Possible Capture of the Mississippi by the Atchafalaya River

by

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Colorado Water

Resources Research Institute

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Submitted to

The Water Resources Planning Fellowship Steering Committee
Colorado State University

in fulfillment of requirements for
AE 695V Special Study

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ABSTRACT

The possible diversion of the Mississippi River and man's effort to resist it, present one of the greatest river engineering problems ever encountered. The evidence that supports the claim that capture of the Mississippi by the Atchafalaya is forthcoming, is available and bountiful. Data on the deterioration of the capacity of the Mississippi below Old River and the increasing capacity of the Atchafalaya has been collected and authenticated. Neotectonic activity also indicates that the tendency toward diversion is increasing.

This report concludes that:

- Congress should, with the approval of the President, establish an independent commission, made up of the world's foremost professionals, to study the problem of diversion.

- The commission should investigate the Corps current policies regarding the problem and investigate other means of addressing the problem, such as slowing the current aggrading nature of the Mississippi below Old River. This could be accomplished by diverting more sediment into the Atchafalaya and/or increasing the efficiency of the lower Mississippi, below Old River, by minor straightening, thus increasing slope.

- In addition to corrective measures, abandonment of the Old River Control System and possible alternate river courses should be investigated.

- Lastly, the commission's findings should not be allowed to be "lost" among the tons of previously commissioned Congressional reports and studies. On the contrary, the results of the study should weigh heavily on future directions that the Corps of Engineers, the Mississippi River Commission and most importantly, the Congress of the United States takes!

INTRODUCTION

> "The Basin of the Mississippi is the BODY OF THE NATION. All of the other parts are but members, important in themselves, yet more important in their relation to this."
> - Editors Table, Harper's Magazine, February, 1863.

The Mississippi River has always had a mystique about it. It has been a lure to the romantic and an obsession for some whose desire it is to contain and physically possess it. To Mark Twain the river was a thread out of which he wove adventures that all the world would come to enjoy. Twain used the river and its lure, to convey upon mankind a set of values which are today cherished by people from all walks of life. But alas, the purpose of this paper is not to address man's romance with the river, but to examine his desire to control it.

In the last 150 years, man has sought to harness the river. The Corps of Engineers has built levees, constructed cutoffs, provided floodways, built reservoirs, improved and stabilized the channel and banks. These measures were undertaken for the sake of flood control and navigation, and there is not much doubt that the Corps has been successful, to a certain degree. The river has a long memory and, like man, it longs for freedom. The river tries to break the shackles which man has placed upon it. The man-made works placed in the river require continuous maintenance, and are, after all, only temporary.

The subject which will be addressed here is the ongoing controversy regarding the possibility of diversion. Many well-informed members of the scientific and technical community believe that the Atchafalaya will capture the flow of the Mississippi River and it is only a matter of time.

The Atchafalaya is a main distributary for the Mississippi River. Presently the Corps of Engineers diverts approximatley 30 percent of the flow in the Mississippi down the Atchafalaya through the Old River control system (see Figures 1 and 2). Most geologists and engineers are in the opinion that if the Corps had not constructed the Old River control system, the Atchafalaya would have already captured the Mississippi River.

In view of the fact that the Mississippi River is such a valuable source of transportation and truly the life's blood for a multitude of our nation's population, the Corps of Engineers has taken the position that we cannot allow diversion of the river. Total traffic on the river between Minneapolis, Minnesota and the Gulf of Mexico in 1978 was 413,065,660 tons.(1)

This document will examine briefly the history of the development of the lower Mississippi and Atchafalaya Rivers. The historical development of the Lower Mississippi will be broken down into four periods. This four-period breakdown is essentially the same as Major D. O. Elliott used in his 1932 examination of the improvement of the Lower Mississippi. The first period is characterized as pre-federal involvement, prior to 1820. The next period extends until the creation of the Mississippi River Commission in 1879. The third period covers the operation of the Mississippi River Commission until the passage of the 1928 Flood Control Act. The last period will cover river development until the present.

Chapter 2 will discuss the lower alluvial valley and the tendencies, both natural and induced, which indicate diversion into the

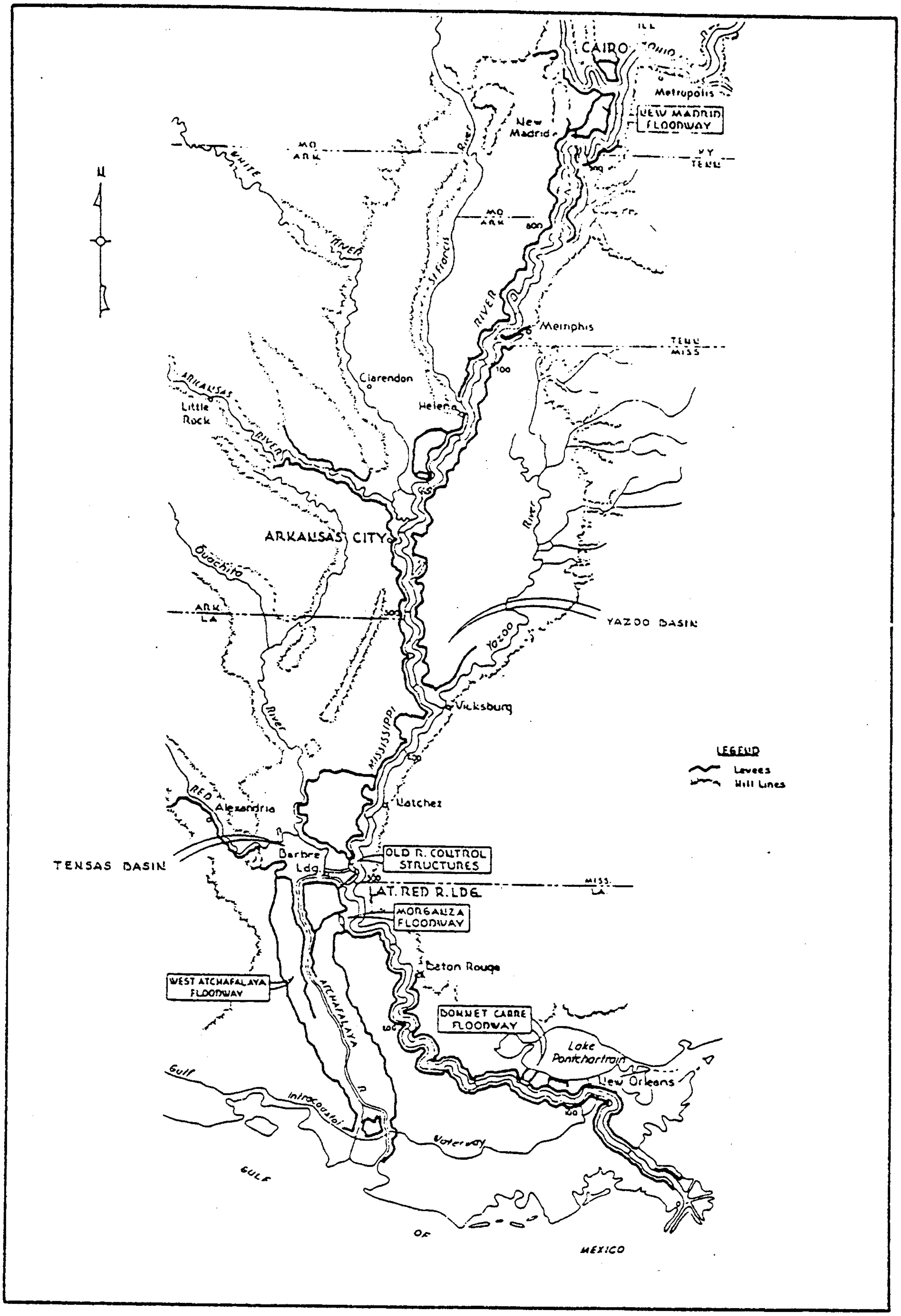

Figure 1. Flood Control Plan, Lower Mississippi River (Madden, 1974).

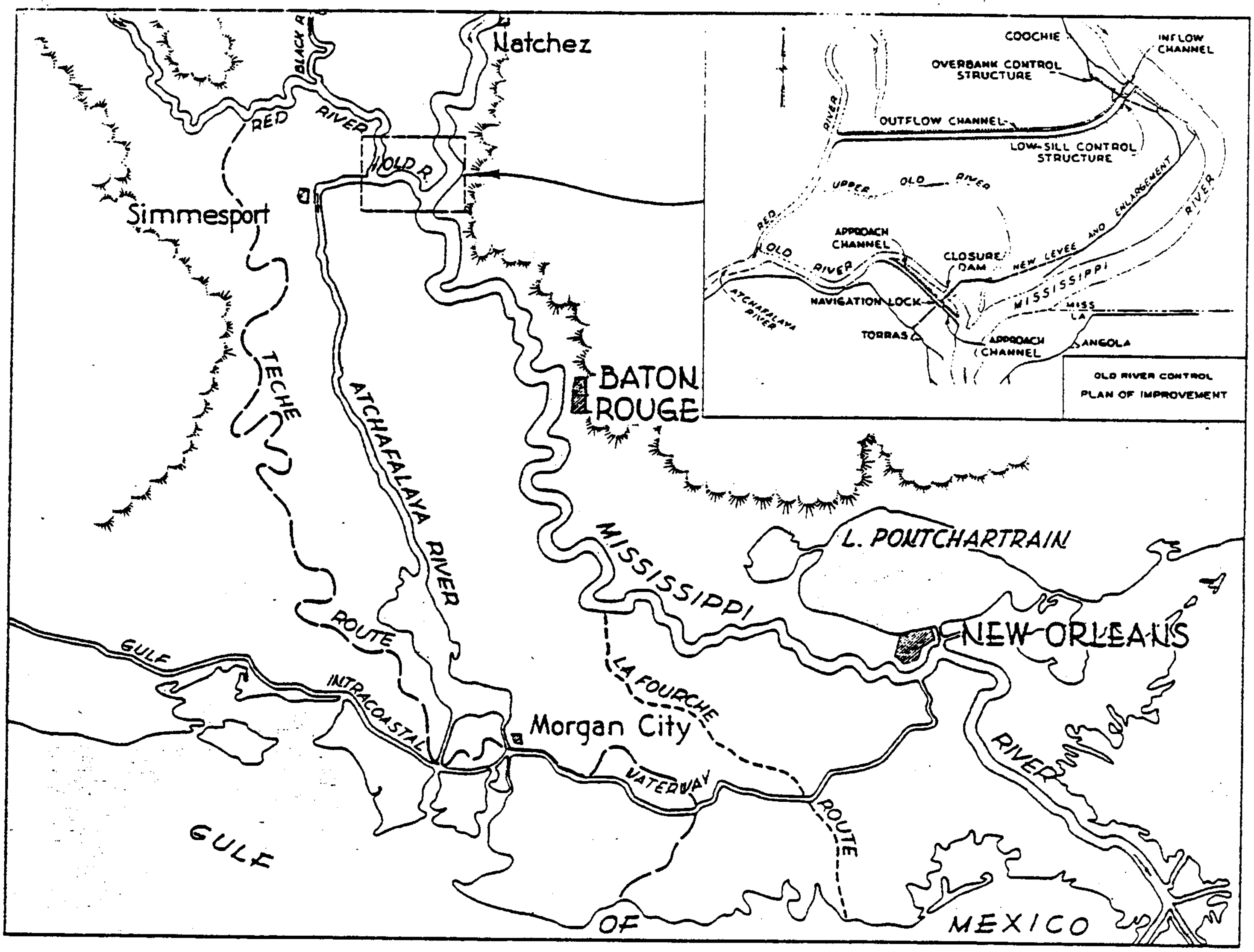

Figure 2. Old River in Relation to the Mississippi and Atchafalaya Rivers (Corps of Engineers, 1965).

Atchafalaya is a distinct possibility. This discussion will consist of a qualitative examination of sediment transport and river response. The Old River control system (Figure 2), its operation and purpose, and its near failure in the 1973 flood will be examined.

The impacts of diversion, both physical and economic will be discussed in Chapter 3, with conclusions and recommendations presented in Chapter 4.

Hopefully this paper will serve to inform those whose desire it is to know, in very general terms, exactly what the problem is, the factors involved and some generally accepted management alternatives for addressing the problem. This paper is not meant to be a total comprehensive analysis. River mechanics, fluvial geomorphology, geology and sediment transport are all complex technical subjects when considered separately. When they are all combined and man's activities are introduced, the results are increasingly complex and often controversial.

CHAPTER 1

RIVER HISTORY AND DEVELOPMENT

River History (Prior to 1820)

There is some controversy over who was the first white man to discover the Mississippi River. Though most historians credit Hernando De Soto with discovery, the "Admiral's Map" which was discovered at the Royal Library in Madrid tends to support the claim that the Mississippi was actually discovered by Columbus. In 1502 Columbus departed Spain on his fourth voyage. It was on this voyage that he landed at Santo Domingo and then proceeded westward to the Central American coast. The "Admiral's Map" which was engraved in 1507 shows what is called the "River of Palms" which some historians conclude are the multiple mouths of the Mississippi River.(2)

The majority of historians support Hernando De Soto as being the first white man to discover the Mississippi. On June 3, 1539, De Soto landed at Tampa Bay and claimed Florida for the King of Spain. From Florida De Soto headed northward into Georgia seeking gold and treasure. De Soto and his men continued their march into South and North Carolina, Tennessee, northern Alabama and finally into Mississippi. Throughout his march, many bloody battles were fought. De Soto was no stranger to battle, he had spent years prior to this time conquering the Indians of Peru and claiming their treasure in the name of Spain. De Soto continued his march, and finally on May 8, 1541, somewhere just below the present location of Memphis, he first beheld the Mississippi River. De Soto continued his search for gold, until he died of malaria on April

17, 1542. De Soto's men gave his body to the river and gave up the search.(3) The Spanish would leave the exploration of the basin to the French.

Several Frenchmen, including Joliet and Marquette, explored the basin. Their explorations were carried out in 1673, many years after De Soto. Most of these French expeditions began in Canada and worked their way down from Quebec. It was not until Sieur de la Salle set out in August 1678 from Lake Michigan that the basin was formally claimed by the French Crown. la Salle proceeded down the Illinois River to the Mississippi and then onward to the mouth of the River where he erected a cross and claimed possession of the river and all lands drained by it in the name of France.(4)

d'Iberville was the next great explorer in the region. He was commissioned by the French to establish relations with the Indians and explore the lower Mississippi and Gulf Coast. Iberville could find no suitable location for a settlement along the Mississippi so he established a colony in Biloxi in 1699. In 1702 he moved his headquarters to Mobile Bay. Bienville, Iberville's younger brother, eventually took over the settlement and continued exploration of the Lower Mississippi. In 1716 he established the first white settlement on the Mississippi and named it Fort Rosalie. This site eventually became known as Natchez.

In 1717 Bienville decided to move his headquarters to the Mississippi. He selected a site against the wishes of his engineer, de la Tour. de la Tour tried to impress upon Bienville the inferiority of the site, telling him that the location would be subject to frequent flooding from the Mississippi. Bienville was stubborn and thus New Orleans was founded. To protect the city from flooding, a levee system was begun and by 1727, 5,400 feet of levee was completed. The levee system extended up and downstream of New Orleans with the individual property owner responsible for construction. The property owners were made responsible by an order from the French Crown with forfeiture of lands the penalty for noncompliance. By 1744 the levees extended from 20 miles below New Orleans to the mouth of the Arkansas River on the left bank (looking upstream) and to Baton Rouge on the right bank. Much work was done in the New Orleans area during this time to stabilize banks and some crude dredging was attempted at the river mouth in order to deepen the channel to increase navigability. Finally in 1803 the basin was purchased from France for the sum of $15 million.(5)

Even before the Louisiana Purchase the river was becoming very important as a means of trade. But navigation on the river was difficult and the means of transportation as well as the river's navigability left much to be desired. Flatboats and rafts were one-way craft only. These craft were loaded upstream and then floated downstream, unloaded and then dismantled and their lumber sold. The keelboat was the first great advancement for river trade. These boats could carry as much as 80 tons of freight. They were floated downstream, unloaded and "cordelled" upstream. Cordelling is a method by which a crew on the bank pulled the boat upstream against the current.

In 1811 the steamboat made its debut on the Mississippi. The first steamboat to make its way down the river was the New Orleans, built in

Pittsburgh at a cost of $40,000. These early steamboats still did not travel very well upstream. It was not until 1816 when the Washington, a paddle-wheeler, made a round trip from Louisville to New Orleans and return in 41 days that the era of efficient transportation, up and downstream, on the river actually began.

Over the next few years the number of steamboats on the river increased and their travel times between cities markedly decreased. In 1814 only 21 steamboats arrived in New Orleans, in 1819 there were 191; in 1833 more than 1,200 steamboats were unloaded. Also before the invention of the steamboat, it took as long as four months to make the trip from Louisville to New Orleans. In 1820 the steamboat could make the trip in 20 days, by 1838 that time was cut to six days.[6]

Though steamboats were effective means of transportation on the river, they were also many times unreliable and hazardous. Besides the hazards posed by the boats themselves (boiler explosions, collisions, etc.), the river itself was dangerous and many times unforgiving. Snags, sand bars and vicious currents and edies made the river treacherous and sometimes impossible to navigate. Improvements were needed.

Early Federal Involvement (1820-1879)

By 1820 the Mississippi River was the major means of inland transportation in our young nation. During these early years most of the emphasis had been on navigation, flood control had not been a major issue. The reason that flood control had not been addressed is simply because there hadn't been a major flood that had affected populated regions.

The first Federal expenditures for the improvement of navigation on the nation's rivers came in 1820. Congress appropriated $5,000 for the Engineer Corps to prepare surveys, maps, and charts on the Ohio and Mississippi Rivers. During the next three years the Corps gave much attention to the river. Several reports resulted identifying the various problems associated with navigation. Much of the attention in these reports was given to the problem of snags.

As a result of the Corps reports, on May 24, 1824, Congress appropriated $75,000 for the removal of snags in the Mississippi River below the mouth of the Missouri and the Ohio River. Special snag boats were constructed. These boats used steam operated tackles for raising the snags and had the means for cutting them up. Snagging operations on the rivers (Mississippi, Ohio, Missouri and Arkansas) were an important means of navigation improvement. Between 1824 and 1879 Congress appropriated approximately $3,093,000 for snagging operations on the aforementioned streams.[7]

Besides snagging, other measures were used in an attempt to improve navigation. In 1831 Captain Shreve, a Mississippi River steamboat captain, proposed an artificial cut-off. Cut-offs are nothing new on the river. Between 1776 and 1884, 16 natural cut-offs occurred on the river. A meandering river, such as the Mississippi will tend to form meander loops. The water tends to erode the same bank and eventually cuts through, these are referred to as neck cut-offs. Chute cut-offs are another type in which high flows tend to cut-off a point bar, eventually the result is a middle bar (Figure 3). What Captain Shreve wanted to do was to short-circuit nature and dig a canal through the

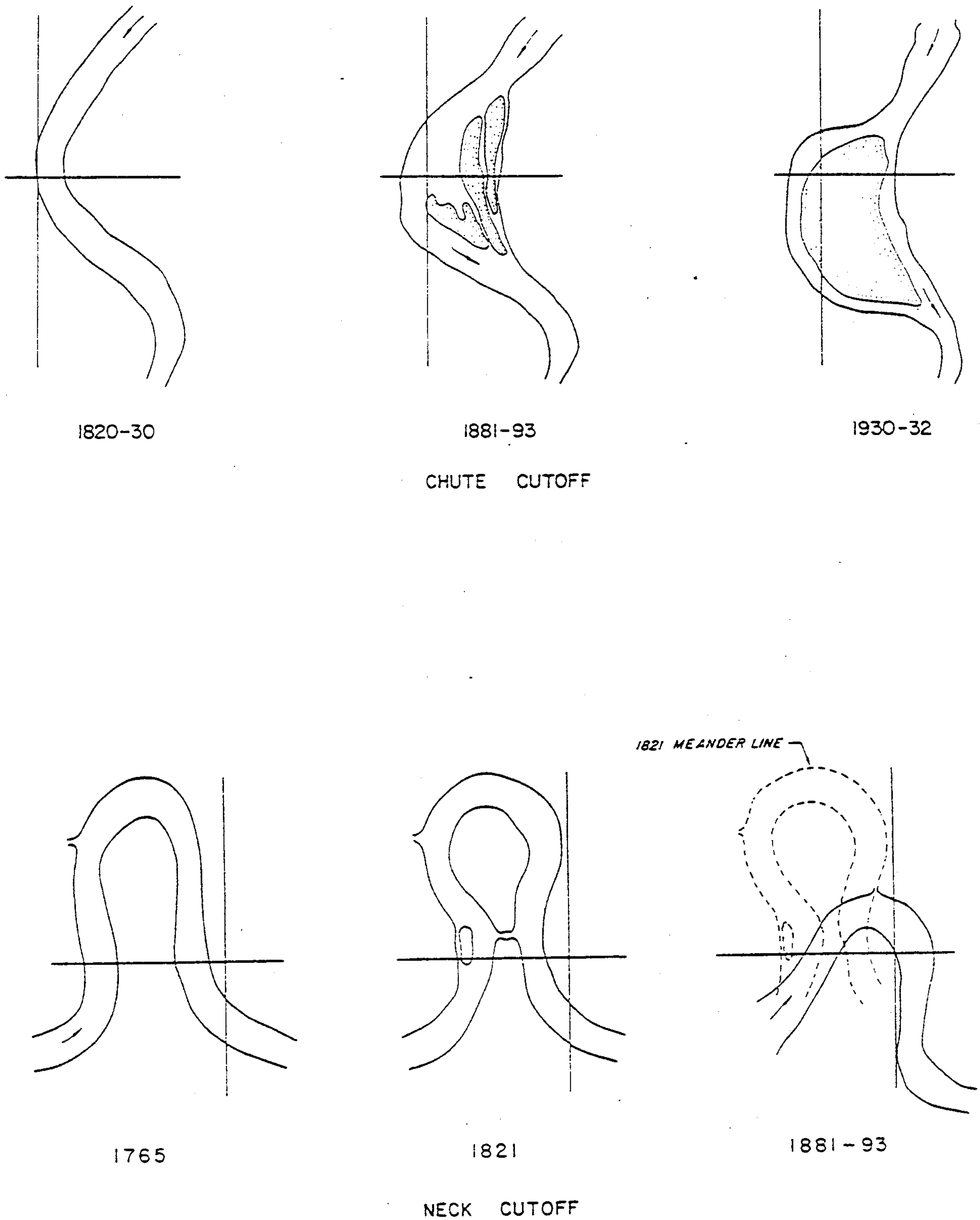

Figure 3. Formation of Natural Cut-Offs (Walters, 1975).

neck. The cut-off Shreve constructed shortened the river 15 miles. The primary reason for the cut-off was to avoid manuvering the shoals that were in the Mississippi at the mouth of the Red River (see Figure 4). But the Shreves cut-off did not eliminate the shoaling problem, it merely moved it downsteam four miles to Raccourci Bend. In an attempt to relieve the situation at Raccourci Bend, the State of Louisiana constructed the Raccourci Cut-off in 1848. This cut-off shortened the river an additional 19 miles.(8)

The cut-off era of the 1800s was shortlived, these were the only two to be constructed in this century. As mentioned earlier, cut-offs occur naturally in alluvial rivers such as the Mississippi. But, there are growing meanders elsewhere on the river such that the overall length is not significantly altered in the long run. On the other hand the artificially constructed cut-offs do have significant repercussions elsewhere on the stream. This subject will be discussed in the next chapter.

It wasn't until the floods of 1849 and 1850 that the Federal Government began to address the problem of flood control on the Mississippi. The Congress directed that studies be undertaken to determine the best means for the improvement of navigation and provision of flood control.

The Swamp Acts of 1849 and 1850 were aimed at relieving the flooding problem. The Swamp Acts were a series of Federal Congressional Acts that granted all unsold swamp lands and overflow areas to the states. The most important provision of the Acts was that the states would use the revenue generated from the sale of these lands to

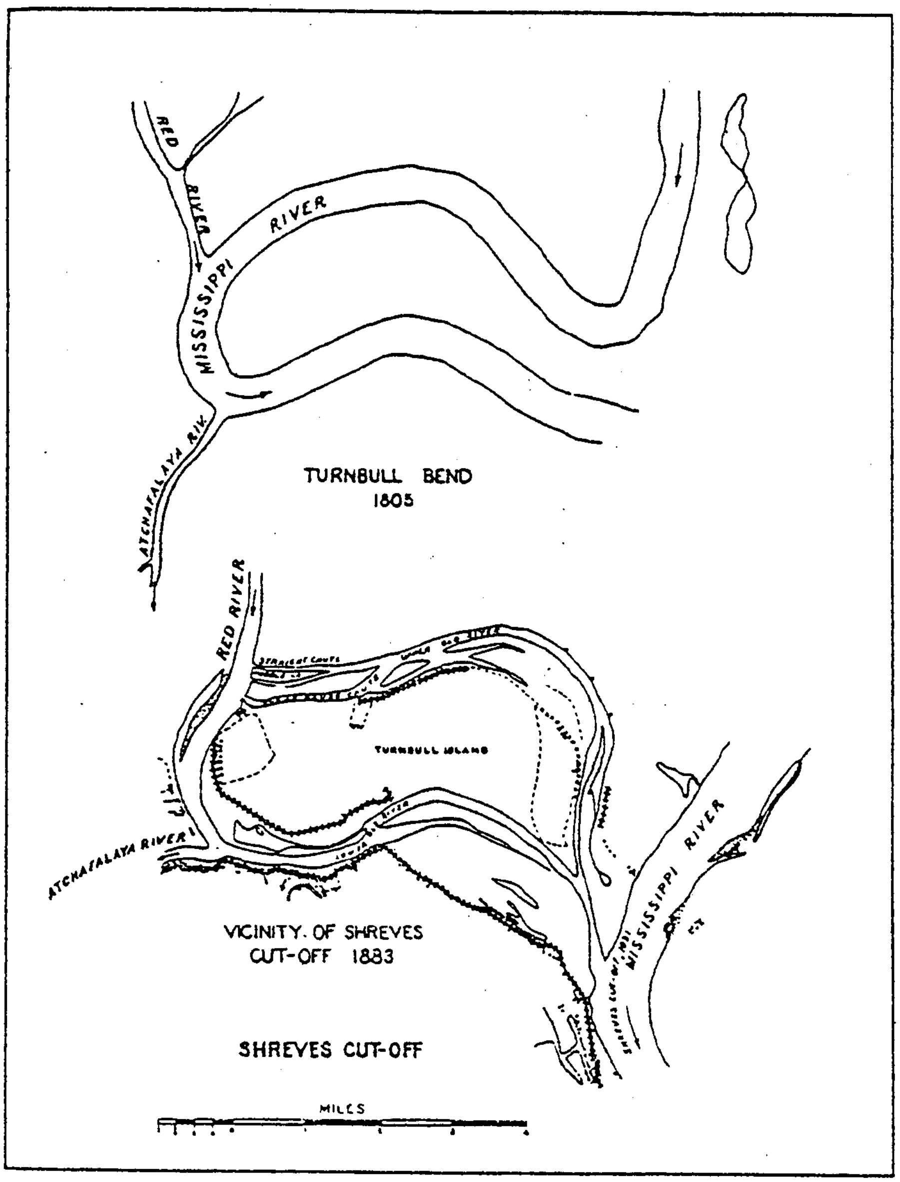

Figure 4. Shreves Cut-Off (Elliott, 1932).

construct drainage, reclamation and flood control projects. The States of Louisiana, Mississippi, Arkansas and Missouri created their own commissions to oversee the sale of lands and the construction of levees. Under these Acts the States of Louisiana, Mississippi and Arkansas alone received approximatley 31,890 square miles.(9)

The Swamp Acts are evidence of the Federal Government's interest in flood control, but they are not taking responsibility for actually providing the measures. The U.S. Congress used these Acts as an instrument by which the States could gain the means with which they could protect themselves. This seems like a good idea, but because of lack of coordination between the states (levee height and quality of construction varied from state to state), the plan proved to be a failure. Subsequent floods in 1858 wreaked havoc on the system.

The floods of 1849 and 1850 were also responsible for Congress initiating two studies investigating the most practical means of providing for flood control and navigation improvement on the Lower Mississippi. One was to be performed by Captain A. A. Humprheys, Corps of Engineers, the other by Mr. Charles Ellet, Jr., a noted engineer.

The Ellet Report was in many ways ahead of it's time. In his report, Ellet observed that as cultivation increased in the valley and as the levees were extended, this would result in an increased frequency of flooding. Ellet advocated the use of levees, the diversion of water from the river (including via the Atchafalaya), prevention of cut-offs, and his strongest appeal was for a system of headwater reservoirs. Except for the use of the reservoirs, his plan has had a great deal of impact over the years.

The Humphreys and Abbot Report entitled, "Report Upon the Physics and Hydraulics of the Mississippi River," was published in 1861. This report is a comprehensive study of the river, and for 50 years served as the principal criteria under which most major river engineering was performed. The report presents thorough discussions of river hydraulics, the effects of cut-offs, overflow basins, tributaries, outlets, levees and crevasses. The report investigated three different approaches to solve the problem of flooding. Cut-offs were examined, but because of adverse impacts on the river they were not encouraged.(10) Another measure investigated was the diversion of tributary streams and the use of artificial outlets to the Gulf and reservoirs, but, because of the costs and the dangers presented by these measures, this plan was also rejected.(11) The recommended plan was to construct a levee system. Detailed plans were given in the report concerning levee height, cross-section, location, method of construction, and costs.(12) But as a result of the timing of the submission of this report and the Civil War, no flood control plan was adopted.

During the Civil War the entire levee and navigation system fell into disrepair. Severe floods during the 1860s caused much damage to the system. In 1867 dredging was again undertaken at the river's mouth in order that some navigation be resumed. But it wasn't until 1874, when the "Levee Commission" was formed that the Federal Government started to show any real conviction to the idea of flood control and navigation on the river.

The Levee Commission, made up chiefly of Corps personnel, was to investigate plans for establishing a system of levees and also submit a plan for reclamation of the Lower Valley. This Commission, actually a forerunner of the "Mississippi River Commission," based its findings on the Humprheys and Abbot report. It advocated a system of levees to be constructed and maintained under the general supervision of a board of commissioners. This report was submitted to Congress in the Annual Report of the Chief of Engineers in 1875. No action was taken at that time.

Because of severe navigation difficulties at the mouth of the river and the Corps inability to maintain navigable depths, Congress authorized Mr. James B. Eads to construct jetties at South Pass. By funneling the flow through a narrow opening, thus inducing scour, Eads maintained that his plan would keep the pass open without dredging. His plan became a reality in 1875 and with slight modifications, is still in use today.

By 1878 the Congress had yet to appropriate funds to institute any of the measures advocated by the Levee Commission. Finally in 1879 a Board of Engineers, all Corps personnel, submitted a report to Congress addressing once more the problem of flooding and navigation on the lower Mississippi. As Elliot concluded, this report was very significant, in that it was the first time that flood control and navigation were concluded as parts of the same problem. The levees would serve as an aid to high-water navigation, but would have little influence on navigation at low stages. The board also recognized basic river instability and resultant bank caving as a major problem.(13)

This brought to an end Federal involvement prior to the creation of the Mississippi River Commission. This period began with the desire of the Federal Government to aid navigation, with development of the frontier as the ultimate goal. As the region developed and flooding began to affect the populated areas, the Swamp Acts were a means by which the Federal Government helped the States to cope with the problem, without assuming full responsibility. But, as indicated in the Corps Report of 1879, with navigation and flood control part of the same problem, the role of the Federal Government in flood control was about to change. This period also saw great advancement in river mechanics with documents such as those prepared by Humphreys and Abbot, and Charles Ellet. And, lastly, with the adoption of the Eads Jetty Plan we see man's ingenuity successfully solve the problem of shoaling at the river's mouth. But there were many problems that were yet to be solved, all of which had to be addressed by the Mississippi River Commission.

The Creation and Operation of the Mississippi River Commission (1879-1927)

In 1879 as a result of growing concern over navigation and flood control on the lower Mississippi, a bill was introduced in Congress calling for the creation of the Mississippi River Commission (MRC). The bill provided for a seven member commission, each member appointed by the President of the United States. The Commission members would be comprised as follows: Three Commissioners would be from the Corps of Engineers; one from the U.S. Coast and Geodetic Survey; and three from civil life. Two of the three from civil life would be civil engineers. The law also provided that the President and the Secretary of the Commission be Engineer Officers. Typically the President of the MRC has been the Division Engineer in Charge of the Lower Mississippi Valley Division of the Corps of Engineers.

Section 4 of the Act prescribes the duties of the Commission as follows:

> . . . It shall be the duty of said Commission to take into consideration and mature such plan or plans and estimates as will correct, permanently locate, and deepen the channel and protect the banks of the Mississippi River; improve and give safety and ease to the navigation thereof; prevent destructive floods; promote and facilitate commerce, trade, and the postal service; and when so prepared and matured, to submit to the Secretary of War a full and detailed report of their proceedings and actions, and of such plans with estimates of cost thereof, for the purposes aforesaid, to be by him transmitted to Congress: Provided, That the Commission shall report in full upon the practicability, feasibility, and probable cost of the various plans known as the jetty system, the levee system, and the outlet system, as well as upon such others as they deem necessary . . . (14)

This bill was not without opposition. Those opposed to the bill argued that flood protection of the alluvial lands was not the responsibility of the Federal Government, but the responsibility of the states and communities. They stated that passage of such a bill would result in massive expenditures by the Federal Government. Those opposed were few and the bill passed on June 28, 1879.

As indicated in Section 4, the Act did not authorize the construction of flood control or navigation facilities, it simply organized the study effort which until that time had been piecemeal. The MRC was to develop plans which carried out the objectives of the Act.

The MRC did not halt the operations of the Corps. The MRC and the Corps have a dual partnership in the operation of flood control and navigation facilities on the river. The Corps works under the direction of the MRC as it pertains to the accomplishment of the objectives of the Act. The jurisdiction of the MRC extends from the Head of Passes upstream to include the entire Mississippi River and also its tributaries insofar as might be necessary.

On February 17, 1880 the Commission submitted its first report to the Secretary of War. This report was an analysis of the river from the Head of Passes to Cairo, Illinois. The report was basically an updated version of the 1879 Corps report in which a permanent levee system and bank protection was advocated. Note that this report reiterated the position that levees tended to deepen the channel and enlarge the bed of the river during a flood, thus improving navigation. They were not considered strictly flood control devices.

The following year Congress appropriated $1,000,000 for the construction of the improvements listed in the Commission report. Congress was careful to stipulate that the funds used in levee construction could only be used to construct those levees whose purpose was channel deepening. Thus, policy regarding Mississippi River levees was established.

During ensuing years the MRC continued to study the navigation problems on the river. In the mid 1890s, the hydraulic dredge started to make its appearance on the river. During the 1890s and early 1900s the main responsibilities of the MRC were to oversee levee maintenance, bank protection (using willow and in 1914, concrete mattresses) and channel dredging. The early MRC reports also began to address navigation and channel rectification on the Atchafalaya and Red Rivers.

In 1884 the MRC published a report calling for a series of brush and stone dams to be constructed just below low-water in the Atchafalaya near its confluence with the Old River. (As you'll remember, Shreves Cut-off effectively separated the Atchafalaya and Red Rivers from the main-stem Mississippi, the cut-off portion of the Mississippi is called Old River.) The low dams were designed to aid navigation.

In subsequent studies and reports prior to the 1928 Flood Control Act, the MRC discussed the possibility of closing off the Red and Atchafalaya Rivers from the Mississippi. Since a log jam had been removed in 1855, the MRC had collected data that indicated the Atchafalaya was gradually enlarging, accepting more flow from the Mississippi. The possibility of diversion was observed many years prior to this time as an excerpt from the 1881 MRC Annual Report indicates.

> Major Stoddard took possession of Upper Louisiana in 1804, under the Treaty of Cession. He was stationed about five years on the Lower Mississippi, and six months on the Red River. He stated that "the channel of the Chafalia, a few miles only from the head of it, is completely obstructed by logs and other material. Were it not for these obstructions, the probability is that the Mississippi would find a much nearer way to the Gulf than at present, particularly as it manifests a constant inclination to vary its course."(15)

As a result of the 1916 flood on the Mississippi, Congress passed the first Flood Control Act on March 1, 1917. Besides extending the limits of jurisdiction of the Commission, the Act called for the construction of levees as a means of flood control. The Act also spelled out a policy of local cooperation. It required local interest to contribute one-half the construction and repair costs allocated by the Commission for the work. It also required local interest to provide cost free rights-of-way for levees, and provided that the local levee district would be held responsible for maintenance of the completed works.(16) Over the next few years Congress continued to pass Flood Control and River and Harbor Acts. The main purposes of these acts were to allocate funds for the flood control works and to extend jurisdiction of the MRC to areas in need of flood protection.

The Mississippi River Commission operated for these first few years (1879-1927) under what is now known as the "levees only" doctrine. The Great Flood of 1927 was about to change that. This period saw the introduction of hydraulic dredges, concrete mats for bank protection, and most importantly, this was the beginning of a coordinated effort for the provision of flood control and navigation in the basin.

Summary of River Improvements Since the 1927 Flood

The 1927 flood on the Mississippi River was the greatest flood that has ever been recorded in the basin. In that flood, at least 300 lives were lost, 17 million acres were flooded forcing 637,000 people to leave their homes, property damage at that time was assessed to be $236 million.(17) This flood exceeded all of the Commission's pedictions regarding possible flood elevations and thus ravaged the levee system.

President Coolidge directed that a comprehensive flood control plan be formulated for the river. The Corps of Engineers and the MRC both began examining the problem. The Committee on Flood Control in the House of Representatives held hearings to consider the over 300 plans submitted.(18) The plans that received most attention were the plans submitted by the Corps and the MRC. These plans had many similarities, but finally the Corps of Engineers plan was selected. Major General

Edgar Jadwin was the author of this plan and thus it became known as the "Jadwin Plan."

The Jadwin Plan was the beginning of flood control on the river as we know it today. Briefly the Jadwin Plan called for a series of lateral floodways that would divert water from the main stem making it possible to control floods of a magnitude of which had not been thought possible. The plan also called for the raising and strengthening of levees; revetment of caving banks; and the provision of training works and dredging to aid navigation.

On May 15, 1928, Congress passed the third Flood Control Act. This Act considered floods on the Mississippi River and its tributaries and had as its basis the Jadwin Plan. The Act authorized $325 million for the purpose of carrying out the plan. In Section 8 of the Act, Congress redefined the duties of the MRC. This section altered greatly the responsibilities the Commission had acquired initially. Section 8 of the 1928 Act states:

> The project herein authorized shall be prosecuted by the Mississippi River Commission under the Direction of the Secretary of War and supervision of the Chief of Engineers and subject to the provisions of this Act . . . (19)

The Act continues by directing the MRC to make inspection trips of the project and hold public meetings and hearings. In describing the duties of the MRC, it appears that Congress had made the MRC an advisory Commission rather than an initiative authority.

Probably of more importance is Section 2 of the Act. This section is very significant in a policy sense. Section 2 of the Act states:

> That it is hereby declared to be the sense of Congress that the principle of local contribution toward the cost of flood-control work, which has been incorporated in all previous national legislation on this subject, is sound, as recognizing the special interest of the local population in its own protection, and as a means of preventing inordinate requests for unjustified items of work having no material national interest. As a full compliance with this principle in view of the great expenditure estimated at approximately $292,000,000, heretofore made by local interest in the alluvial valley of the Mississippi River for the protection against the floods of that river; in view of the extent of national concern in the control of these floods in the interest of national prosperity, the flow of interstate commerce, and the movement of the United States mails; and, in view of the gigantic scale of the project, involving flood waters of a volume and flowing from a drainage area largely outside the States most affected, and far exceeding those of any other river in the United States, no local contribution to the project herein adopted is required.[20]

The Act continues in Sections 3 and 4 to declare what the liabilities and responsibilities are for both the States and the Federal Government. Section 3 states:

> . . . no money will be appropriated . . . until the States or levee districts have given assurances satisfactory to the Secretary of War that they will (a) maintain all flood control works after their completion, except controlling and regulating spillway structures, including special relief levees; maintenance includes such matters as cutting grass, removal of weeds, local drainage, and minor repairs of main river levees; (b) agree to accept land turned over to them under the provisions of Section 4; (c) provide without cost to the United States, all rights of way for levee foundations and levees on the main stem of the Mississippi River between Cape Girardeau, Missouri, and the Head of Passes.
>
> No liability of any kind shall attach to or rest upon the United States for any damage from or by floods or flood waters at any place:[21] (provided the damage is not a result of flooding caused by levees, i.e. levees on one bank now cause area not previously subject to flooding on opposite bank to flood, Federal Government must pay damages or obtain flowage easement on lands previously not subject to flooding.)

Section 4 of the Act addresses the subject of flowage easements in the floodways. The floodways are the areas that will be subject to inundation when it becomes necessary to divert flood waters from the main-stem via one of the floodways identified in the Jadwin Plan. This section describes the condemnation and compensation procedures with respect to these lands.

As indicated in the excerpts, this Act was responsible for major changes in previously established flood control policies of the Federal Government. Beginning with the Swamp Acts in 1849-50 the Federal Government started to assume a role in addressing the problem of flooding along the Mississippi. In 1879, with the creation of the MRC, the Government increased its share of the burden of addressing this problem. The great flood of 1927 made the Federal Government realize that nothing short of assuming full responsibility for the design and construction of the project would solve the problem of flooding along the Mississippi River and its tributaries. Thus the project, as a whole (flood control and navigation), became known as the Mississippi River and Tributaries Project.

During the years following the enactment of the 1928 Flood Control Act, various amendments, bills, flood control and river and harbor acts were passed. This legislation served to modify and expand the plan authorized under the 1928 Act. The project area was expanded to include flood control in backwater areas. In this case, backwater areas are the flood plains of tributary streams that are subject to inundation from floods on the Mississippi. To protect these areas from frequent flooding, that is, floods of a magnitude less than the project design flood on the Mississippi, levees were constructed. These levees are not to the elevation of the main line levee so that during great floods these areas can be used for storage. The 1936 Flood Control Act authorized the Red River and Yazoo River backwater area protection projects. The St. Francis River was the last backwater protection project and it was authorized by the 1950 Flood Control Act.

A detailed explanation of the legislation during this period is beyond the scope of this paper. The previous paragraph served as an example of how the original plan was modified and expanded to include backwater areas. The remainder of this chapter is dedicated to outlining and describing briefly the various features of the plan that have been constructed. These can be divided into levees, cut-offs, channel improvement and bank stabilization, and floodways.

Levees - As indicated earlier, the Jadwin Plan called for the raising and strengthening of levees. In 1972 the main-stem levee system had a total length of 2193.7 miles. Of that length, 1599.3 miles lay along the Mississippi River and 594.4 miles lie in the basins of the Arkansas, Red and Atchafalaya Rivers.[22] In geographical terms, the main-stem levees on the west bank extend from Cape Girardeau, Missouri downstream to Venice, Louisiana (within 10 miles of the Head of Passes). On the east bank the main-stem levees extend intermittently from Hickman, Kentucky, to north or Vicksburg, Mississippi, and pick up again at Baton Rouge and extend to Bohemia, Louisiana (within 40 miles of Head of Passes). The northern portion of the east bank system is intermittent because levees occasionally tie to high ground.

As mentioned previously, there is extensive levee work in the Arkansas, Red and Atchafalaya River basins. Of special interest in this report is the Atchafalaya Basin. The Atchafalaya levee system as it exists today was designed and constructed as a part of the West Atchafalaya and Morganza Floodways (see Figure 6). These floodways were conceived by General Jadwin and were modified and finally constructed under Public Law No. 761 (75th Congress), June 28, 1938.

Cut-offs - From June 15, 1932, to August 31, 1939, Brigadier General Harley B. Ferguson served as President of the MRC. During his term, General Ferguson was an avid supporter of the cut-off scheme for controlling floods and aiding navigation. Ferguson is directly responsible for constructing 14 neck cut-offs in a reach of the river between Memphis, Tennessee and Angola, Louisiana. Additionally two natural cut-offs were allowed to form thus bring the total to 16. These 16 cut-offs shortened the Mississippi 151.9 miles. Neck cut-offs have not been allowed on the river since 1942.[23] Further discussion of cut-offs will be presented in Chapter 2.

Channel Improvement and Bank Stabilization - Today, as was the case when the project was conceived, the major means of channel improvement are channel dredging, bank revetment and contraction works.

Bank Revetment is the means by which caving banks are controlled. Controlling the banks is important to both flood control and navigation. It is important to flood control in the sense that a uncontrolled meandering river can soon endanger the levee system. Bank revetment is important to navigation in that it is necessary to keep the navigation channel in desired alignment. Articulated concrete mattresses are the means by which this is accomplished today. The banks are graded to form a smooth gradual slope (slope dependent on soils properties, but generally 1 on 3 to 1 on 4). Once the banks are prepared the barge mounted mattress sinking plant is moved in and lays the mat. Rock riprap serves to protect the upper non-matted bank.

Contraction works use dikes to contract and direct low flows such that the navigation channel follows a desired alignment. Many means of dike construction have been attempted. Pile dikes, stone dikes, and sand filled nylon bags have been used. As of 1972, and as Moore indicates, contraction works are the least understood of the channel stabilization works. This is probably the reason for the continued experimentation in this area.

When necessary, dredging is the means by which navigation depths are maintained. The river consists of a series of "pools" and "crossings." The crossings occur where the stream current crosses from one side of the river to the other. Bars form in these crossings and often require extensive dredging. Hydraulic pipeline dredges are most common and they generally discharge back into the river.

Floodways - There are four floodways that are used to divert floodwaters from the Mississippi River. Figure 5 is a schematic showing how the overall project functions in the event of the "project flood" (58A-EN). The project design flood results when the most severe storms of record are placed in a pattern which produces the greatest flood having a reasonable probability of occurrence. This flood is considered to be of "standard project flood" proportions.[24]

The first floodway constructed was the Bonnet Carre Floodway. This project is approximately 30 miles above New Orleans. Construction was

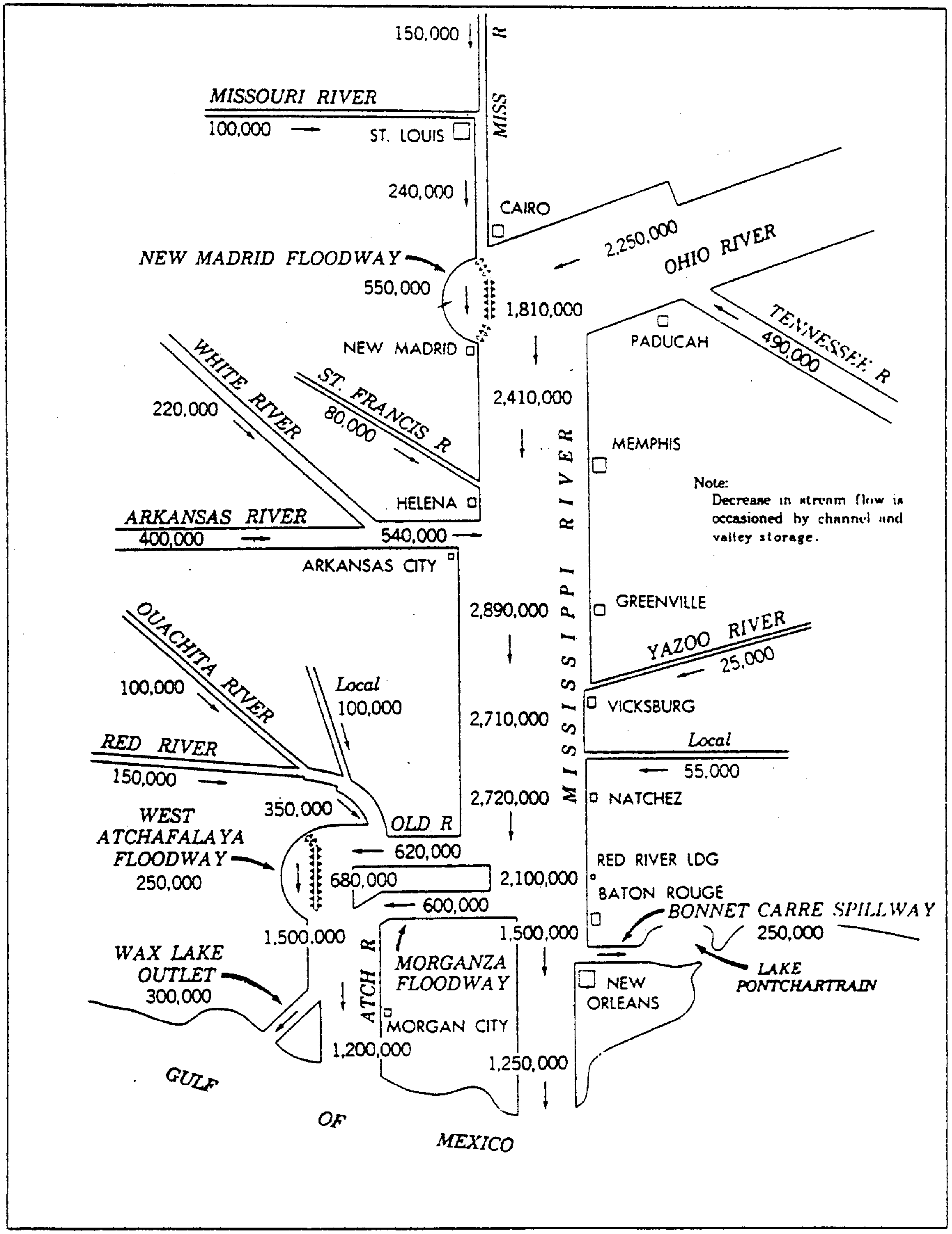

Figure 5. Project Design Flood Discharge in CFS (Madden, 1974).

completed in February 1931. The spillway structure is 7,000 feet in length and side levees, 5.7 miles long, guide the floodwaters to Lake Pontchartrain.

Work on the New Madrid Floodway began in 1929 and has been restudied and modified intermittently since then. Basically, it is a levee system that is designed to breach when the stage in the Mississippi reaches a certain critical elevation. When the fuseplug goes out, approximatley 26,000 acres become available as a sump, thus decreasing discharge and stages in the river.

Floodways in the Atchafalaya basin were considered as an essential part of the 1928 Flood Control Act. Flood waters diverted from the main stem Mississippi are carried to the Gulf of Mexico through the Atchafalaya River, the Morganza Floodway and the West Atchafalaya Floodway (Figure 6). Flood waters carried through the Atchafalaya River and West Atchafalaya Floodway are diverted through Old River. The West Atchafalaya Floodway is controlled at the upstream end with a fuseplug levee. This floodway is only expected to be used, on the average, once in a hundred years.[25] Until the fuseplug is breached, flow goes down the Atchafalaya River.

The Morganza Floodway is located 35 miles northwest of Baton Rouge. The structure is 4000 feet in length and consists of 128 gated openings. It was placed in service in 1953 and thus far has been used only once, during the flood of 1973.

Wax Lake Outlet is designed to accommodate some of the floodwaters coming down the Atchafalaya. This is done to reduce stages in the Morgan City area.

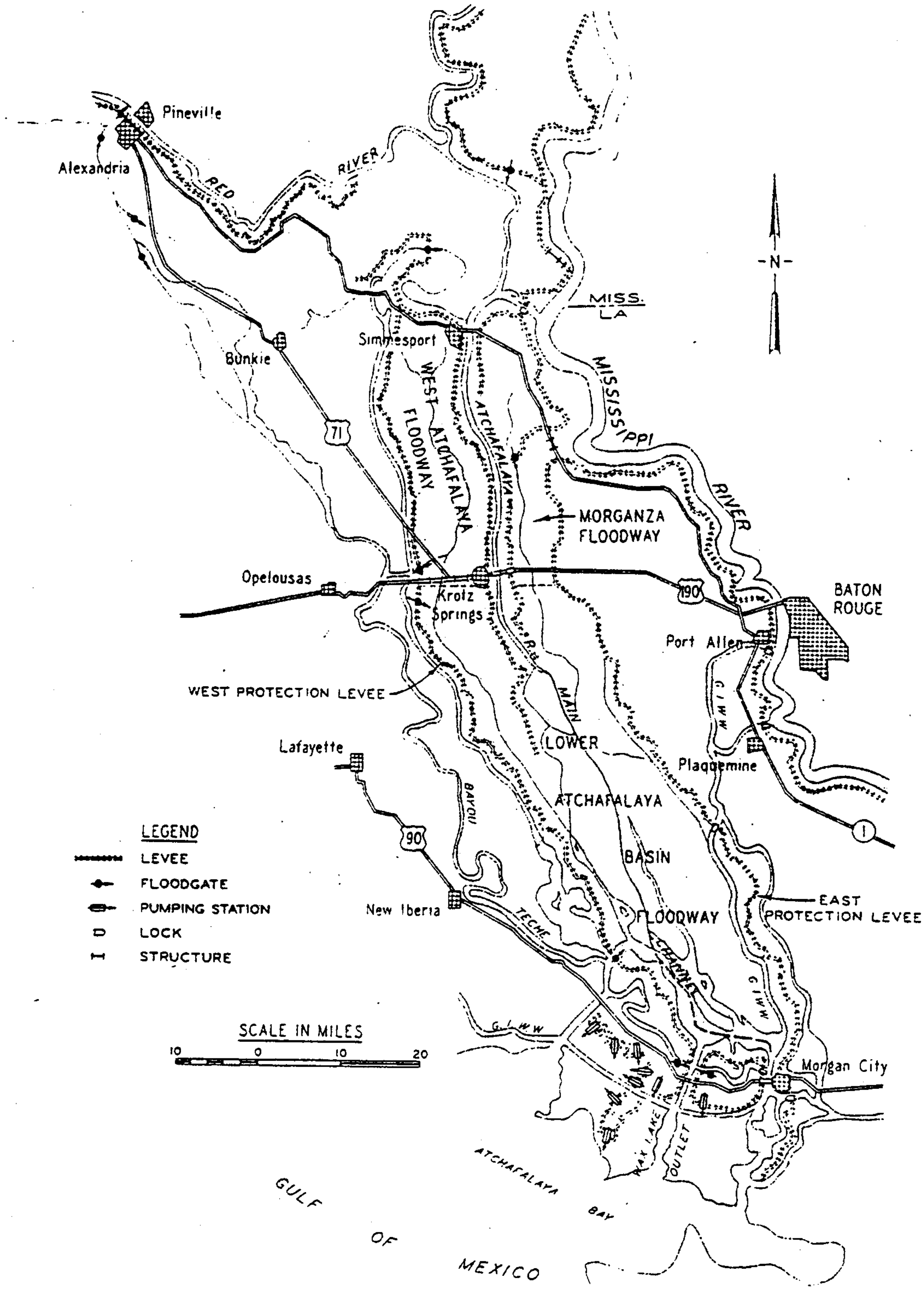

Figure 6. Atchafalaya River Project (Moore, 1972).

CHAPTER 1

ENDNOTES

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(3) Carter, Hodding, Lower Mississippi, Rinehart and Company, Inc., 1942. pp. 15-22.

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(5) Ibid. pp. 4-6.

(6) Mississippi River Commission and U.S. Army Corps of Engineers, Lower Mississippi Valley Division, "Mississippi River Navigation," May 1969. pp. 2-4.

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(17) U.S. Army Corps of Engineers, "Floods and Flood Control on the Mississippi 1973."

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CHAPTER 2

POSSIBLE DIVERSION OF THE MISSISISPPI RIVER INTO THE ATCHAFALAYA BASIN

The Lower Alluvial Valley

In 1941 the MRC commissioned a geological investigation of the alluvial valley of the Lower Mississippi River. Dr. Harold N. Fisk, Associate Professor of Geology at Louisiana State University performed the study. The objective of this study was to try and gain a better understanding of the various factors responsible for the river's activities. (The Fisk reports of 1944 and 1952 are the principal sources used in this section on the Lower Alluvial Valley.)

The Mississippi River had its origin some 1,000,000 years ago during the first advance of the Pleistocene glaciers. As the ice accumulated in Canada and in the eastern United States sea level dropped several hundred feet. Due to the drop in sea level the newly formed river, seeking to adjust its slope, cut a deep trench in the valley. At this time the mouth of the river was about 60 miles southwest of the present river delta.(1) The upstream end of the entrenched valley can be found at the head of the Gulf Coastal Plain or in the vicinity of Cape Girardea, Missouri.(2)

As the glaciers started to melt, sea level began to rise. As sea level began to rise, the valley slope decreased. As the slope decreased, so did the river's ability to transport sediment. But the tributaries' slope was still greater than the main-stem, so they still continued to supply large quantities of coarse materials. These gravels, unable to be transported by the main-stem, were deposited at their mouths.

Sea level continued to rise and the substratum in the entrenched valley continued to thicken. With this decrease in slope, both the grain size and the quantity of sediment reaching the valley decreased. Thus, the alluvium deposited in the valley became progressively finer grained.[3] As Fisk states:

> . . . The decrease in quantity and grain size of the load and the lowering of stream gradients permitted a gradual adjustment between the river flow and load, and the valley slope . . . . Only after the sea reached its present stand was complete adjustment effected between the river and its environment."[4]

Fisk goes on the describe how the Mississippi became a graded stream. A graded stream is a stream that has achieved slopes such that their energy is just sufficient to transport the material through the system that is delivered to the streams.[5] As the stream became graded, it also picked up its meandering habits. Control of meandering has been one of man's main objectives on the river. But before man can attempt to control it, he must first understand it.

Basically alluvial rivers such as the Mississippi meander because their natural tendency is to do so. As the thalweg begins to proceed downstream, "bouncing" from one side to the other, the stream begins migration. The thalweg is the centerline of flow and generally follows the deepest portion of the channel. Migration is caused by two actions in the stream, alternate bar building and bank caving. As the bars continue to build, the erosion on the opposite bank continues, the material from the eroded bank moves downstream to nourish other point bars and crossings. Eventually, due to the erosive action, a cutoff occurs and a oxbow lake is formed. Over the course of time these oxbows are filled with clays and silts and are referred to as bendways.

An important factor controlling the rate of migration is the composition of the bed and bank materials. It logically follows that in a thick deposit of fine-grain topstratum the migration is relatively slow. As Fisk indicates this is exactly the situation in the southern portion of the Mississippi Valley. In this reach where the topstratum is cohesive and coarse sediments are rare, the channel is narrower and deeper and less sinuous than the channel in the upper valley. In the upper valley the topstratum is thinner and deposits of coarser sediments are more easily eroded, thus this reach is more sinuous.(6)

The Mississippi River has been a meandering stream since sea level became stationary approximately 5000 years ago.(7) During this time the river has occupied several courses. On Figure 7 are shown some of the course changes in the lower valley. The Maringovin-Mississippi started to develop approximately 3000 years ago; the Teche-Mississippi 2,000 years ago; the Lafourche-Mississippi 1,600 years ago and the present course downstream of Donaldsonville approximately 800 years ago.(8) Dating was performed by methods developed by Fisk and have been substantiated by the radiocarbon method.

The primary reason for these diversions is the river's aggrading character and it's subsequent desire for a steeper, quicker route to the Gulf. The diversion process begins when one of the Mississippi's meander loops intersects with a small alluvial valley stream. The smaller streams develop on their own between old meander belt ridges and

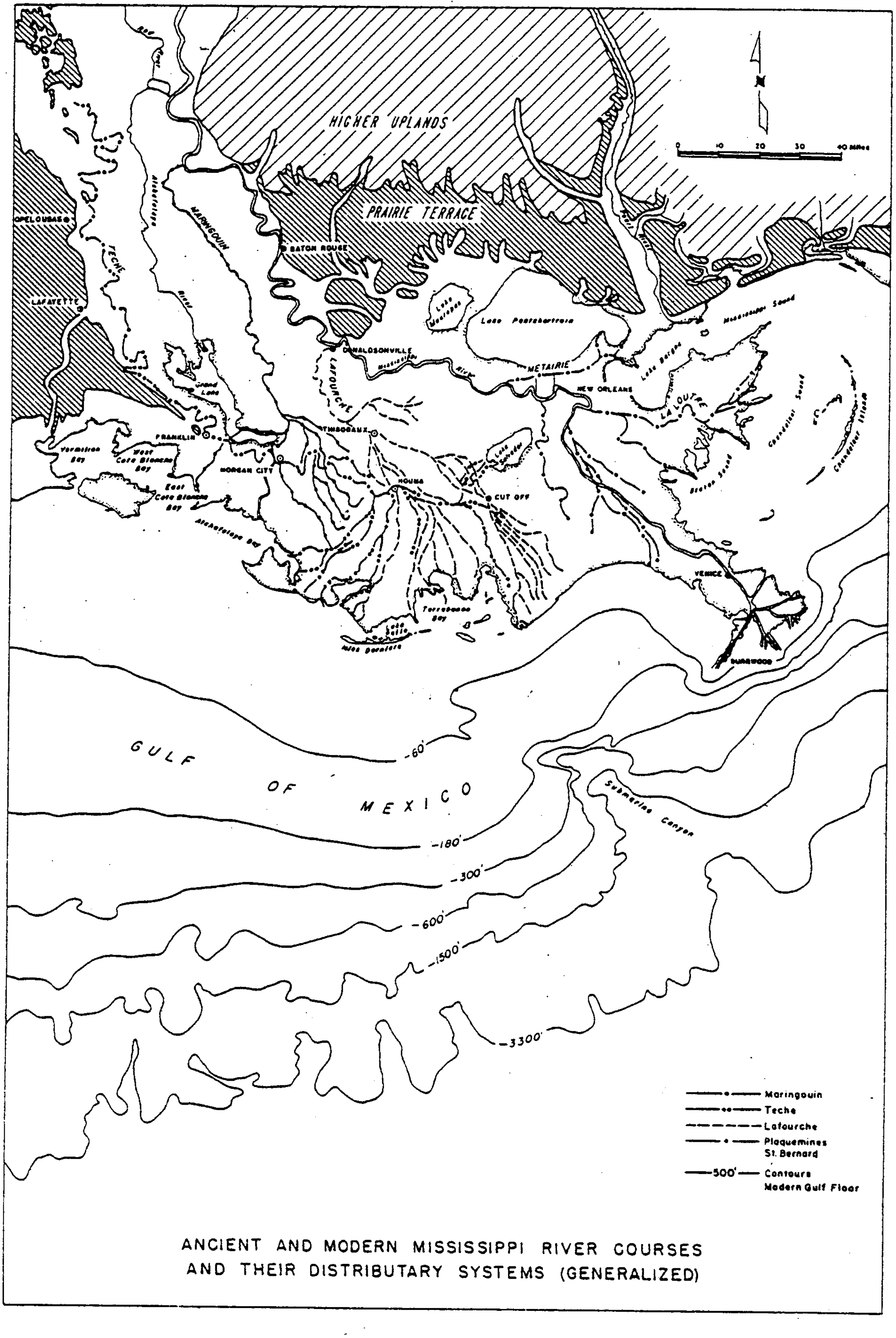


Figure 7. Mississippi River Courses (Fisk, 1952).

their slope to the Gulf is relatively steeper than that of the Mississippi. Once the smaller stream is intersected it then becomes a distributary of the main river.(9)

Diversion does not take place all at once. According to Fisk, "No more than 100 years and probably a shorter length of time was required for any of the former Mississippi River diversions to be accomplished."(10) This relatvely slow process is required so that the distributary can enlarge sufficiently enough to carry the flow. Once the diversion is complete the abandoned river is gradually filled with sediment deposited during flood flows.

During the time the Mississippi River was changing courses, the Atchafalaya began to develop. Figure 8 shows the sequence of the development of the Atchafalaya Basin.

The following is a chronological history of the significant events in the development of the alluvial valley:

a) The Mississippi entrenched valley system was formed approximately 25,000-30,000 years ago during the peak of the Late Wisconsin glacial stage. At this time sea level was approximately 450 feet lower than at present.

b) The entrenched valley system was filled with alluvium as sea level rose and reached its stand approximately 5,000 years ago.

c) The meandering habit of the river, so essential for development of diversion arms such as the Atchafalaya, was established when sea level reached its stand. Well-defined meander belts in the southern part of the valley show that during the past 3,000 years the Mississippi has occupied and abandoned several courses. Most information is available for the three latest shifts in river position which occurred within the past 1,500 years. Each of these courses was occupied for periods ranging from 400 to 800 years prior to its abandonment.

d) The Atchafalaya Basin was created from 1,100 to 1,600 years ago, after the abandonment of the Teche-Mississippi

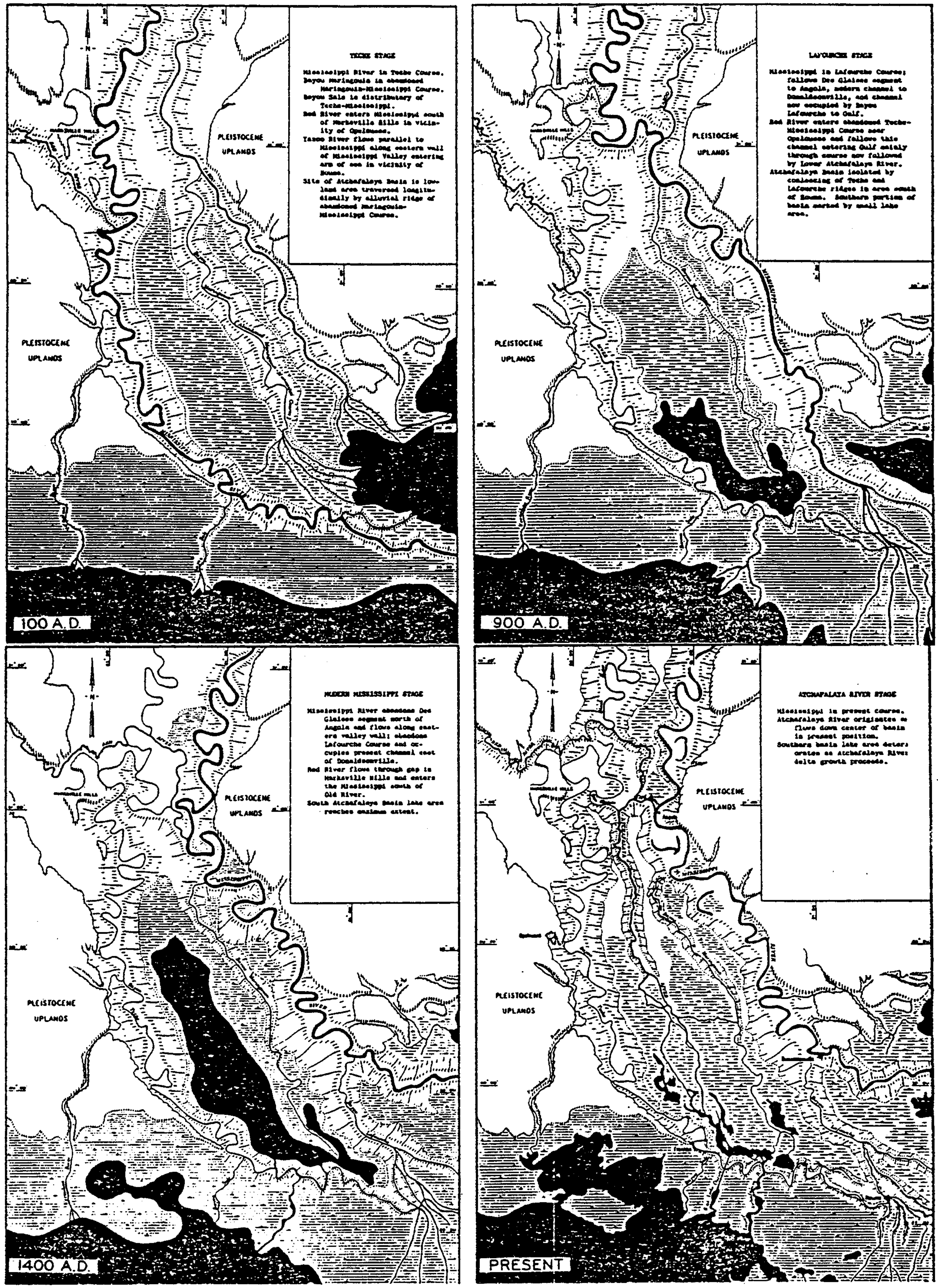


Figure 8. Development of the Atchafalaya River Basin (Fisk, 1953).

course and during the development of the alluvial ridge and delta of the Lafourche-Mississippi course.

e) The Atchafalaya River originated not more than 500 years ago and postdates the development of the present Mississippi course.(11)

The Old River Control Structure

The possibility of capture of the Mississippi by the Atchafalaya has been recognized for many years. As indicated earlier, Major Stoddard made this observation in the early 1800s. By 1950 almost 25% of the annual flow in the Mississippi was being diverted naturally down the Atchafalaya. This percentage was growing exponentially and studies indicated that by 1970, if nothing were done, 40% of the Mississippi's flow would be captured by the Atchafalaya.(12)

As a result of studies performed by the Waterways Experiment Station at Vicksburg, Mississippi and Dr. Harold N. Fisk, it was decided that something must be done. These studies examined past Mississippi River diversions and concluded that what was happening currently with the Atchafalaya was no different than what had occurred historically and no natural process would stop eventual capture.

Under the authority granted in a special provision of the 1935 Rivers and Harbor Act, which gave the Chief of Engineers the power to act (perform an investigation or study) without a customary congressional resolution, the Corps proceeded to prepare plans for corrective measures at Old River. The Corps Report was submitted to Congress on February 2, 1954. This report formed the basis for the authorization given in the 1954 Flood Control Act.(13)

The Corps plan called for the construction of two concrete control structures, a navigation lock and a earthen dam to close the Old River (see Figure 9). The two concrete control structures consisted of the overbank and low sill structures. Both had mechanically operated gates. The low sill control structure had 11 gates, each 44 feet wide. Total width of the low-sill structure was 566 feet between abutments.[14]

The overbank control structure consisted of 73 gate bays, each having 44 feet clear between piers. Total width of the overbank structure is 3,356 feet between abutments.[15]

The reason for the terminology, "low sill control structure," is because the weir crest elevation on three of the bays is -5.0 feet NGVD (National Geodetic Vertical Datum, formerly Mean Sea Level). The four end bays on each end have a weir crest elevation of 10.0 feet NGVD.[16] The weir crest elevation on the overbank control structure is 52 feet NGVD.

One of the most important problems considered in the design of the system was sediment diversion. It was desired that the amount of sediment diverted should be directly proportional to flow diverted. Physical model tests were used to determine the appropriate alignment of the structure and intake channel.[17] Subsequent investigations have shown that a disproportionately large amount of suspended sediment is being retained in the Mississippi below Old River. The effects of this will be discussed in the next section, Factors Involved in Possible Diversion at Old River.

Construction of the low sill structure began in September 1955. This portion of the project was started first, so if for any unforeseen reason Old River had to be closed before completion of the entire project, some degree of control would exist. The next year work commenced on the overbank structure and excavation for the navigation

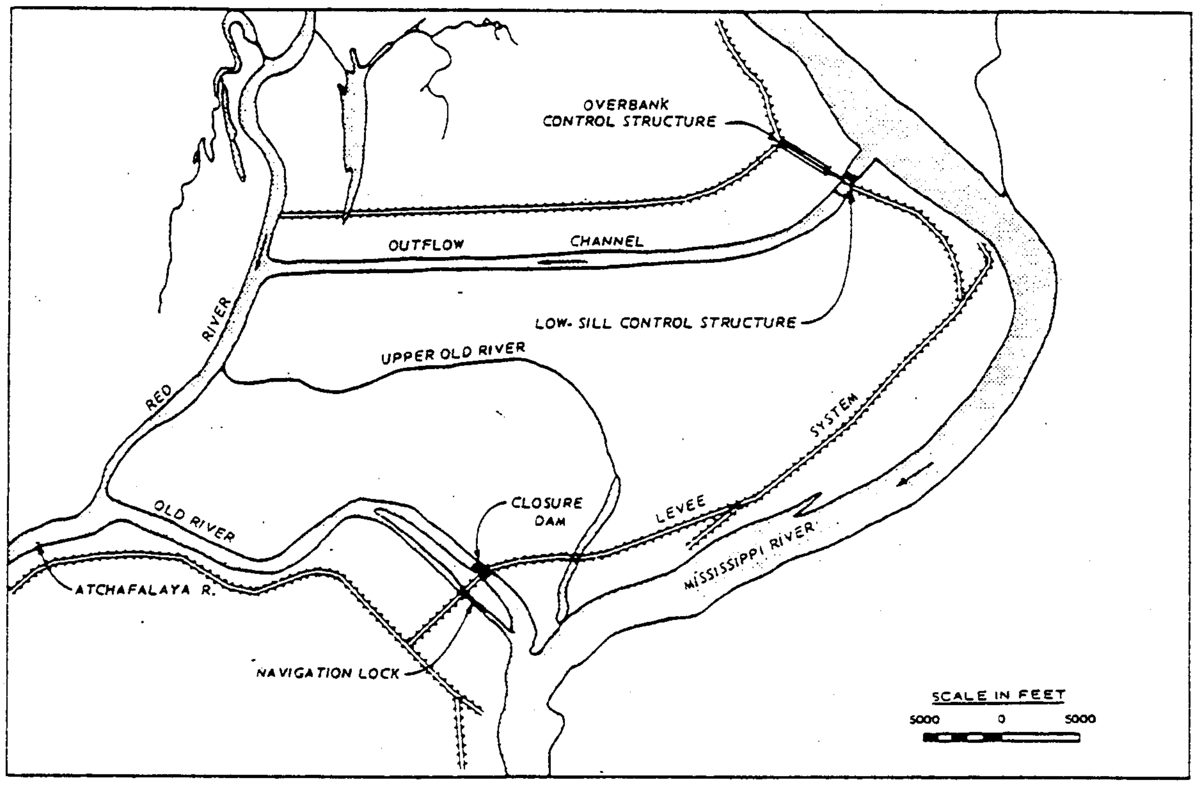


Figure 9. Old River Control System (Corps of Engineers, 1976).

lock was begun. In 1959 both control structures and appurtenant channels and embankments were completed. The navigation lock began operation in March 1963. In October of 1963 the construction of the earthen dam across Old River was completed and uncontrolled flow from the Mississippi to the Atchafalaya ceased.[17]

In 1973 the Old River Control System had its greatest test to date. The 1973 flood was the largest flood on the lower Mississippi since the 1927 flood. The return interval on the 1973 flood at the latitude of Red River Landing and Simmesport, Louisiana, was a once-in-40-years flow.[18] The peak discharge in the Mississippi River above Old River was 2,041,000 cfs on May 16, 1973. The maximum amount of Mississippi River flow discharged through the Old river control structure was 684,000 cfs on April 17; 496,000 cfs of this flow passed through the low sill structure.[19]

Though the low sill structure was functioning as designed unseen problems were developing. On April 12 the wing wall on the left decending bank of the inflow channel shifted riverward from the vertical and was separating from the remaining portion of the wall. Two days later the wing wall separated from the structure and fell into the inflow channel. The Corps immediately began construction of a rock dike to replace the wall.[20]

In order to reduce the velocities at the low sill structure the Corps decided to open the overbank control structure and the Morganza Floodway. All 73 bays of the overbank structure were open by 15 April. Morganza Floodway evacuation began 15 April and the Floodway gates were open the next day.[21]

Scour in the vicinity of the low sill structure had occurred in the past. Holes had developed downstream in the outflow channel, but the situation in April 1973 was critical. On May 5, the Crops was finally able to determine the magnitude of the scour hole that caused failure of the upstream wing wall. Figure 10 shows scour holes to -60.0 feet NGVD had developed upstream. This hole was approximately 320 feet wide and extended about 200 feet underneath the structure.(22)

By June 11 the Corps had filled the holes with rock. The dike used to replace the wing wall required approximately 97,500 tons of rock. The upstream scour hole required 118,500 tons. Some scour had taken place downstream, that hole took 25,300 tons.(23)

During the years following the 1973 flood the Corps performed extensive repair and rehabilitation work on the Old River Control Structure. Work included:

a) Additional scour protection in both the inflow and outflow channel of the low sill structure;

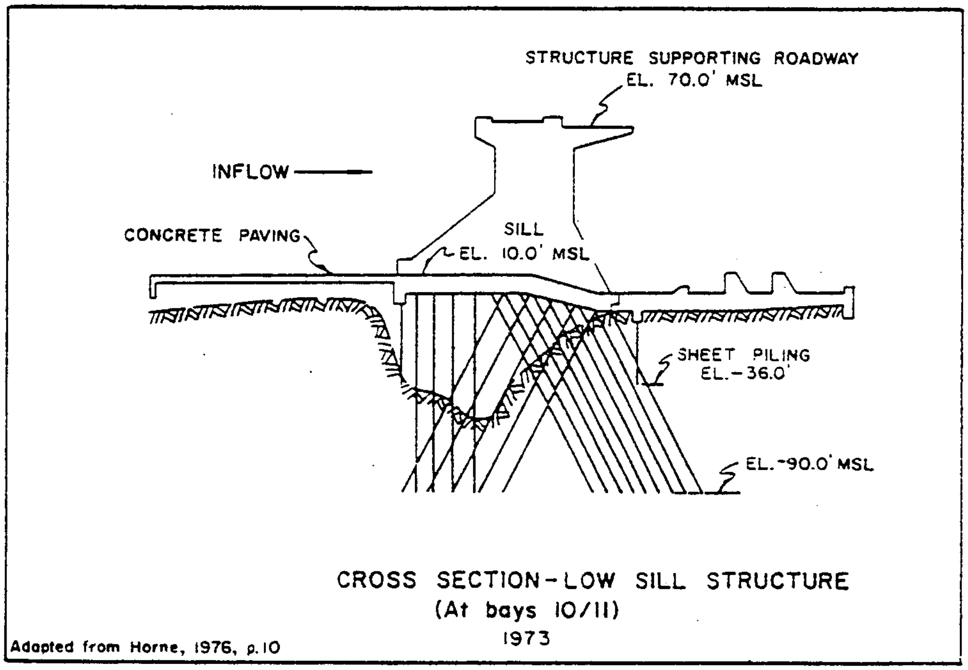
b) Modification of the gates of the low sill structure to allow orifice flow operation,

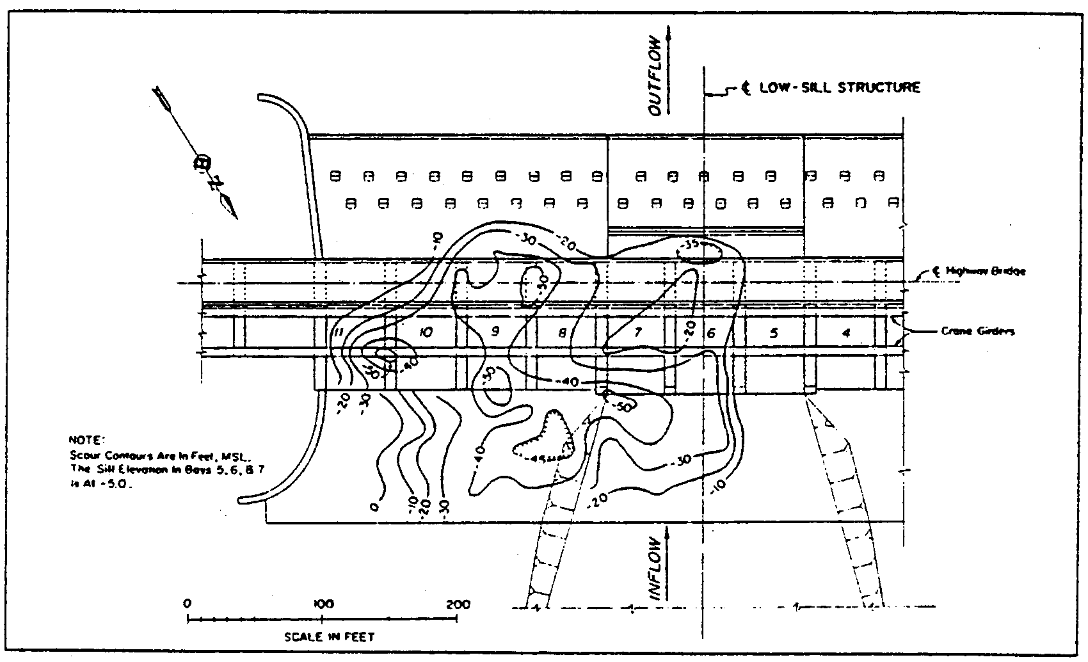
c) Replacement piezometers at the low sill structure,

d) Cleaning of drainage systems at the low sill structure,

e) Modifications of the ovebank structure to prevent potential future scour damage.

These measures have once again given the Corps full flow control at Old River. The 30/70 percent flow distribution has been maintained since 1977. But due to the scour activity alluded to earlier, the foundation of the low sill structure was permanently damaged. The safe





SCOUR IN INFLOW CHANNEL AND UNDER LOW-SILL STRUCTURE. 1973 FLOOD
(From U.S. Army Corps of Engineers sketch)

Figure 10. Scour in Inflow Channel and Under Low Sill Structure, 1973 Flood.

limit of differential head is now estimated to be 22 feet instead of 37 feet provided in the original design.[24] This head differential limitation is not a problem in the day-to-day operation of the structure. The problem could develop during an emergency situation, such as an errant barge becomming pinned against the structure during a major flood. If this should happen and removal of the barge during the flood was deemed necessary, problems could develop. Depending upon many factors, gate closure might be necessary, if so, head differential would increase. The increase in head would result from a drop in tailwater elevation and an increase in headwater elevation. Because repair of the damaged foundation in not practicable and the severe limitations placed on the structure by this damage, studies were undertaken to determine the best way of dealing with the problem. The construction of an auxiliary structure was found to be the best way to deal with the situation.

The Auxiliary Control Structure - Construction of the auxiliary control structure began in July 1981. When completed in November 1985 it will restore the capability of the Old River Control System to deal with emergency situations.

The auxiliary structure was added to the project under the discretionary authority of the Chief of Engineers. The need for this structure was recognized in the House Committee on Fiscal Year 1980 Supplemental Appropriations Report 96-1086 dated 11 June 1980. The report stated:

> The Committee is cognizant of the vital function performed by the Old River, Louisiana, complex and of the

> unacceptable consequences to southern Louisiana should the existing low sill structure fail. Therefore, within available funds, $500,000 is for the Corps of Engineers to begin construction of the Auxiliary Structure. The Corps is expected to expedite the completion of this facility.(25)

The auxiliary structure is a reinforced concrete structure consisting of six 62-foot wide gate bays with steel tainter-type gates. The sill elevation is -5.0 feet NGVD. Approximately 15,000 feet of conveyance channel and 22,000 feet of levees will be constructed.(26) When completed the auxiliary structure will be operated together with the low sill structure. Figure 11 shows the physical location of the auxiliary control structure.

Factors Involved in Diversion at Old River

There are several natural forces at work on the Lower Mississippi and Atchafalaya basins which tend to substantiate the claim that capture of the Mississippi by the Atchafalaya is imminent. As discussed previously, the construction of the Old River Control System has served to impede the process and is the only physical barrier that separates the river's will and man's desire. The main factors involved in the possible diversion are changes in the hydraulic capacity of the Mississippi and Atchafalaya Rivers and evidence that an uplift feature in East Mississippi and West Louisiana is causing adjustments in the Mississippi's course.

Changes in the Hydraulic Capacity of the Mississippi - The hydraulic capacity of the river is changing. This is important, both from the standpoint of flood control, and in this case diversion into

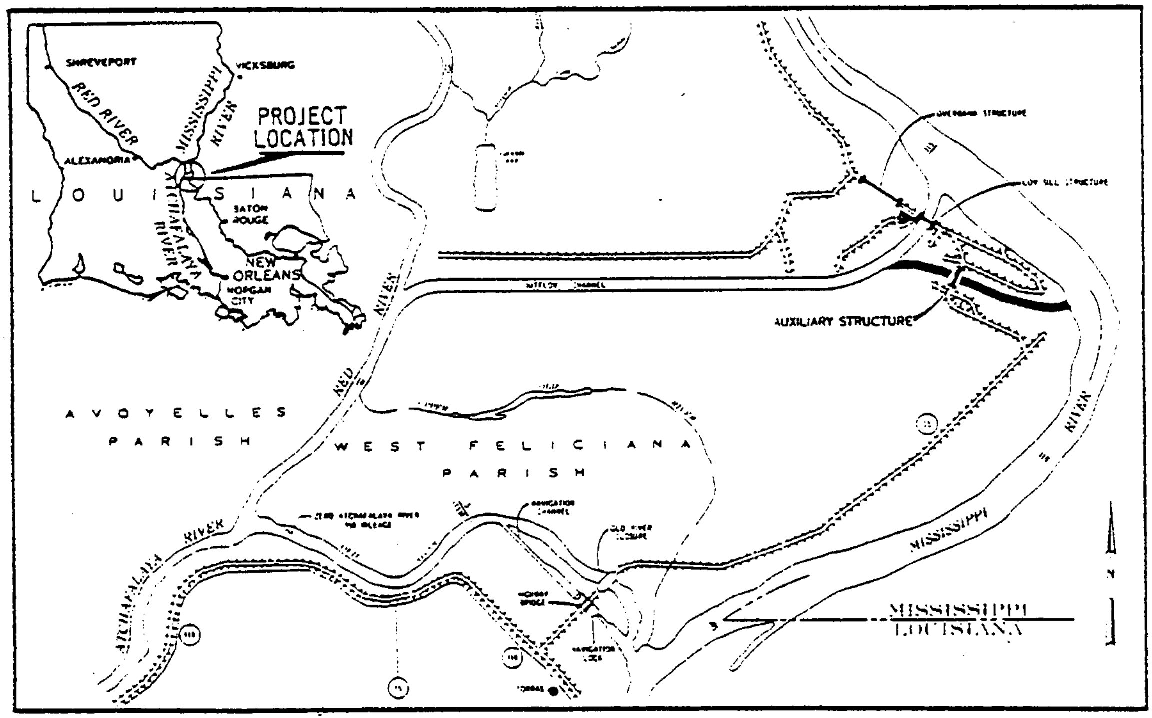


Figure 11. Location of Auxiliary Structure (Corps of Engineers, 1981).

the Atchafalaya. Changes in capacity are important to flood control in that the river might be more or less efficient in passing certain flood discharges. Aggradation, the "filling in" of the channel cross section with sediment, can cause slope to flatten, a loss in hydraulic capacity and an increase in stage. Aggradation, with the resultant increase in stage can have significant implications on a leveed stream such as the Mississippi.

Degradation is just the opposite of aggradation in that, if for some reason the slope increases, so will the stream's ability to transport sediment. As the stream channel degrades, the capacity will increase and stages will decrease.

As mentioned in Chapter 1, General Harley B. Ferguson instituted the cut-off program on the Mississippi. During his term as President of the MRC, he was responsible for 16 cut-offs (see Figure 11). These cut-offs shortened the Mississippi 151.9 miles. The main objective in this cut-off program was to improve navigation and lower stages. With regard to lowering stages, the program was successful. River stages at Arkansas City, Arkansas, were lowered 16 feet and at Vicksburg, Mississippi, stages came down about 10 feet.[27]

The net effect of this system of cut-offs is that due to straightening and increasing the slope in this reach much degradation has occurred. The cut-offs were and have been supplemented with bank revetment. The natural tendency would have been for the river to regain its pre-cut-off length, but the revetment and levee programs have made this impossible. So the river's response has been contained to the channel. The result was the channel degraded and the increased sediment

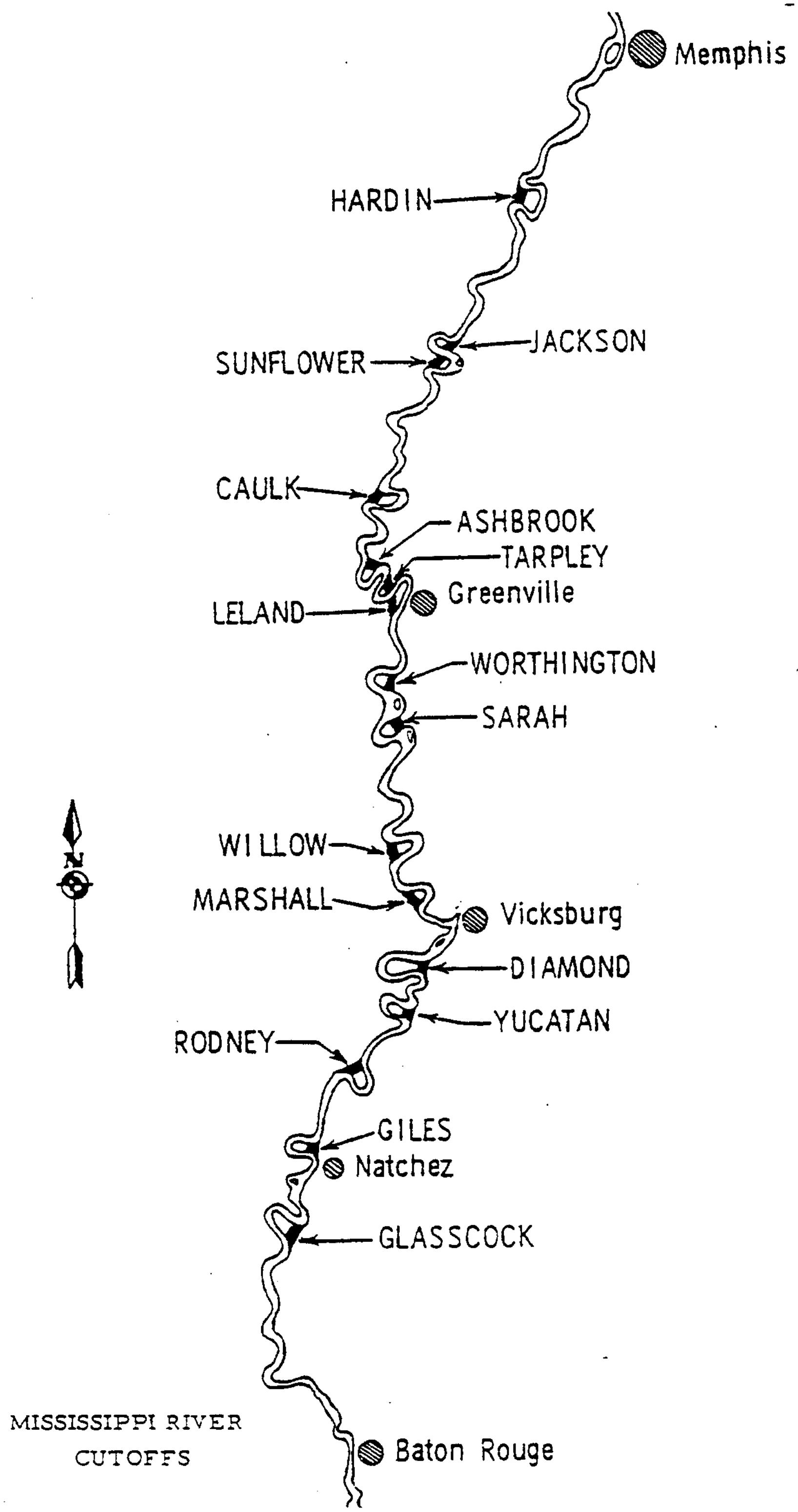


Figure 12. Mississippi River Cut-Offs (Corps of Engineers, 1965).

was transported downstream. Downstream the gradient is less steep and much of the sediment is deposited. Thus the trend of degradation in the cut-off reach and aggradation below Old River is established. Figure 13 is an example of how the stages have varied at various gages over the years. Notice specifically the years 1930 to 1940.

This problem is also compounded by the fact that through basin development, and to a lesser extent, lowering of the base level of the river, sediment supply to the river has increased tremendously. By lowering the river's base level the tributaries are subject to degradation and possible headcutting, which in turn increases the supply of sediment to the system.

Development of the drainage basin is responsible for the bulk of the increase in sediment inflow. Deforestation and the subseqent increase in area used by agriculture are prime examples of activities that increase sediment production.

Another factor which has increased the sediment supply to the Mississippi below Old River has been the Old River Control System itself. As mentioned in the previous section, the system at Old River was designed to divert equal proportions of sediment and water. But investigations by Simons and Chen have shown that this is not the case.(28) Their studies indicate that the Old River Control System is not extracting sediment in proportion to flow, resulting in higher concentrations of sediment below Old River.

All of these factors, basin development, the cut-off program, bank protection and levees, degradation upstream of Old River and aggradation downstream have significantly altered the hydraulic capacity of the

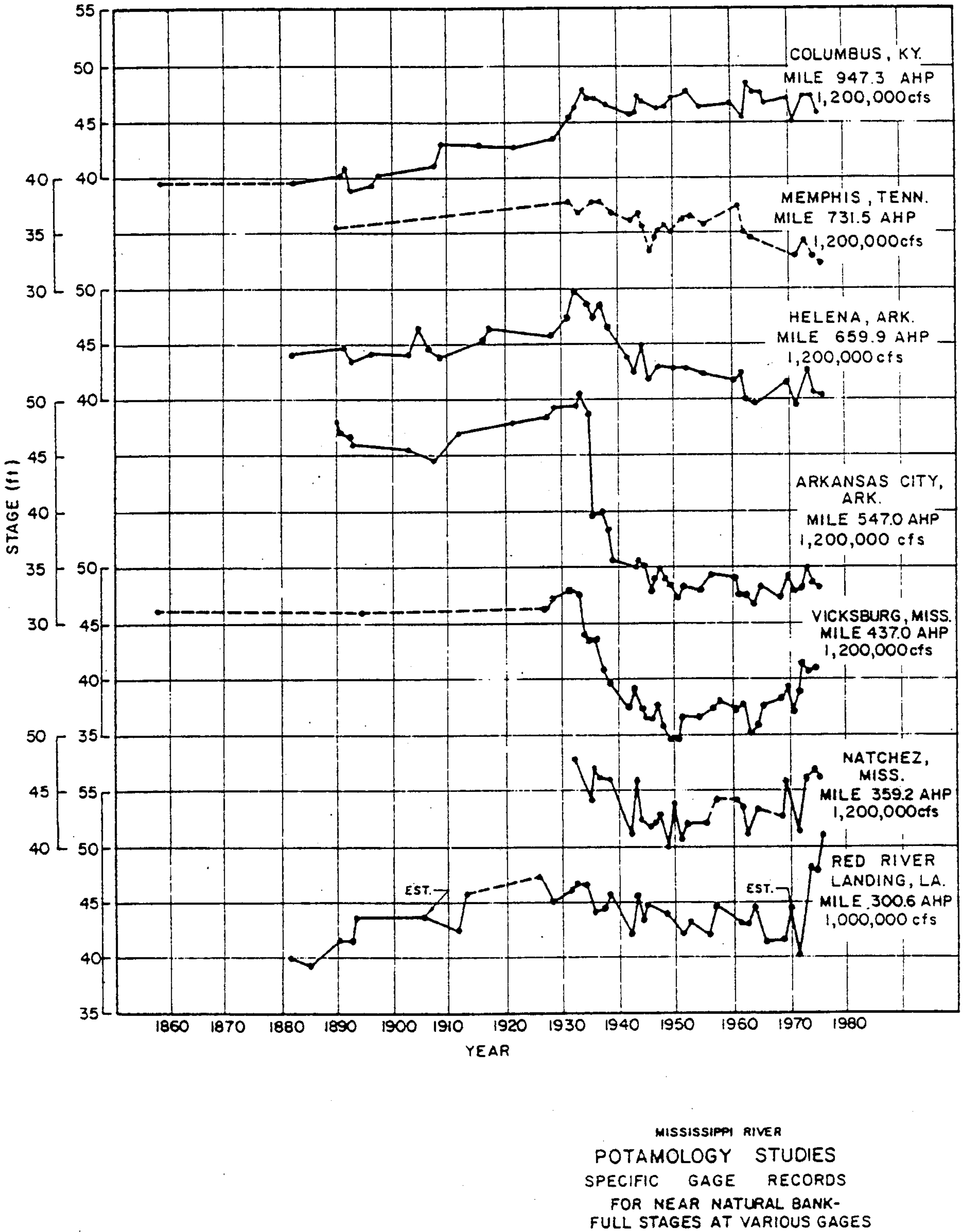


Figure 13. Plot of River Stage vs. Time at Various Locations on the Mississippi (Winkley, 1977).

Mississippi. The aggradation below Old River is especially significant in relation to the diversion problem. As the capacity of the lower Mississippi continues to deteriorate, the likelihood of diversion is enhanced. This means that a shorter, steeper route to the Gulf, such as that offered by the Atchafalaya becomes more attractive as time passes.

Changes in the Hydraulic Capacity of the Atchafalaya - During the years after the great log jam was removed from the Atchafalaya, the channel began to enlarge. It continued to enlarge and accept more of the Mississippi's flow until construction of the Old River Control System. The Corps of Engineers maintains the 70/30 percent distribution between the Mississippi and Atchafalaya that existed just prior to the completion of the control facilities. Therefore, it should follow that the capacity of the Atchafalaya would stabilize. This is not the case.

Because sediment is not being discharged through Old River in proportion with the flow, the result is a relatively clear water discharge into the Atchafalaya. The Lane relation states that the product of discharge (Q) and slope (S) is proportional to the product of sediment discharge (Q_s) and sediment size (D_{50}).[29]

$$QS \sim Q_s D_{50}$$

Applying the Lane relation to the situation downstream of the Old River Control Structure we have:

$$QS^- \sim Q_s^- D_{50}$$

A decrease in sediment results in a decrease in slope. In order to accommodate the decrease in slope, degradation will occur. The degradation results in a larger channel cross section. Therefore, due to the semi-clear water release from Old River, the Atchafalaya is enlarging at a rate greater than the rate in its natural state.

It has been observed that the channel degradation is extending downstream well beyond the leveed reach of the Atchafalaya River. Aggradation is occurring in the backswamps of the lower Atchafalaya. The filling of these swamps is of great concern to the environmentalist. Environmentalists claim the basin's present hydrological cycle and complex water circulation patterns support one of the world's most highly natural productive areas.(30)

The fact that the Atchafalaya is enlarging, and at a rate greater than that prior to the Old River Control System is documented.(31) This indicates that if a critical situation did develop at Old River, and the control provided by the present facilities were lost, the Atchafalaya would be capable of accepting a greater percentage of the flow than the Corps currently allows and capture would be hastened.

Neotectonic Activity in the Lower Mississippi Valley - Another more subtle factor that might have implications in the diversion process are neotectonic activities in the area. Neotectonic activities are recent changes in the earth's crust. These changes are determined by precise leveling performing by the National Geodetic Survey (NGS). Using these precise leveling techniques the NGS will rerun level lines and determine any vertical movement of bench marks. Vertical movement over time establishes a rate, generally expressed in millimeters per year. Figure 14 is a plot of apparent isovels of surface movement in the Lower Mississippi Valley.(32) According to Watson, "the pattern of surface

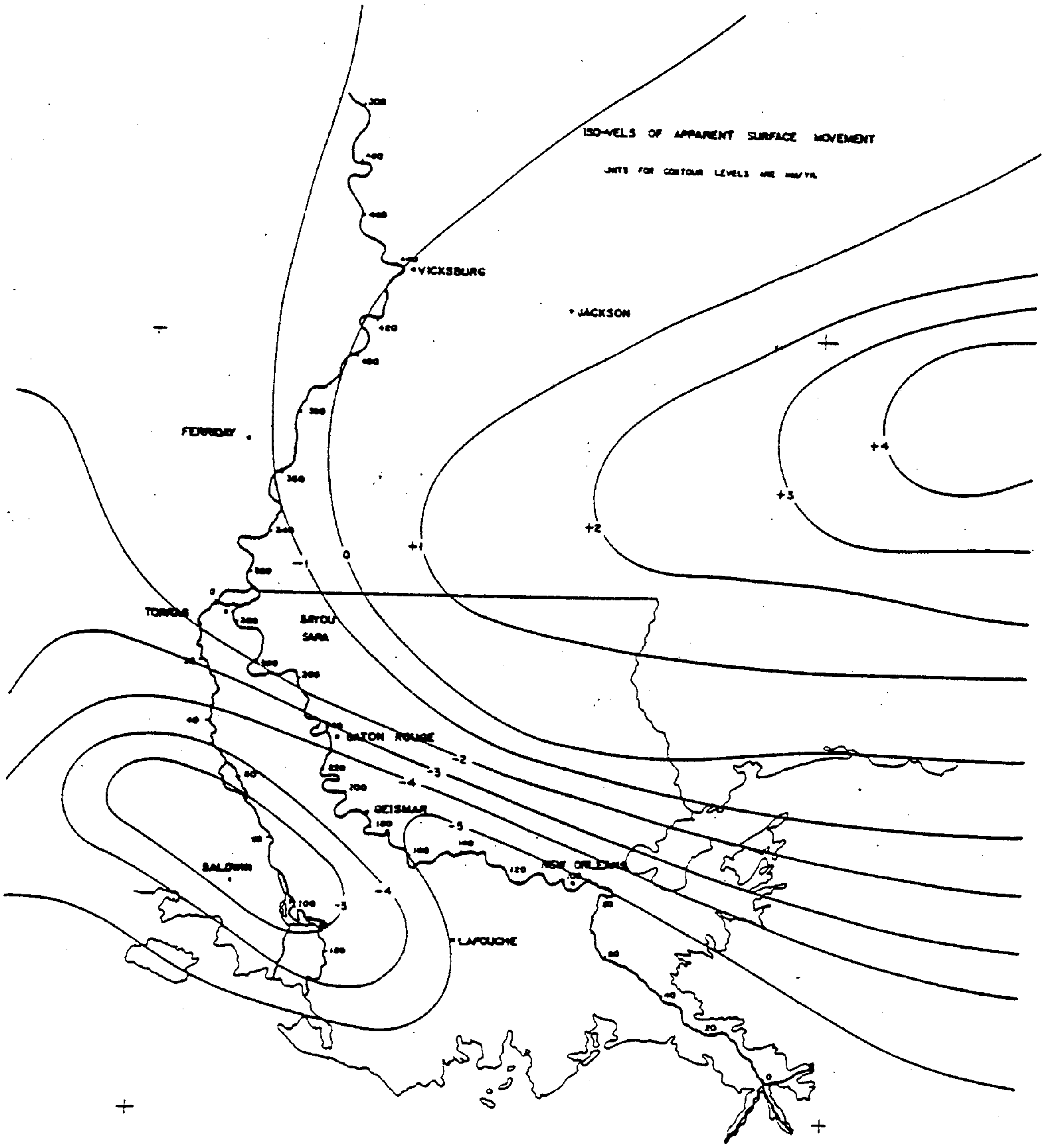


Figure 14. Iso-Vels of Apparent Surface Movement (Watson, 1982).

movement is likely due to a combination of the Wiggins uplift feature, and normal faulting and subsidence as a result of sediment accumulation on the deltaic plain."[33] Watson also observed that the tilt rates on the Atchafalaya between miles zero and 40 are greater than tilt rates on the Mississippi at equal latitudes.[34]

When these factors are combined with other geologic features, such as local faulting and salt domes, the indication is that the Mississippi might be more "comfortable" flowing through the Atchafalaya basin.

CHAPTER 2

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CHAPTER 3

IMPACTS OF DIVERSION

Impacts on the Lower Mississippi

The major impacts would be on water supply and navigation. Environmental impacts are too numerous to mention, let it suffice to say the nature and habitat of the entire lower basin would undergo major changes. Marsh deterioration in the delta would accelerate and the entire lower basin (below Baton Rouge) would change character due to salt water intrusion.

Salt Water Intrusion - If diversion of the Mississippi became a reality, the reduced discharges on the Mississippi below Old River might ultimately allow salt water intrusion to extend upsteam as far as Baton Rouge.(1)

The elevation of the bed of the Mississippi is below sea level well above Old River. As a result salt water, being heavier and more dense than fresh water, tends to move upstream from the Gulf of Mexico. Salt water travels along the bottom in a wedge shape of increasing thickness downstream. There is a distinct interface between the fresh and salt water. The flow of fresh water tends to erode the interface and retards the upstream movement of the salty water. The interface forms a distinct line between fresh and salt water. Above the interface concentrations of chloride might be a few hundred parts per million (ppm) and below it a few feet the concentration might be as high as 15,000 ppm.(2)

The futherest that this wedge has extended upstream in the Mississippi was in October 1939. That fall flow was the lowest recorded on the Mississippi and stayed between 75,000 and 100,000 cfs for 30 consecutive days. That fall the salt water intrusion extended upstream approximately 15 miles above New Orleans.(3)

It is not known exactly how much of the Mississippi's flow would be diverted to the Gulf via the Atchafalaya. But the amount is expected to be significant enough that the remaining flow will not be able to hold back salt water and those cities such as New Orleans and Baton Rouge will be without a fresh water supply. In 1975, the parishes below Old River using Mississippi River water were withdrawing almost 6.8 billion gallons per day (3) for municipal and industrial use.

The impacts of loss of water supply from the Mississippi below Baton Rough have not been quantified. But one can see how devastating this would be to the economy of the area. There are many industries, especially petro-chemical, located on the banks of the Mississippi. The primary reasons for locating here is the proximity to the oil producing areas, local availability of minerals such as salt and sulphur and an abundance of fresh water.(4) The loss of these industries would have far reaching implications. The production of electricity in stream-powered generators is also dependent on fresh water. Eventual pollution of the groundwater by saltwater is another problem.

The impacts of salt water intrusion on the Mississippi are many. A few of the primary impacts have been identified here. An in-depth economic analysis in this area could indicate somewhat severe impacts nationwide, especially in the chemical and petro-chemical products market.

Mississippi River Navigation - The major impacts on Mississippi River navigation would be felt on the river upstream of Baton Rouge.

After diversion there is a good chance that major bars would develop in the Mississippi just downstream of Old River. The aggradation would be caused by lower velocities and lower flows still present in the old main-stem. Velocities in the new system would be greater due to the increased gradient provided by the Atchafalaya. Increased dredging and/or the addition of major structural elements to help control aggradation might be used to aid navigation at, and downstream of, Old River on the Mississippi.

The impacts on the Mississippi upstream of Old River could be severe. If the majority of the Mississippi flow was suddenly allowed to flow into the Atchafalaya, the steeper gradient downstream would tend to cause degradation and possibly headcutting upstream on the main-stem Mississippi. This action would extend many miles upstream as the river attempted to balance and regain its pre-diversion character. Most of the bank stabilization would not survive the river's transition. Navigation would become difficult as the river changed form, and well defined channels disappeared. This scenario on impacts on the Mississippi upstream of Old River is conjecture based on the principles of river response. These changes would occur over a long period of time, not overnight.

Impacts on the Atchafalaya Basin

The impacts due to diversion in the Atchafalaya Basin could be broken down into transportation, flood damages, fishing industry, and natural gas pipelines.[5] As was stated with regard to impacts on the Lower Mississippi, the environmental consequences of diversion will not be addressed here. But again, as was the case with the Lower

Mississippi, the environmental impact will undoubtedly be severe. Large amounts of sediment will be deposited in the basin thus filling the backswamps. This aggradation will continue resulting in a growing delta. After diversion, the resulting Atchafalaya environment will not resemble the environment that exists there today.

Transportation - According to Kazmann, one of the most significant potential effects of failure of the Old River Control System would be the collapse of highway and railroad bridges crossing the basin. Kazmann assumes that the failure of the control system would occur during the height of a flood on the Mississippi and failure would be relatively sudden. So, Kazmann's assessment, which is used extensively in this Chapter, might be considered "worst case."

There are four major highways and four railroad lines in the basin that would be affected as a result of diversion. All of the structures would sustain some damage, mostly as a result of scour and erosion of embankments. Whether or not the structures would fail cannot be predicted. Kazmann estimates the cost of replacement of the highway bridges, plus time and additional expense to motorists for detours would be in excess of $1 billion (1977 prices). The cost to replace the railroads was not computed, but detour cost for the railroads were computed to be $38 million for one year.(6)

Kazmann did not address the impacts on waterborne transportation, but it is expected to be adversely affected. The increased discharges along with aggradation in the lower reaches will significantly affect the existing navigation project. Increased dredging will be necessary to maintain channel depth. Maintaining depth and alignment will probably be a difficult task since it will take many years for the river to become somewhat manageable.

Flood Damages - The cities most affected by floods resulting from failure of the Old River Control System are Morgan City, Berwick, Melville, Krotz Springs and portions of Franklin, Houma and Thibodaux. According to Kazmann there would be approximately 60,000 residents directly affected by the flood resulting from failure at Old River. These people would be subject to frequent, if not permanent, innundation. Total private real property wealth of those affected is valued at $380 million. If 60 percent losses were experienced, the total damages resulting from flooding would be $228 million (1977 prices). Expected also will be some damages from flooding outside the basin. These damages are expected to total $34 million, bringing the total for private property to $262 million.(7)

Total government damages were not computed. If diversion did occur, a total reassessment of the Mississippi River and Tributaries Project for the lower basin would be necessary. Expenditures to establish a new navigation and flood control plan would be t133tememdous.

Fishing Industry - The livelihood for many residents in southern Louisiana is the fishing industry. The most productive areas are the coastal areas where oysters and shrimp are the primary catches.

Both shrimp and oysters are affected by the temperature and salinity of the water. The tremendous influx of fresh cooler water brought about by flooding would adversely affect the crop for the first couple of years. But, in the long run, the nutrient laden sediment would enhance the coast. Currently in the Mississippi, the sediment is efficiently funnelled by the levee system to the deep Gulf Waters. In the lower Atchafalaya a broad delta would form thus enlarging and enriching the coastal areas. It is believed that in the long run the fishing industry would be favorably affected by diversion.[8]

Natural Gas Pipeline Failure - Of the seven major interstate gas pipelines crossing the Atchafalaya Basin it is not known how many or which ones might rupture since all are not equally vulnerable. Kazmann and Johnson divided the pipelines into three categories. There are two in category 1 which are least likely to fail; there are three in category 2 which are next most likely to fail; and finally there are two pipelines in category 3 which are most likely to fail. The figures given here represent the impact should the pipelines in categories 2 and 3 fail. The following tabulation indicates the percentage of gas delivered to various states that would be affected should those pipelines fail.[9]

Alabama	27.7%
Connecticut	23.0%
Georgia	33.5%
Kentucky	17.3%
Louisiana	15.4%
Massachusetts	18.3%
Mississippi	15.8%
New Jersey	15.0%
New York	10.1%
Pennsylvania	13.2%
Rhode Island	24.8%
South Carolina	26.7%
Tennessee	11.9%

There are other states that would be affected to a lesser extent. Altogether, 28 states would be directly impacted if failure of the five pipelines in categories 2 and 3 should become reality.

Johnson (Kazmann and Johnson, 1980) performed an input-output analysis on the economies of those states affected. The results of the input-output analysis are the total decrease in the states gross output, employment and income. The following figures are the total impacts for all 28 states affected by failure of the pipelines in categories 2 and 3 (1977 prices).[10]

	Per Day
Shortage of Natural Gas	$2,400,000 Net
Reduction in Gross Output	$4,500,000
Reduction in Income	$5,400,000
Unemployment	$ 56,000

Most of the impacts addressed in this Chapter came from the Kazmann and Johnson publication. The impacts are by no means complete. As mentioned earlier, the environmental impacts would no doubt be severe. Those impacts listed here tend to illustrate the potential for disaster should a rapid change occur for the worst at Old River. And it should be emphasized that the scenario described here is only educated speculation.

CHAPTER 3

ENDNOTES

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CHAPTER 4

SUMMARY AND RECOMMENDATIONS

Diversion of the Mississippi River is not a new phenomena. As Fisk has indicated, and as described in this report, the Mississippi River has occupied and subsequently vacated many courses over the past 5000 years. These course changes are documented and what was happening at Old River, prior to the construction of the Old River Control Structure, was nothing different that what had happened historically. If the Corps of Engineers had not intervened at Old River, the main-stem of the Mississippi would today occupy the Atchafalaya River Basin.

As discussed in this paper, the evidence that supports the claim that capture is imminent is readily available. Corps of Engineers studies indicate that the reach of the Mississippi below Old River is aggrading. This aggradation is caused by an increased sediment load and the River's inability to transport the sediment through the lower reach of the system. The increased sediment loading results from a combination of sources. The development and deforestation of the basin, the cut-off program of the 1930s and the failure of the system at Old River to subtract sediment from the Mississippi proportional to flow are all to blame for the increase in sediment. The aggradation, or filling-in of the channel, causes a decrease in slope and also a decrease in the flow carrying capacity of the channel. Both of these factors indicate that the shorter, steeper route to the Gulf offered by the Atchafalaya would be readily accepted by the Mississippi.

There is also documented evidence that indicates that the channel capacity of the Atchafalaya is increasing even though the Corps maintains the 30/70 percent flow distribution between the Atchafalaya and the Mississippi Rivers. The reason for this gets back to the water and sediment proportional distribution problem. Because of the relatively clear water discharge through the low sill structure, degradation or enlargement of the Atchafalaya is occurring. This fact would hasten the diversion process should control at Old River be lost.

Lastly, neotectonic activity in the lower basin, in the form of regional uplift and subsidence, is playing an important role in the process of diversion at Old River.

All of this evidence indicates that capture of the Mississippi by the Atchafalaya is possible and, in all likelihood, probable.

The Corps of Engineers on the other hand, maintains it can hold the Mississippi in its present course into the foreseeable future. When Major General William E. Read, current president of the MRC, was asked at a Senate Hearing whether the Corps could maintain the current situation at Old River, he replied:

> I believe that our judgement is clear on that, that that is in the affirmative. We believe that with the rehabilitation work that has taken place on the low sill structure and the overbank structure and it will be completed by this next summer, and with the introduction of the auxiliary structure which we now see going under contract this summer and being completed in 1985, that that capability exists as far as we can see into the future.(1)

As General Read has stated, the Corps position is very clear on the matter. There is not much doubt that the Corps is preeminent in its field. As discussed in this document, the Corps and the MRC have been very successful in managing the river and, thus far, their record is virtually unblemished. But, in view of the mass of evidence which firmly establishes the possibility of diversion, isn't it time for a reassessment of the situation in the Lower Basin?

The Corps bulwarks in the vicinity of Old River are only minor obstacles preventing a major disaster. The damage done to the low sill structure during the 1973 flood could not be foreseen and was not a design deficiency. The possibility of a flood on the order of magnitude of the 1973 flood, or the even the project design flood, always exists. If control at Old River should be lost during this event, then the Kazmann scenario might become reality. The consequences would be disastrous.

The history of flood control on the River has always been crisis oriented. Always after a major flood, reassessments, restudies, reexaminations, and a variety of re-looks are made. But, can we afford a hindsighted examination with regard to the possibility of a change in course of the Mississippi?

In view of the facts presented in this report, it should be clear that the current situation cannot be maintained forever. A course change is ultimately inevitable. The Corps' position is that they can maintain the current situation into the "foreseeable" future. How long is this? During the next 50 or 100 years many investments can be written off and many people relocated.

This report concludes that:

- Congress should, with the approval of the President, establish an independent commission to study the problem of diversion.(2)
- The commission should be made up of the world's foremost professionals in river engineering, geology and water resources policy and planning.

- The commission should take into consideration the MRC's current policies regarding the problem and investigate other means of addressing the problem, such as slowing the current aggrading nature of the Mississippi below Old River. This could be accomplished by diverting more sediment into the Atchafalaya and/or increasing the efficiency of the Lower Mississippi, below Old River, by minor straightening, thus increasing slope.
- In addition to corrective measures, abandonment of the Old River Control System and possible alternate river courses should be investigated.
- The commission findings should not be allowed to get "lost" among the tons of other Congressionally commissioned studies. On the contrary, this commission's report should weigh heavily on the future directions that the Corps of Engineers, the Mississippi River Commission and most importantly, the Congress, takes!

CHAPTER 4

ENDNOTES

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