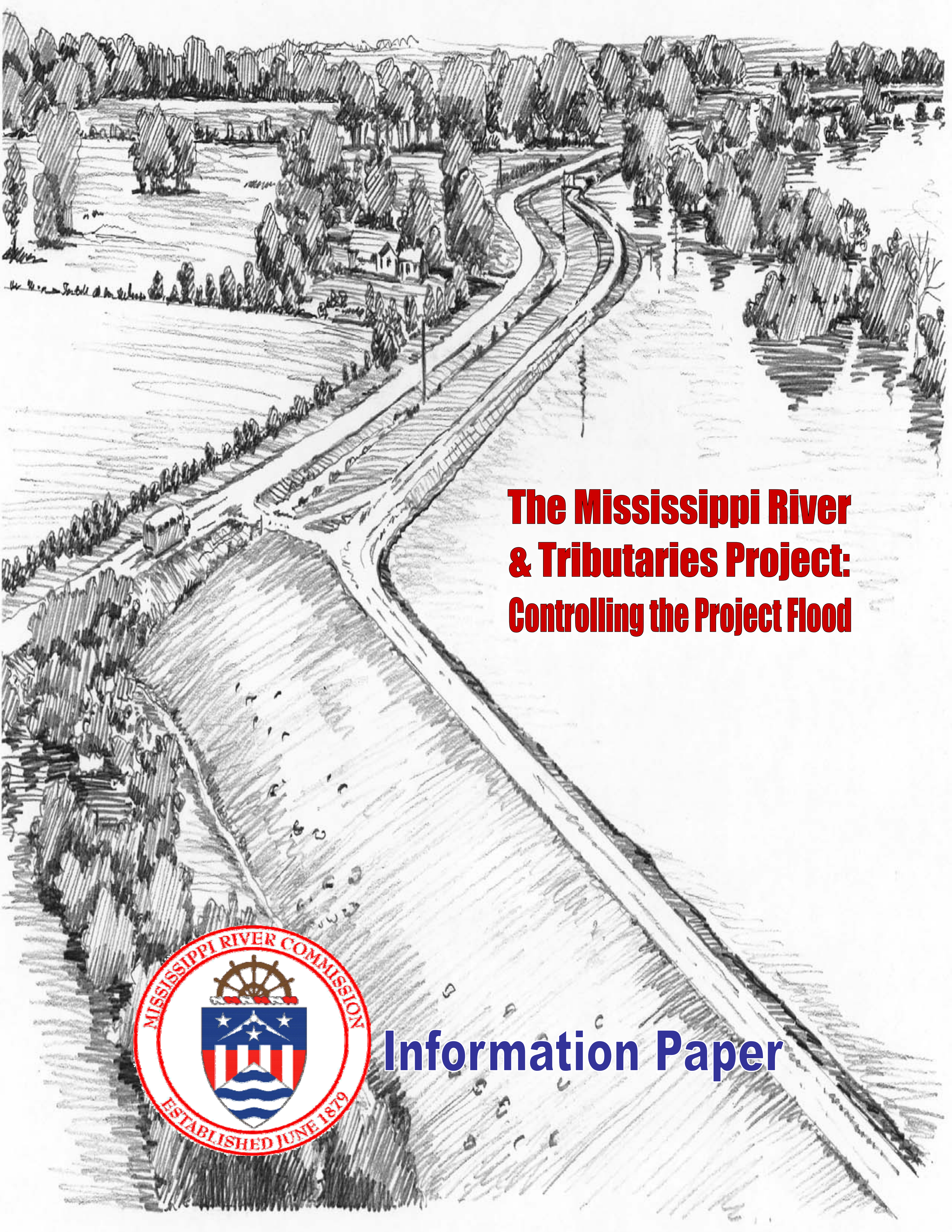
The Mississippi River & Tributaries Project: Controlling the Project Flood



MISSISSIPPI RIVER COMMISSION
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Information Paper

The Mississippi River & Tributaries Project

Controlling the Project Design Flood

Following the Great Mississippi River Flood of 1927, the nation galvanized in its support for a comprehensive and unified system of public works within the lower Mississippi Valley that would provide enhanced protection from floods, while maintaining a mutually compatible and efficient Mississippi River channel for navigation. Administered by the Mississippi River Commission under the supervision of the Office of the Chief of Engineers, the resultant Mississippi River and Tributaries (MR&T) project employs a variety of intensely managed engineering techniques, including an extensive levee system to prevent disastrous overflows on developed alluvial lands; floodways to safely divert excess flows past critical reaches so that the levee system will not be unduly stressed; channel improvements and stabilization features to protect the integrity of flood control measures and to ensure proper alignment and depth of the navigation channel; and tributary basin improvements, to include levees, reservoirs, and pumping stations, that maximize the benefits realized on the main stem by expanding flood protection coverage and improving drainage into adjacent areas within the alluvial valley.

Since its initiation, the MR&T project has brought an unprecedented degree of flood protection to over 4.5 million people living in the 35,000 square-mile project area within the lower Mississippi Valley. The nation has contributed $13 billion toward the planning, construction, operation, and maintenance of the project and, to date, the nation has received a 27 to 1 return on that investment, including $350 billion in flood damages prevented. Such astounding figures place the MR&T project among the most successful and cost-effective public works projects in the history of the United States.

The Project Design Flood

The success of the MR&T flood control program is rooted in a profound change in engineering policy the evolved after the 1927 flood. Prior to that tragic flood event, the control of floods on the lower Mississippi was attempted by building levees high enough to withstand the last great flood of record.

The Mississippi River & Tributaries Project

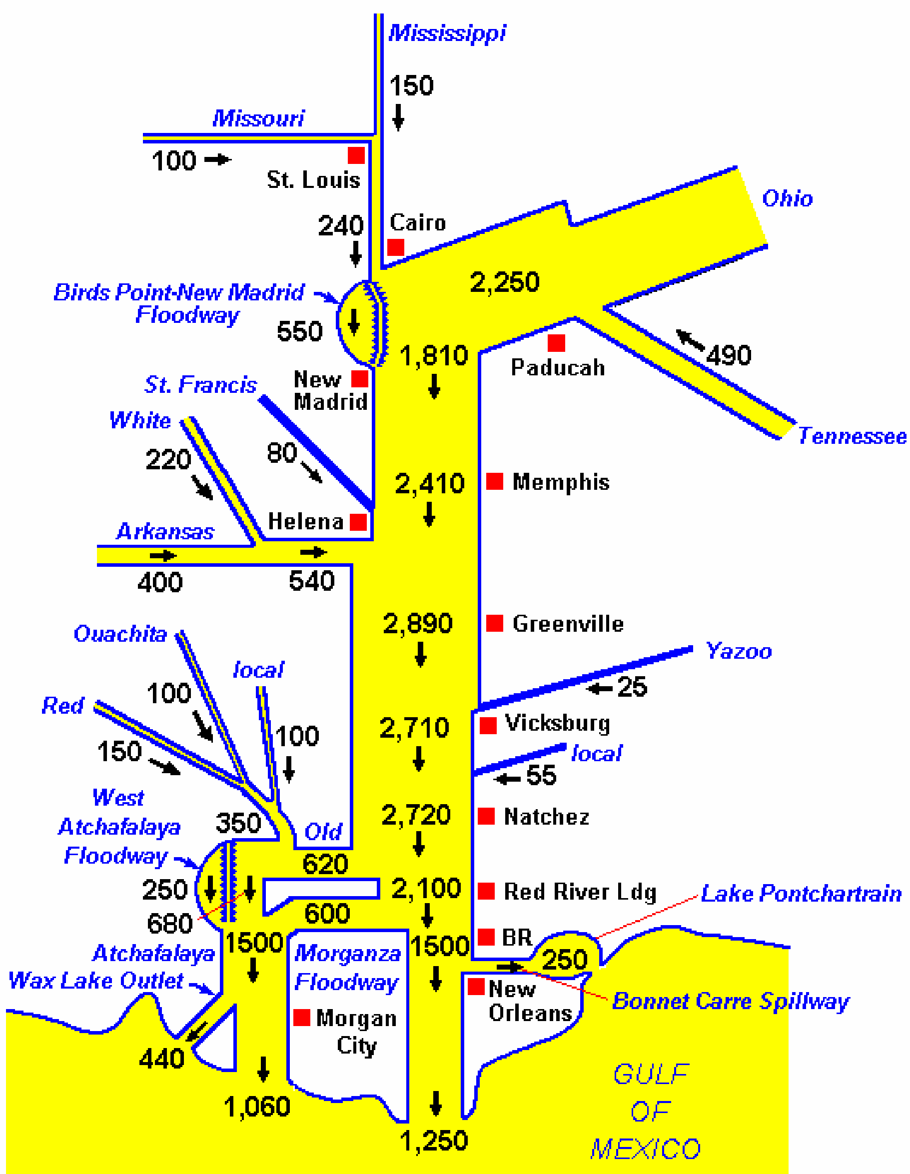
Controlling the Project Design Flood

Since the inception of the MR&T project in 1928, however, the comprehensive flood control program is designed to control the "project design flood."

The current project design flood, developed between 1954 and 1955 at the request of the Senate Committee on Public Works, resulted from a thorough and cooperative effort by the Weather Bureau, the U.S. Army Corps of Engineers, and the Mississippi River Commission that incorporated previously unavailable data regarding the sequence, severity, and distribution of past major storms and investigated 35 different hypothetical combinations of actual storms that produced significant amounts of precipitation and runoff.

The historical storms were arranged sequentially to mimic frontal movements and atmospheric situations consistent with those occurring naturally to determine the most feasible pattern capable of producing the greatest amount of runoff on the lower Mississippi River.

This included the consideration of storm transpositions, storm intensity adjustments, seasonal variations, and storm mechanics. In simpler terms, the project design storm series was developed from various combinations of actual storms and resultant floods—referred to as hypo floods—that had a reasonable probability of occurring from a meteorological viewpoint.



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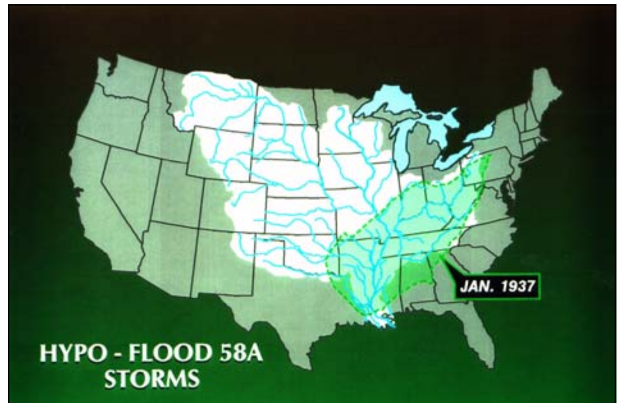
The study revealed that Hypo-Flood 58A had the most probable chance of producing the greatest discharge on the lower Mississippi River from Cairo to the Gulf of Mexico. Three severe storms comprised



The first storm is the 1937 storm that struck the Ohio and lower Mississippi River basins, with runoff increased by 10 percent. It is followed three days later by the 1950 storm over the same general area. This storm is followed three days later by the 1938 storm, with its center transposed 90 miles to the north and the rainfall pattern rotated by 20 degrees to maximize its coverage over all the tributary basins on the lower Mississippi River.

To convert Hypo-Flood 58A into the project design flood, the Mississippi River Commission developed the flood flows that would occur from the three storms and routed them through the tributary systems under three conditions: unregulated by reservoirs; regulated by reservoirs in existence; and regulated by existing reservoirs, plus those proposed to be constructed in the near future (1960 timeframe).

The flood flows were then routed down the Mississippi River to determine the peak discharges at key locations.

The Mississippi River Commission selected the 58A flood with near-future reservoirs condition, referred to as 58A-EN (existing or near completion), as the basis for the project flood flowline and adopted it as the project design flood in 1956.

The peak discharges for the revised project design flood, which has no assigned flood frequency, were 2,360,000 cfs at Cairo; 2,890,000 cfs at Arkansas City, and 3,030,000 cfs at the latitude of Red River Landing.

Controlling the Project Design Flood

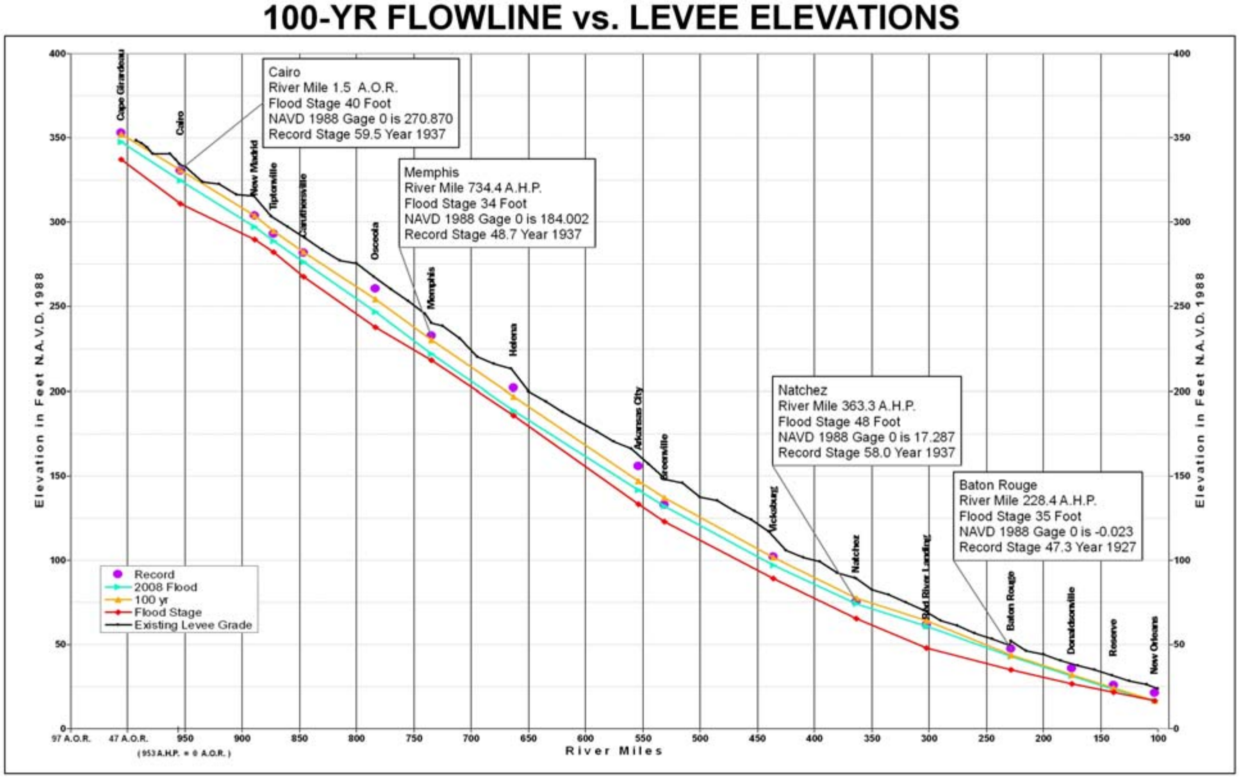
Following the 1973 flood, the Mississippi River Commission once again reviewed the adequacy of the project design flood. The review concluded that the thorough approach used in 1954-55 was based on sound technology that was still reliable by current standards. The project design flood peak discharges remained unchanged. The current project design flood—regulated by reservoirs—is about 25 percent greater than the devastating 1927 flood.

Conveying the Project Design Flood

<u>Levee System</u>

Levees are the mainstay of the MR&T project flood-control plan. The system protects the vast expanse of the developed alluvial valley from periodic overflows of the Mississippi River. The main stem levee system begins at the head of the alluvial valley at Cape Girardeau, Missouri, and continues to Venice, Louisiana, approximately 10 miles above the Head of Passes near the Gulf of Mexico. The MR&T levee system includes 3,787 miles of authorized embankments and floodwalls. Of this number, nearly 2,216 miles are along the main stem Mississippi River and the remaining levees are backwater, tributary, and floodway levees. No project levee built to Mississippi River Commission standards has ever failed, despite significant floods in 1937, 1945, 1950, 1973, 1975, 1979, 1983, 1997, and 2008.

MISSISSIPPI RIVER LEVEES
100-YR FLOWLINE vs. LEVEE ELEVATIONS



Controlling the Project Design Flood

The grade and section of the present levee system dwarfs by comparison those of the levee system overwhelmed during the 1927 flood. In addition to higher and wider levees, the MR&T levee system design incorporates technological breakthroughs from the science of soil mechanics that take into account the type, condition, and moisture content of material used in the construction of the levees.

The integrity of the current levee system is enhanced by advancements in the design, construction, installation, and maintenance of seepage control measures, to include landside berms, drainage trenches, drainage blankets and relief wells. More than 1,000 miles of articulated concrete mattress revetment also protect the levee system by preventing erosion.

In an effort to further guarantee the soundness of the levee system, levee districts and other local sponsors implement strict levee maintenance programs with their own labor and funds. Normal operations and maintenance activities conducted daily by local sponsors include mowing, clearing brush and trees, filling holes, restore rain washed areas, clearing drainage ditches, correcting drainage problems, and spraying chemical to control noxious and unwanted growth.

This effort is augmented through daily inspections by pasture tenants who depend on a sound and reliable levee system to protect their lives, homes, and property from destructive floods. Together these inspections are also used to identify any deficiencies and weak spots in the levee system so that immediate corrective actions can be taken. The addition of 15-foot wide, all-weather access roadways on top of the levee system aids federal personnel and local levee districts during the inspection process and during flood-fighting operations, when the level of intensity of daily inspection increases.

Personnel from USACE Districts additionally ensure that maintenance requirements are met through annual inspections.

To maximize protection from floods, current levee grades provide for freeboard--the distance between the project design flood flowline and the top of the levee. The presently-authorized freeboard is a minimum of three feet above the project design flood on the Mississippi River levees below Cairo, Illinois, and two feet on the Atchafalaya basin floodway levees. Levee grades between Cape Girardeau and Cairo and along the south banks of the Arkansas and Red rivers provide for a 3-foot minimum freeboard over the maximum tributary flood meeting the maximum flood of record on the Mississippi River, with provisions to insure that the same flood meeting the project design flood will not overtop the levee. In the vicinity of New Orleans, Louisiana, project levees are authorized up to 5.7 feet of freeboard because of the increased danger to the urban areas from wave wash and storm surges that are common along coastal areas.

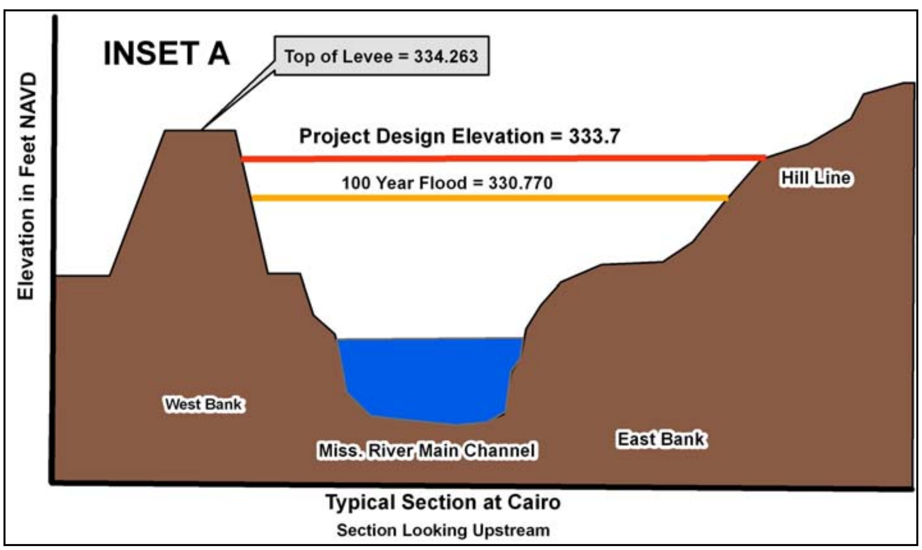
When flood stages begin to approach project design flood dimensions, additional project features are operated to control and convey potentially-damaging floodwaters to relieve stress on the levee system. A synopsis of how the MR&T project features in the northern, middle, and southern section of the project convey the project design flood follows.

Northern Section

The first key location on the flood control system is in the vicinity of Cairo. When the flood stage reaches a critical level at Cairo, the Birds Point-New Madrid floodway is placed into operation to prevent the project flood from exceeding the design elevation at and above Cairo and along east bank levee adjacent to the floodway. The floodway varies in width from about three to ten miles and has a length of nearly 36 miles.

The floodway is designed to divert 550,000 cfs from the Mississippi River during the project flood and provides about seven feet of stage lowering in the vicinity of Cairo, with smaller reductions above Cairo and through the floodway reach.

The floodway has two fuseplug levees at its upper and lower end.



Controlling the Project Design Flood

The fuseplug sections are levees constructed to a lower height than the main stem levees. The floodway is activated when sections of the frontline levee naturally overtop or are artificially crevassed. The floodway requires timely operation to ensure its design effect during a flood approaching the project flood magnitude. For this reason, the plan of operation involves the placing and detonation of explosives at the required crevasse locations.

The operation of any floodway within the MR&T project is directed by the president of the Mississippi River Commission after consultation with the Chief of Engineers. The Birds Point-New Madrid Floodway, completed in 1933, has only been operated during the 1937 flood.

There are two major reservoirs—Kentucky and Barkley lakes—on the Tennessee and Cumberland rivers that are not features of the MR&T project, but are authorized through the 1944 Flood Control Act to reduce flood stages on the Mississippi River in the vicinity of and downriver from Cairo.

Because of the close proximity of the reservoirs to the Birds Point-New Madrid floodway, their regulation has a major predictable impact on the operation of the floodway. The impacts of these reservoirs were accounted for in the development of the MR&T project design flood.

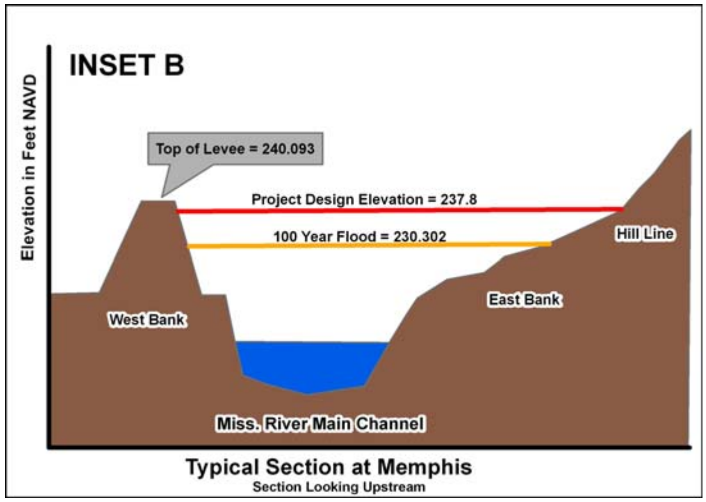
The 1944 Flood Control Act directs the Tennessee Valley Authority (TVA) to regulate the release of water from the Tennessee River into the Ohio River in accordance with instructions from the Corps of Engineers. Objectives developed by the Corps of Engineers Lakes and Rivers Division for the Kentucky-Barkley reservoir outflows have priorities to safeguard the Mississippi River levee system, to reduce the frequency of use of the Birds Point-New Madrid Floodway and to reduce the frequency and magnitude of flooding of lands along the lower Ohio and Mississippi rivers which are unprotected by levees.

The Mississippi River & Tributaries Project

Controlling the Project Design Flood

When flood control within the Mississippi Valley and/or the MR&T project is threatened, the Mississippi River Commission president and the Great Lakes and Ohio River Division commander—a position that also serves as a member of the Mississippi River Commission—work together to regulate releases from Barkley and Kentucky lakes with the concurrence of the general manager of the Tennessee Valley Authority to accomplish these objectives.

<u>Middle Section</u>

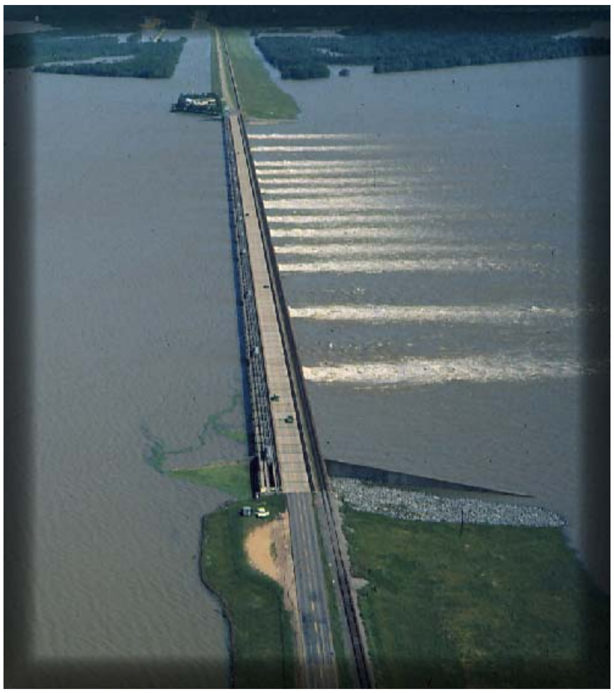


Between the lower end of the Birds Point-New Madrid floodway and the Old River Control Complex, the project design flood is confined by levees on the west bank and levees and a high bluff on the east bank.

The confinement of the project design flood in this stretch of the river was made possible by a comprehensive dredging program conducted between 1932 and 1942 that greatly improved the carrying capacity of the channel and lowered the project flood flow line. The levee system in this segment of the project is supplemented by four backwater areas located at the mouths of the St. Francis, White, Yazoo, and Red rivers. Significant portions of the upper sections of these backwater areas are protected by main stem levees from overflows of the Mississippi River. The lower portions of these areas serve as natural storage areas during floods approaching the project flood design. The backwater areas are placed into operation by overtopping at a time sufficient to reduce project flood peak stages. When flood stages on the Mississippi River or its tributaries subside, floodwaters from within the backwater areas evacuated through floodgates.

The next key location on the flood control system is the Old River Control Complex at the head of the Atchafalaya River basin. The control complex was constructed to prevent the Atchafalaya from capturing the Mississippi River.

The complex is designed to maintain the 1950 flow distribution between the Mississippi River and the Atchafalaya River of 70 percent to 30 percent, respectively. Three separate structures comprise the Old River Control Complex. The low sill structure and the auxiliary structure remain operable at all river stages, but the overbank structure is only operated during flood stages. During project flood conditions, the Old River Control Complex is designed to divert 620,000 cfs from the Mississippi River to the Atchafalaya River.



Approximately 30 miles downstream from Old River, the MR&T flood control plan provides for a major diversion of floodwaters from the Mississippi River to the Atchafalaya basin through the Morganza Floodway.

Governed by a 3,900-foot long and a 125-bay intake structure, the floodway is designed to divert 600,000 cfs from the Mississippi River during the project design flood. The Morganza Floodway is operated when the Mississippi River flows below Morganza are projected to exceed 1,500,000 cfs, thereby assuring that flows between Morganza and Bonnet Carré remain at or below 1,500,000 cfs. The Morganza Floodway, completed in 1953, has only been operated during the 1973 flood.

The West Atchafalaya Floodway extends along the west side of the Atchafalaya River. The floodway contains an 8-mile long fuseplug section of levee at the head of the floodway. The floodway is designed to divert 250,000 cfs and is placed into operation when the fuseplug section is crevassed or when the west bank Atchafalaya River levee is overtopped.

The West Atchafalaya Floodway would be the last feature of the flood control system to be used under the project design flood. It has not been operated to date.

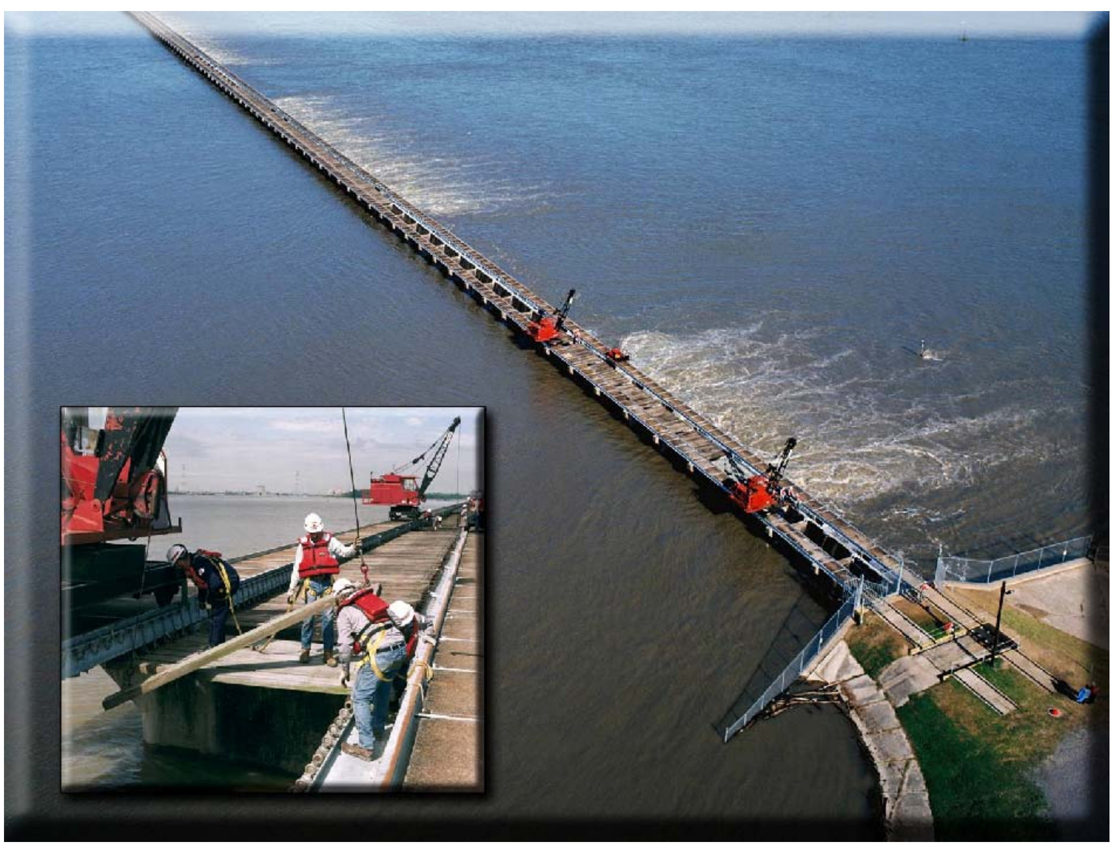
Controlling the Project Design Flood

The Atchafalaya River, the Morganza floodway, and the West Atchafalaya floodway converge at the lower end of the Atchafalaya River levees to form the Atchafalaya basin floodway. This floodway is designed to carry 1,500,000 cfs or nearly one-half of the project flood discharge of 3,000,000 cfs at the latitude of Old River. The floodway is confined on either side by levees to a point below the latitude of Morgan City, Louisiana, whereby 1,200,000 cfs is conveyed to the Gulf of Mexico by the Atchafalaya River and the remaining 300,000 cfs is passed to the Gulf through the Wax Lake outlet.

Southern Section

The flood control system provides protection against the remaining 1,500,000 cfs in the Mississippi River below the Morganza floodway. The next key location in the system is the Bonnet Carré Floodway, located approximately 30 miles above New Orleans, Louisiana. The 7,200-foot long spillway structure is governed by 350 intake bays and connects to a 5.7-mile long floodway that empties into Lake Pontchartrain.

The floodway is designed to divert up to 250,000 cfs from the Mississippi River, thereby insuring a peak discharge flow under project flood conditions at New Orleans not to exceed 1,250,00 cfs. Since its completion in 1932, the Bonnet Carré Floodway has been operated 9 times—1937, 1945, 1950, 1973, 1975, 1979, 1983, 1997, and 2008.



Worlds 3rd Largest Watershed

Drainage basin for 41% of the United States