	-0.27	-0.29	-0.30	-0.24	-0.25	-0.22	-0.29	-0.17	-0.12

Table 5.15-5. Revised Mississippi River LWRP (feet).

Alt.	St. Louis	Chester	Thebes	Cairo	Memphis	Helena	Arkansas City	Vicksburg	Natchez	Red River Landing
CWCP	-3.5	-0.6	4.8	9.9	-6.7	-2.2	-1.1	2.4	7.3	12.3
MLDDA	-3.55	-0.68	4.71	9.80	-6.76	-2.26	-1.16	2.33	7.24	12.28
ARNRC	-3.47	-0.57	4.79	9.69	-6.87	-2.35	-1.25	2.19	7.19	12.22
MRBA	-3.85	-1.03	4.36	9.73	-6.83	-2.36	-1.29	2.12	7.05	12.18
MODC	-3.96	-1.17	4.20	9.59	-6.84	-2.39	-1.32	2.05	7.01	12.18
BIOP	-3.67	-0.77	4.64	9.60	-6.95	-2.47	-1.30	2.13	7.19	12.21
FWS30	-3.74	-0.87	4.51	9.60	-6.94	-2.45	-1.32	2.11	7.13	12.18

Table 5.15-6. Mississippi River channel improvement features cost by alternative.

Alternative	St. Louis LWRP (feet)	Change in LWRP (feet)	Increased Cost ($millions)
CWCP	-3.50	0.0	0
MLDDA	-3.55	-0.05	2.5
ARNRC	-3.47	0.0	0
MRBA	-3.85	-0.35	17.5
MODC	-3.96	-0.46	23.0
BIOP	-3.67	-0.17	8.5
FWS30	-3.74	-0.24	12.0

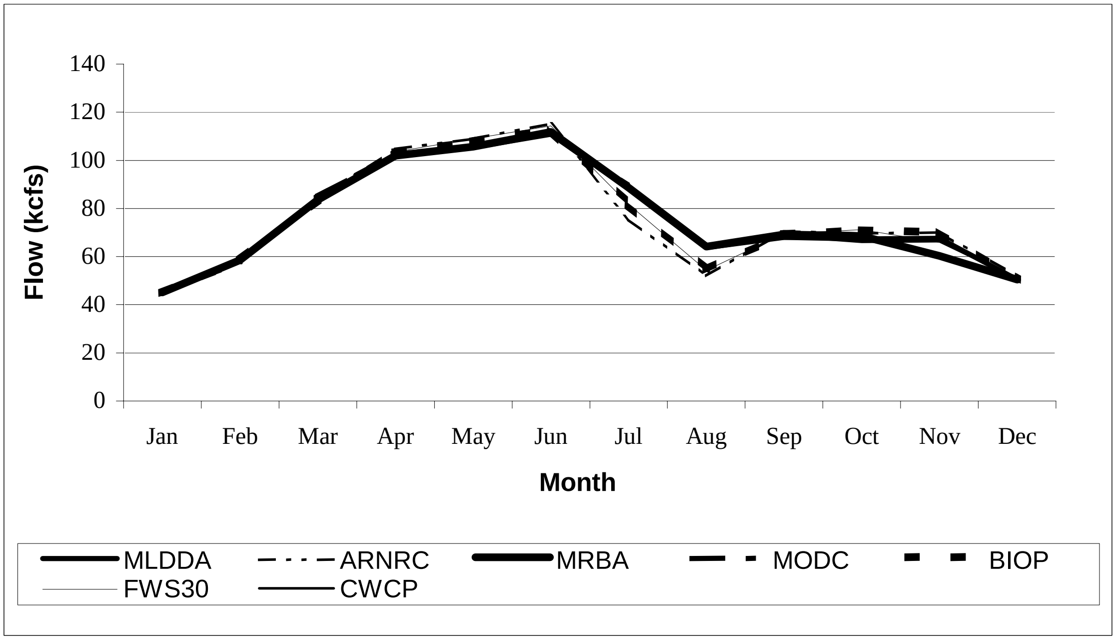

Figure 5.15-1. Average monthly flow at Hermann, MO.

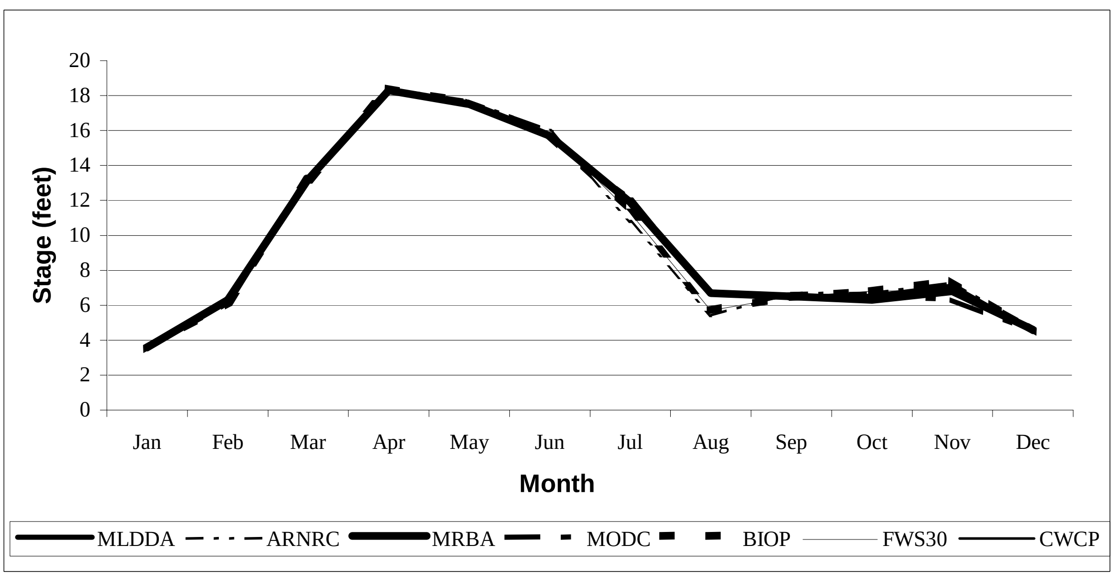

Figure 5.15-2. Mean monthly stage at St. Louis.

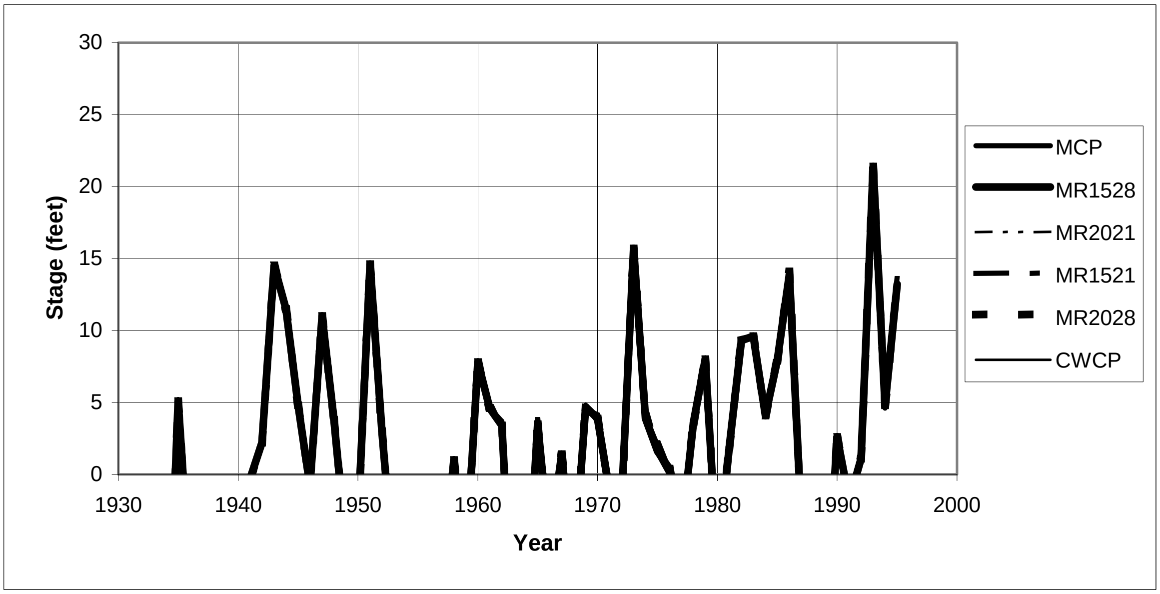

Figure 5.15-3. Maximum annual stage at St. Louis.

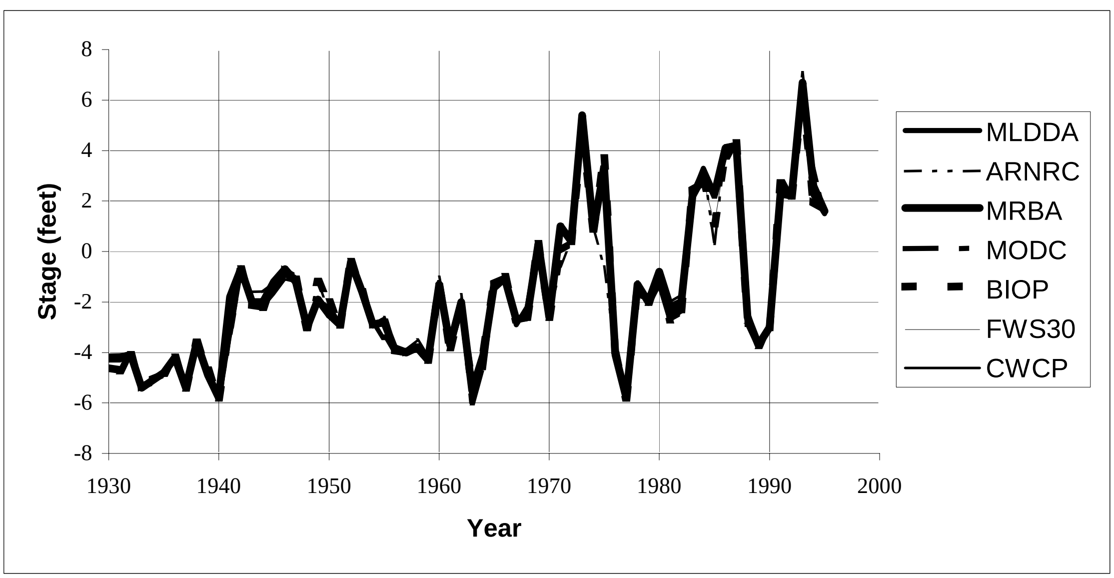

Figure 5.15-4. Minimum annual stage at St. Louis.

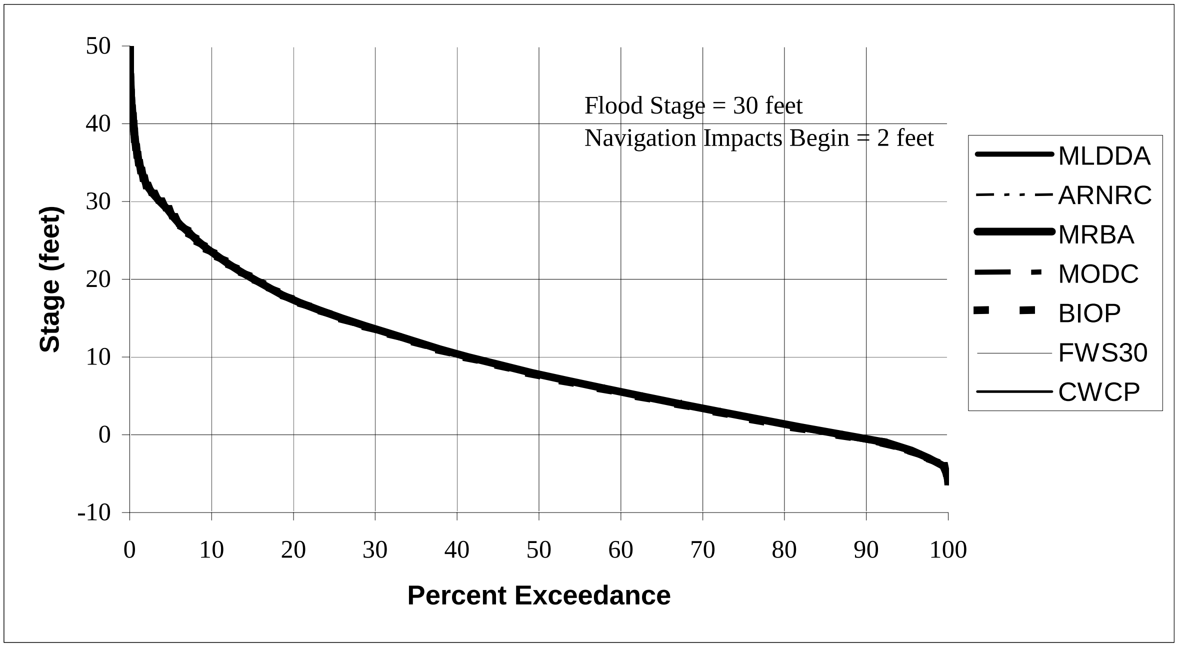

Figure 5.15-5. Average annual St. Louis stage duration.

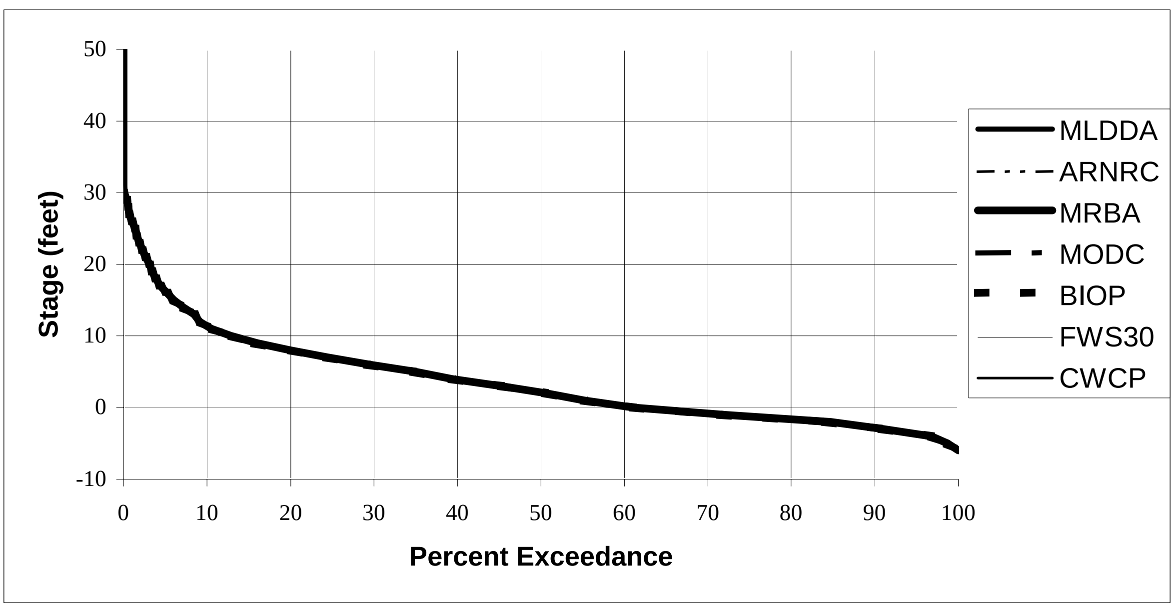

Figure 5.15-6. St. Louis stage duration, January.

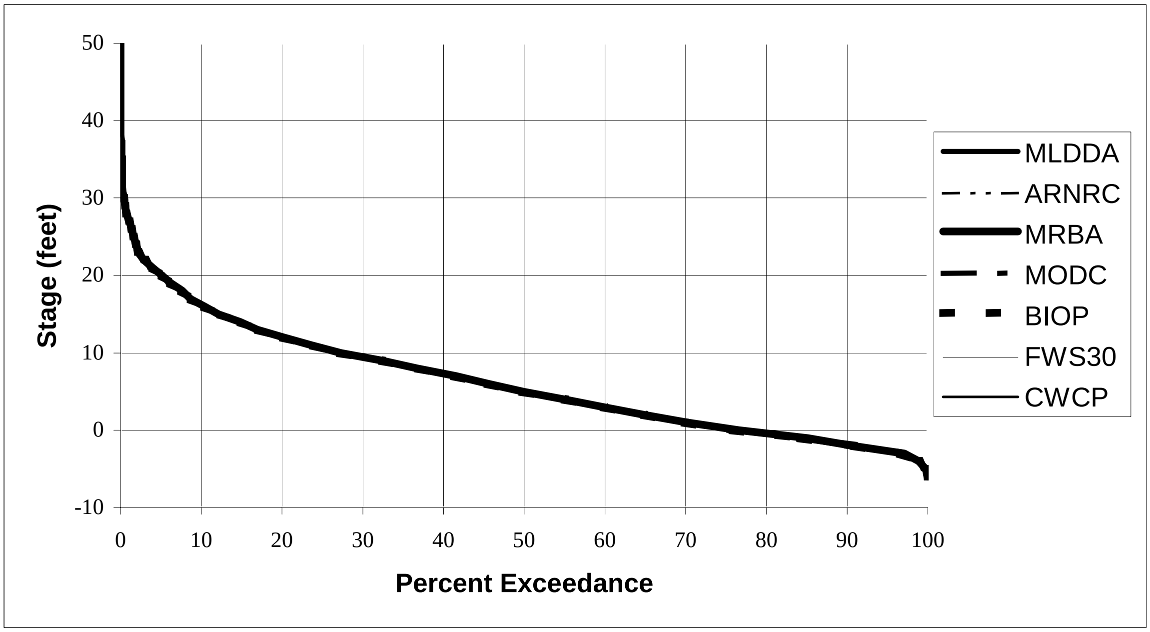

Figure 5.15-7. St. Louis stage duration, February.

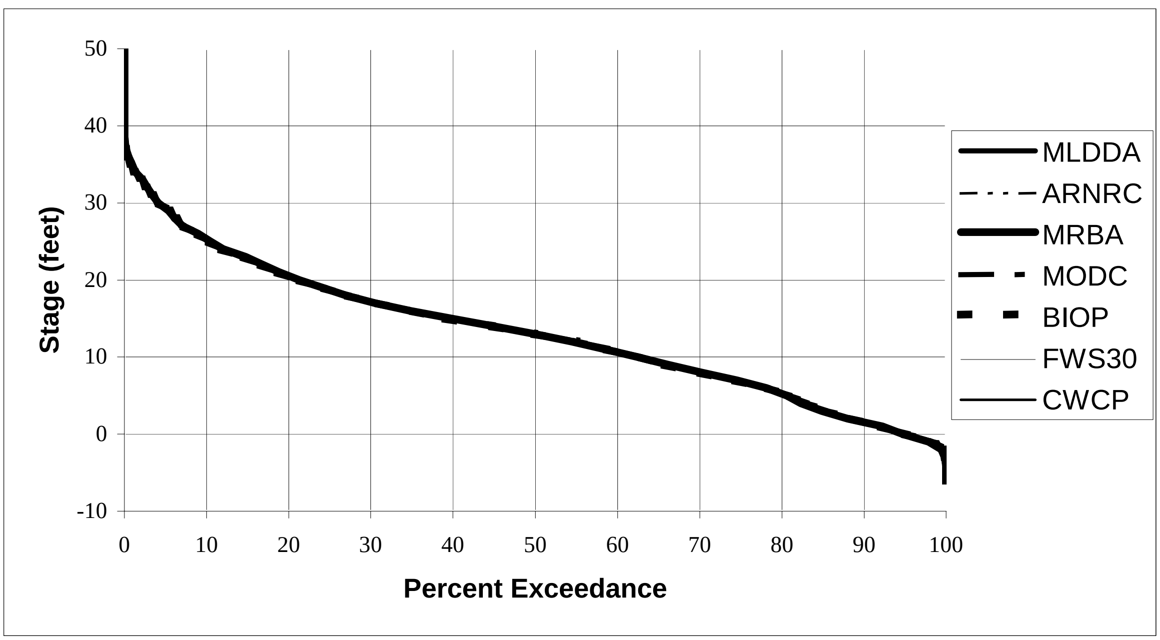

Figure 5.15-8. St. Louis stage duration, March.

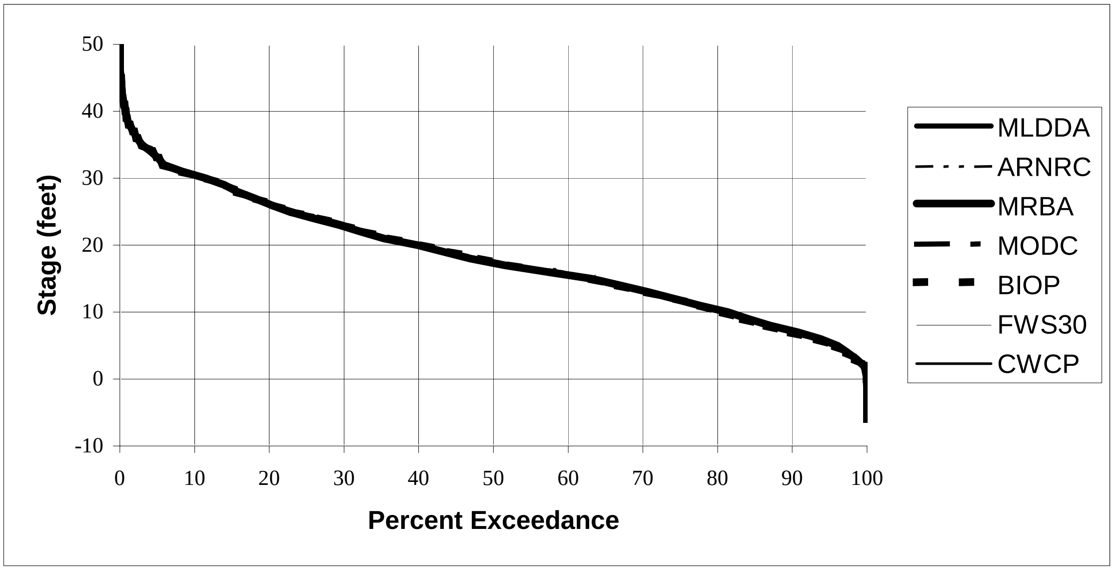

Figure 5.15-9. St. Louis stage duration, April.

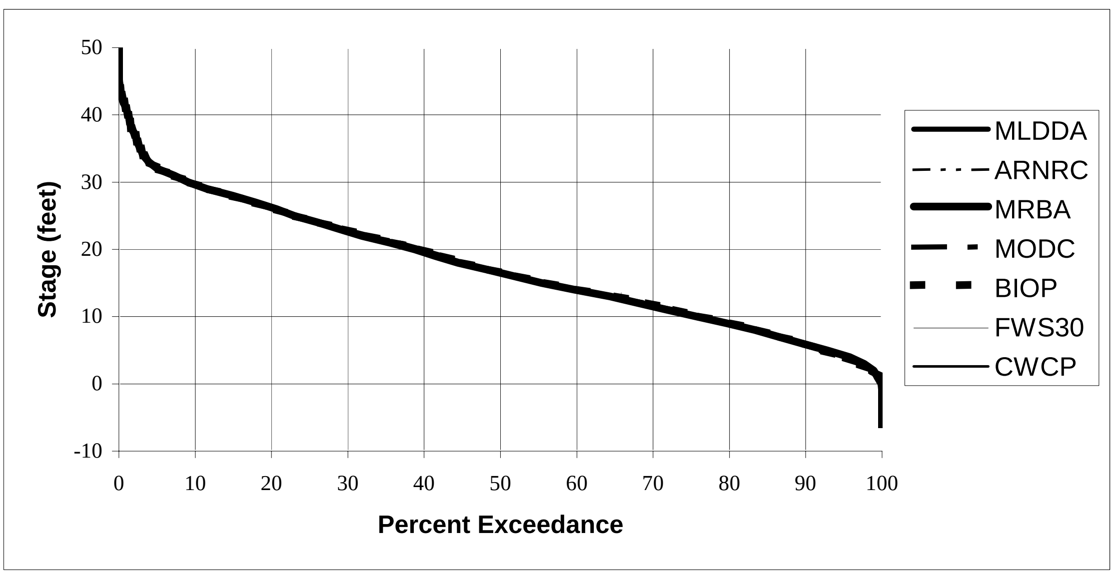

Figure 5.15-10. St. Louis stage duration, May.

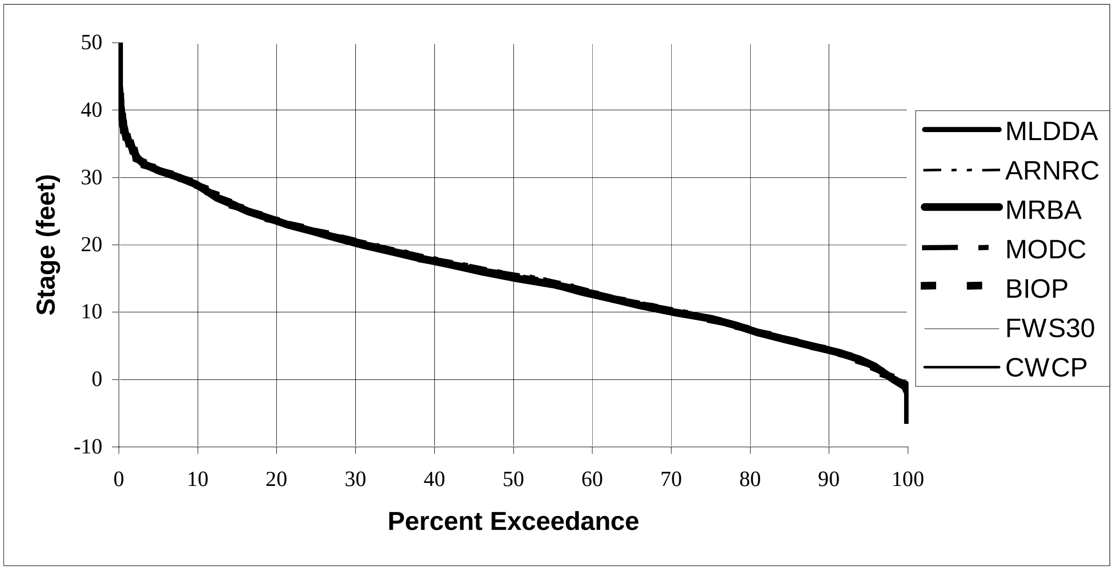

Figure 5.15-11. St. Louis stage duration, June.

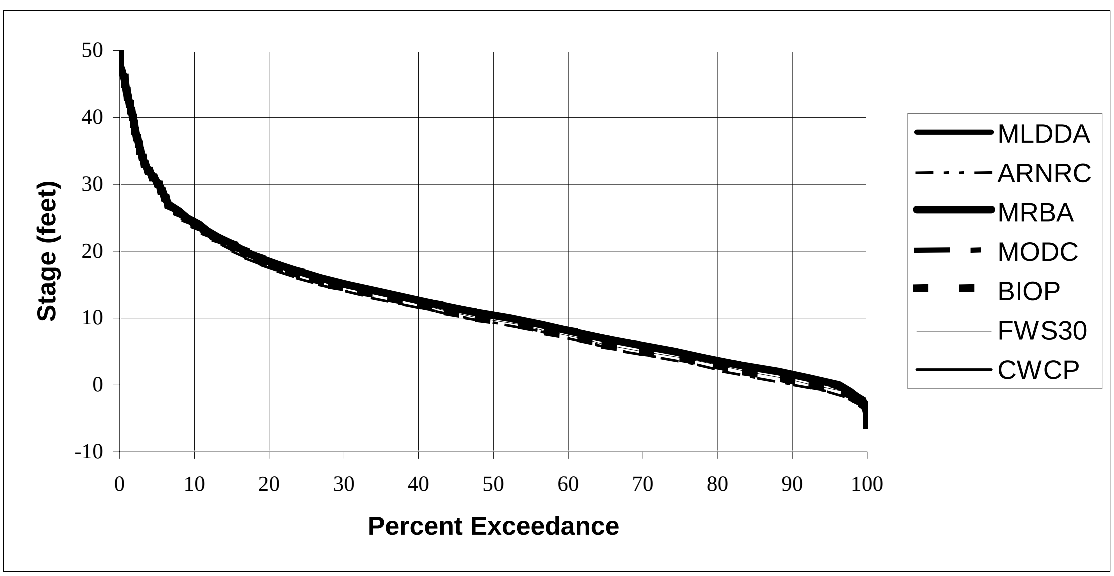

Figure 5.15-12. St. Louis stage duration, July.

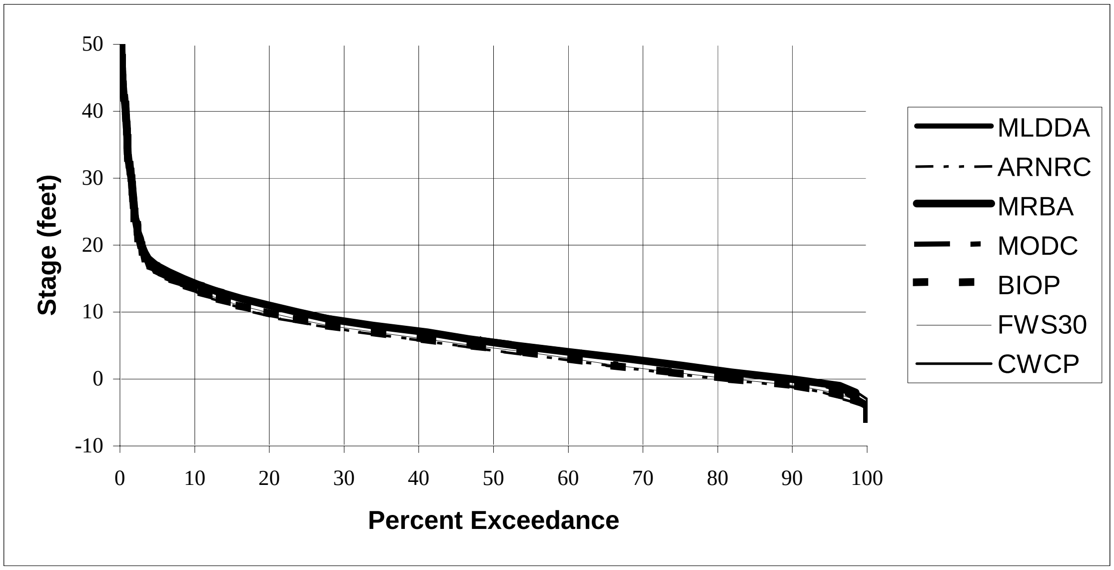

Figure 5.15-13. St. Louis stage duration, August.

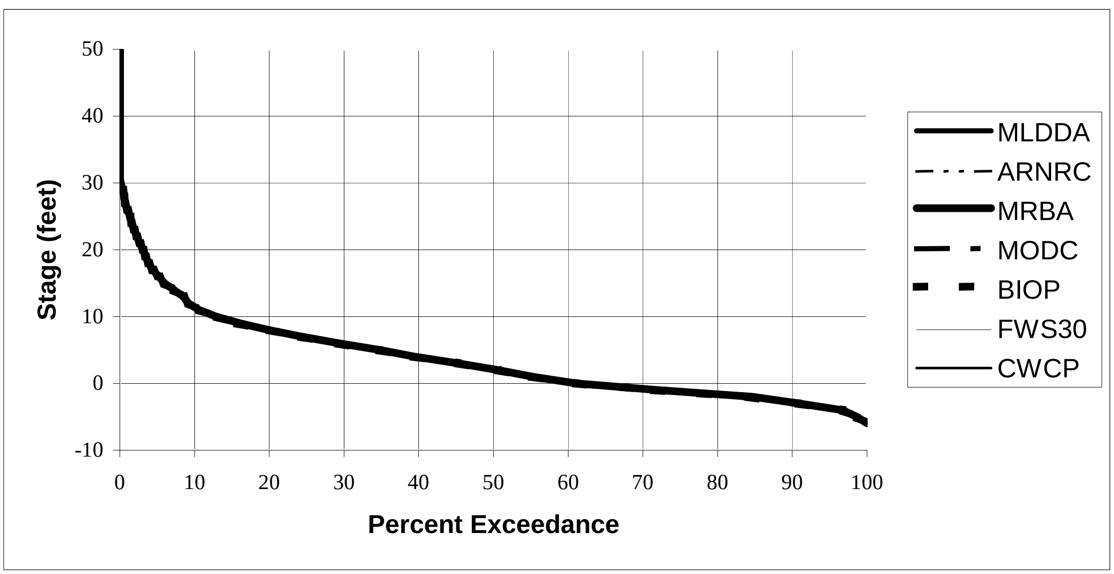

Figure 5.15-14. St. Louis stage duration, September.

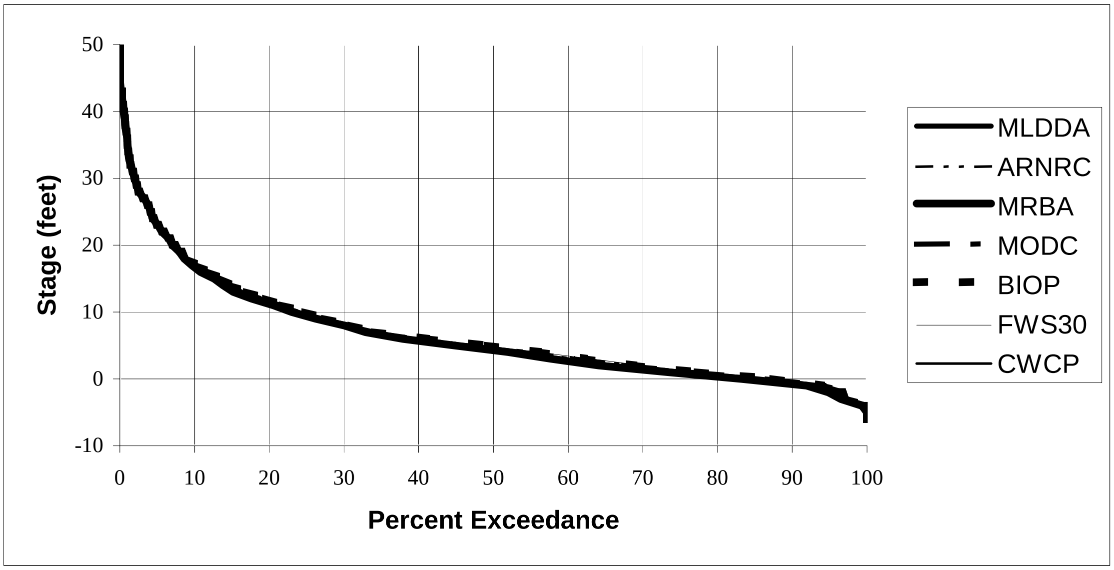

Figure 5.15-15. St. Louis stage duration, October.

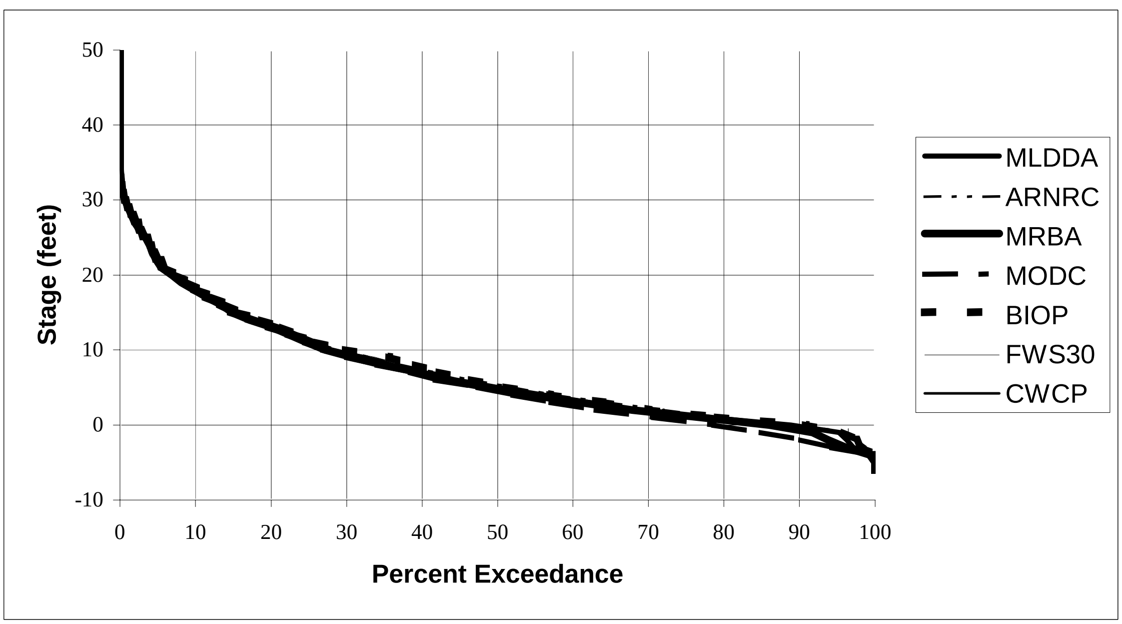

Figure 5.15-16. St. Louis stage duration, November.

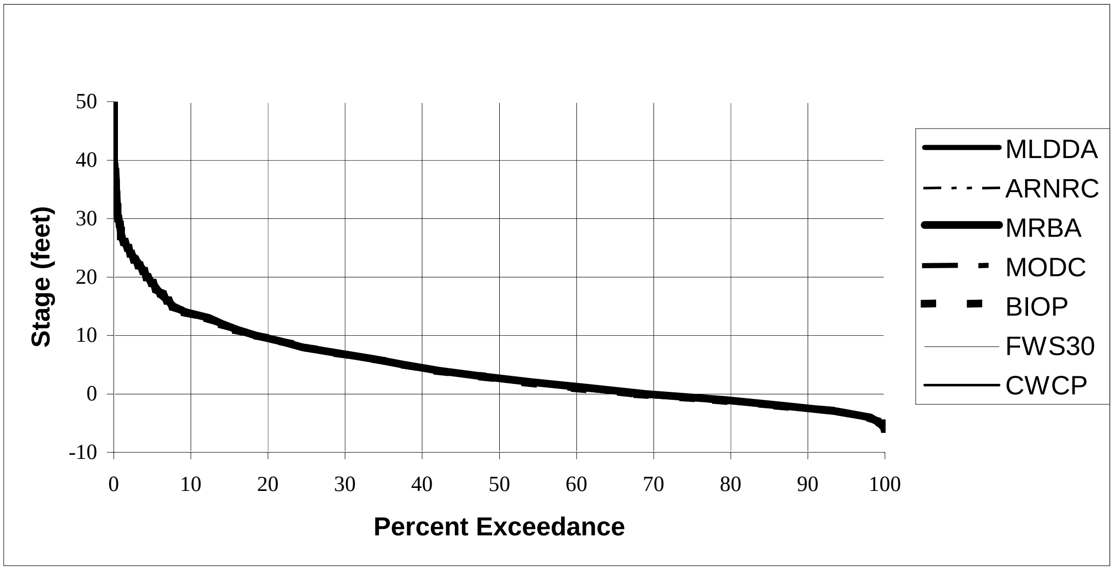

Figure 5.15-17. St. Louis stage duration, December.

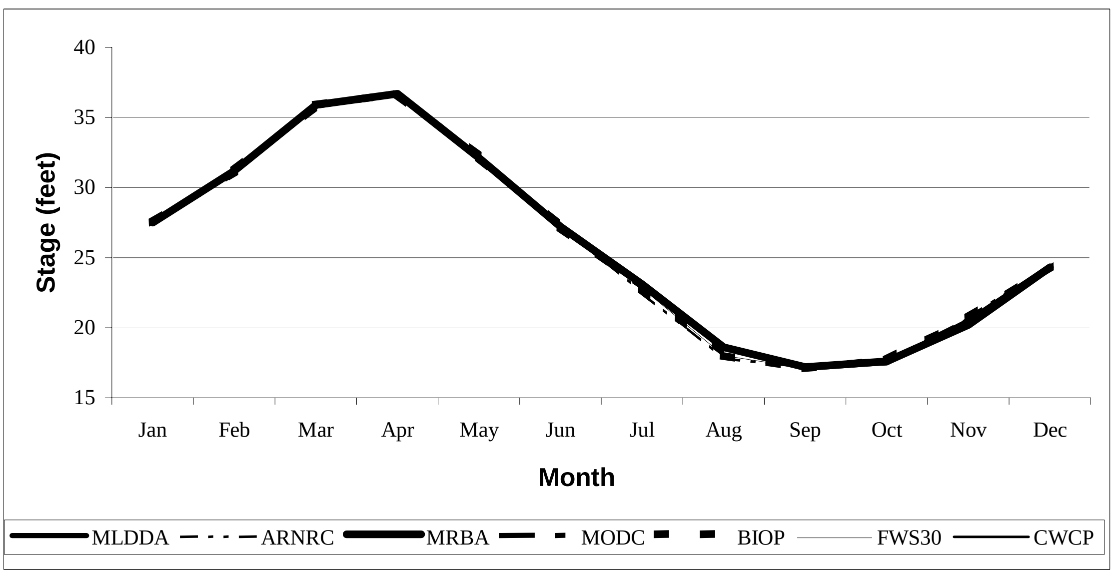

Figure 5.15-18. Mean monthly stage at Cairo.

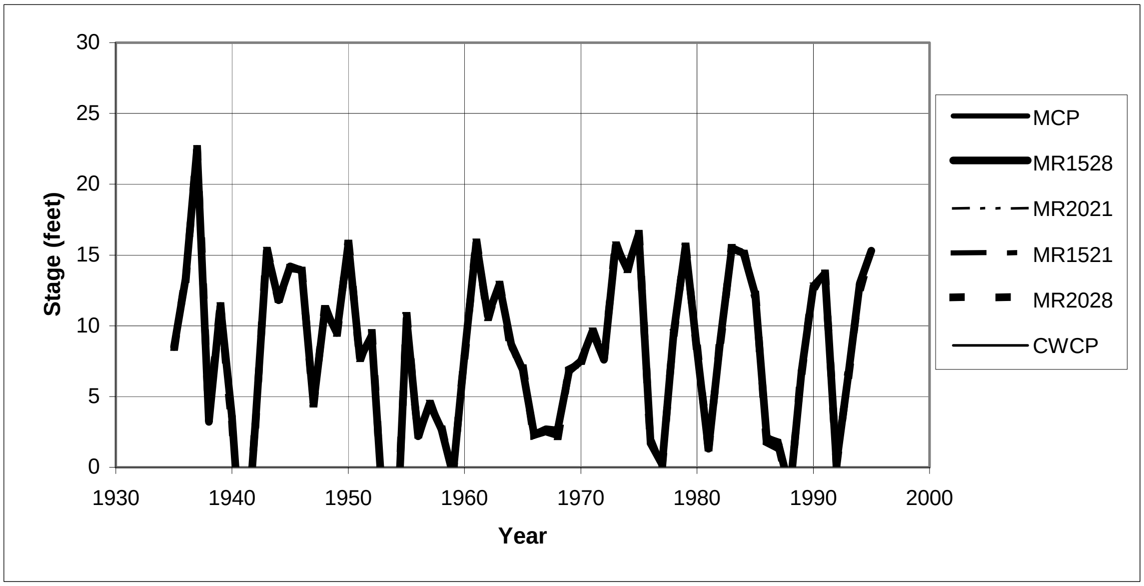

Figure 5.15-19. Maximum annual stage at Cairo.

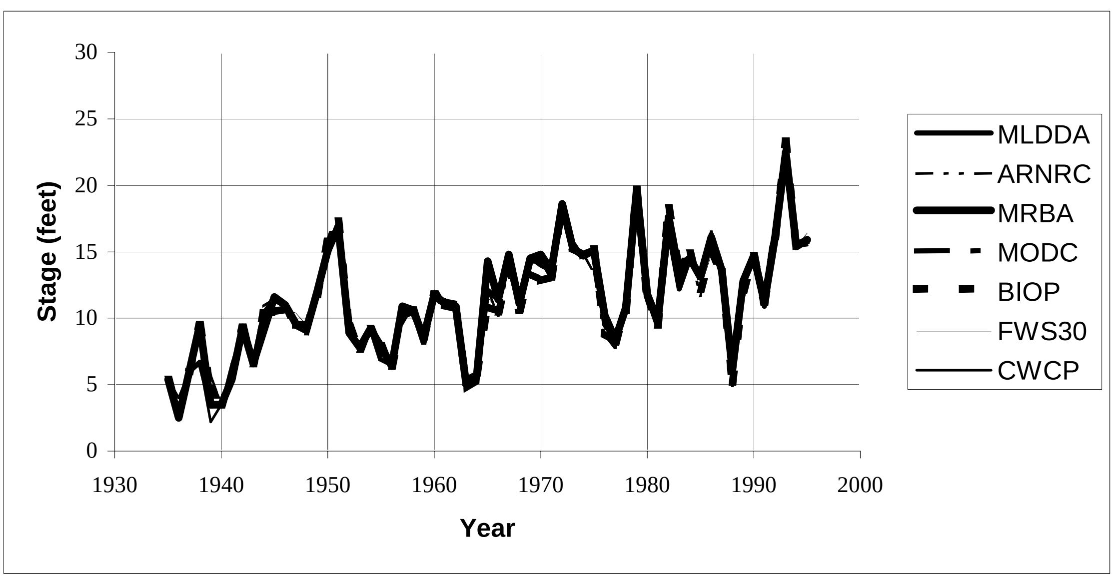

Figure 5.15-20. Minimum annual stage at Cairo.

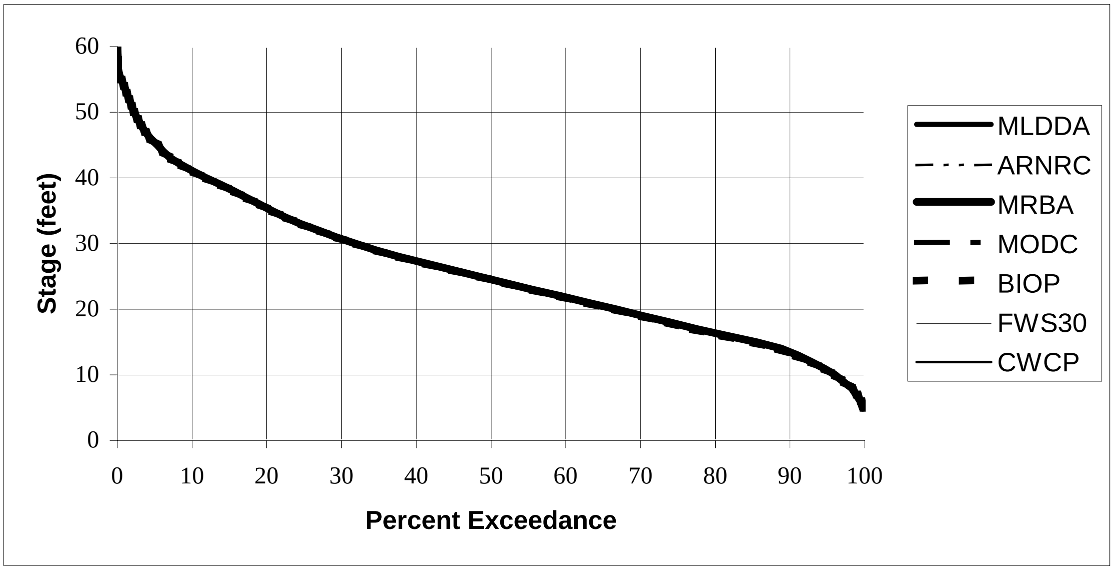

Figure 5.15-21. Cairo stage duration.

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