Upper Mississippi River Nine-Foot Channel Project, Locks and Dams 11 through 22
Upper Mississippi River
Dubuque
Dubuque County, Iowa
Saverton
Ralls County, Missouri

HAER No. IA-33

HAER
IOWA,
31-DUBU,
12-

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
Rocky Mountain Regional Office
National Park Service
U. S. Department of the Interior
P.O. Box 25287
Denver, Colorado 80225

HAER
IOWA
31-DU
12-

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The assistance provided by various individuals and organizations in the research, photographing, writing, and assembling of this documentation is very much appreciated. Many employees of the U. S. Army Corps of Engineers gave their time and knowledge. Mr. Charles R. Smith, Assistant Chief of the Rock Island Planning Division, took a particular interest in this project. Mr. Floyd Mansberger, Cultural Resource Specialist, Rock Island District Planning Division, deserves special thanks for the kindness and professional understanding of historic research he provided in his role as district liaison for the project. Mr. Kenneth Barr, Rock Island District Archeologist, also took time from his busy schedule to answer questions and provide assistance. Particular thanks are due to the Rock Island District lockmasters and personnel at Lock and Dam Complexes 11 through 22; their valuable hospitality, assistance and information contributed immeasurably to this project. Other Corps staff were also helpful. Dr. Paul K. Walker and Dr. Janet McDonnell of the Office of the Chief of Engineer's Office of History assisted with this project, as did Dr. Michael C. Robinson, historian for the Lower Mississippi Valley Division; Ms. Katharine A. Hayes, Acting Chief of the St. Louis District Support Service Branch; and Dr. John Anfinson, historian for the St. Paul District Environmental Division.

Many employees of the National Archives and Records Administration were also helpful. Special thanks go to Mr. Alan Perry, Ms. Rosemarie Wise, and Ms. Nancy Holsten of the Kansas City National Archives and Records Center; Ms. Gloria Grouzos of the St. Louis Civilian Records Center; Mr. Ken Shanks of the Chicago National Archives and Records Center; and Mr. Richard Boylan and Mr. William Wehman of the Washington National Archives and Records Center in Suitland, Maryland.

Ms. Loraine Adkins, Government Publications Reference Librarian at the State Historical Society of Wisconsin Library, went well beyond normal efforts to provide assistance, and this help is gratefully acknowledged. The staffs of the Curt F. Wendt Engineering Library and the Law Library at the University of Wisconsin-Madison were also both helpful and professional. Ms. Amy Johnson at the Clinton (Iowa) Public Library went out of her way to provide useful research assistance. Staff of the Washington Power Company were also most helpful, especially Rory Vincent, Journeyman Operator at the Long Lake Power Plant near Ford, Washington.

Employees of the Rocky Mountain Regional Office of the National Park Service were also directly and actively involved in this project. First, Mr. Keith Warner and then Ms. Carolyn Clark served ably as contracting officers. Mr. William Patrick O'Brien, historian in the Branch of National Preservation Programs of the Division of Cultural Resources, was the contracting officer's technical representative throughout the project. Ms. Suzanne Evans provided information on technical photographic matters.

In addition, Dr. Roald Tweet of the last two official histories of the Corps of Engineers' Rock Island District, directly provided counsel on research issues. While Dr. Leland R. Johnson, author of several Corps district histories and a number of historical monographs on Corps projects, provided indirect research assistance. After reviewing Mr. O'Brien's documentation on the Upper Mississippi River Nine-Foot Channel Project locks and dams in the St. Paul District, Dr. Johnson conducted some research in the National Archives in Washington, D. C., which he subsequently sent to Mr. O'Brien. Because it arrived too late for inclusion in his narrative, Mr. O'Brien kindly passed this information along for use in this documentation effort, where it proved particularly useful.

Peter A. Rathbun was the principal photographer for this project, in addition to serving as an investigator. He also edited the whole text, revising and condensing many portions. In addition to Peter Rathbun, Mary Yeater Rathbun, and David W. Vannoy, other Rathbun Associates employees, assisted in the production of this documentation. Carrie A. Gaberell, Brenda Johnson, Randall J. Massey, Kimberly R. Phillips, Karla J. Ryan, and Kent Underwood served as darkroom and photographer's assistants. Genia M. Davidson provided clerical support. All this assistance is gratefully acknowledged. Finally, a special thanks goes to the entire professional and support staff of Rathbun Associates Sandy Rock Research Center. Their support, encouragement, and assistance were invaluable, but their patience when the deadline pressures were most intense and the frustration levels highest, and their willingness to adjust their work schedules to accommodate this project are equally appreciated.

FOREWORD

The following Historic American Engineering Record (HAER) history documents the technological significance of Lock and Dam Systems 11 through 22 of the U. S. Army Corps of Engineers' 26-unit, Nine-Foot Channel Project on the Upper Mississippi River between St. Louis, Missouri, and Minneapolis, Minnesota, 1927-1940.

This report is divided into three principal sections. The first, Administrative History, deals with the decision to do the project, its form, and its administration. The second, History of Technology, traces the evolution of waterway improvement technology leading to the 1927-1940 Upper Mississippi River Nine-Foot Channel structures and equipment. This section also examines the technological significance of the twelve lock and dam complexes in terms of the project and within the national context. The third section, Individual Inventories and Photograph Indexes, presented in outline format, describes the twelve individual lock and dam complexes, their construction histories including construction methods, unique design considerations, and the working technology of each system. This section also includes the original configuration and subsequent changes. Notes for all three sections are numbered consecutively and included as a group at the end of the section. A bibliography follows the notes and precedes the third section.

Illustrations are not included with this text. Rather, reference is made within the text to the original architectural/engineering drawings for complexes 11-22 and to the HAER numbers for the copy photographs of those drawings, where appropriate. These drawings are the most important source of documentary information on the technological aspects of this project. The Rock Island District assigned an individual alphabetic-numeric code number to each original drawing when it was completed. The drawings are referred to by those numbers. Copy photographs of select drawings are part of the HAER documentation, of which this written documentation is but one part. Twelve photodata sets, organized by lock and dam complex, constitute the other major portion of the documentation. These data sets complement this written documentation. The Index to Photographs for the relevant data set accompanies each individual complex outline in the third section of this report.

INTRODUCTION

This is one of three sequential Historic American Engineering Record (HAER) documentation projects documenting the U. S. Army Corps of Engineers' 1927-1940 Upper Mississippi River Nine-Foot Channel Project. Each documents the project lock and dam complexes in one Corps of Engineers district; collectively, they document the entire system.

Beginning in August 1986, William Patrick O'Brien, historian, with the Rocky Mountain Regional Office of the National Park Service, and Clayton B. Fraser, photographer with Fraserdesign, produced "Historic American Engineering Record Documentation, Lock and Dam Systems 3-10, Upper Mississippi River 9-Foot Channel Project, U.S. Army Corps of Engineers, St. Paul District." That project not only served as a model for this second documentation in the series, but also provided a base of information and interpretation upon which the researchers and author could draw. This project documents the Lock and Dam Systems 11 through 22, presently located in the Rock Island District. The third study, not yet begun, will cover Lock and Dam Systems 24-27 in the St. Louis District. There is no lock and dam system 23.

In July 1987, the Rocky Mountain Regional Office hired Rathbun Associates to document the twelve lock and dam systems located in the U.S. Army Corps of Engineers District, Rock Island. The assignment included both research on the administrative and technological significance of the complexes and photographic documentation. Rathbun Associates conducted research and took photographs during the late summer and fall of 1987.

The Corps of Engineers' 1927-1940 documentation of the Upper Mississippi River Nine-Foot Channel Project planning and construction process, much of which has been preserved, reached massive proportions with literally thousands of maps, drawings, letters, memorandum, photographs, and feet of motion picture film produced in the course of ten years' work. Records held by various National Archives depositories contain an overwhelming number of files and boxes; the Chicago National Archives and Records Center collection of that portion of Entry 81 of Record Group 77 which pertains to complexes 11-22 contains about 700 boxes which National Archives staff estimate hold approximately 720,000 individual sheets, while the collection of those portions of Entries 111 and 112 of Record Group 77 located at the Washington National Archives and Records Center in Suitland, Maryland, include another 73 boxes, which National Archives staff estimate to encompass over 58,000 sheets. Materials contained in these collections range from handwritten engineering computations and mathematical equations on various aspects of lock and dam machinery and operations through letters and memos from the construction period to completion reports on the construction projects.

In addition to the written and drawn documentation, the Rock Island District photographically documented project construction in both high-quality 8x10 format, black and white still photographs and 16mm black and white, silent movies. The district has approximately 18,000 8x10 prints of photographs of Nine-Foot Channel construction taken between 1931 and 1940 (plus nearly 3,000 prints of photographs of the construction and operation of Lock 19 between 1900 and 1960). The negatives from which these prints were produced have been destroyed, and the prints pasted onto paper pages in bound volumes. The majority of the volumes are stored in a warehouse in the Rock Island Arsenal, Rock Island, Illinois. The rest are in a vault in the basement of the Clock Tower Building, the main Corps headquarters building in Rock Island. Selections from this photograph collection were copied as part of the present documentation project and are included in the eleven photodata sets discussed above. They are a valuable supplement to the drawings in terms of showing the actual physical objects built, some elements of which are not visible in the finished products.

The motion pictures taken during the construction process provide valuable information on the construction process. The construction technologies used in this project are particularly well-documented in the 83 surviving reels of 16mm motion picture film taken between 1931 and 1940. The Rock Island District has stored these with the still photographs in a Rock Island Arsenal warehouse. The reels vary in length from 20 minutes to over an hour and are in generally good condition. No samples from this set of documentary materials are included in the photodata sets. However, future researchers should not overlook this very valuable source of information.

Due to the volume of records and materials, Rathbun Associates' research methodology involved inspection of selected holdings of National Archives Record Group 77 at the Chicago National Archives and Records Center and at the Washington National Archives and Record Center. The holdings of the Corps of Engineers' Rock Island District office and the technical resource holdings at the Curt F. Wendt Engineering Library at the University of Wisconsin-Madison, and the State Historical Society of Wisconsin were also consulted. During 1984, Rathbun Associates examined the unaccessioned records at the twelve individual lock and dam complexes. Its researchers also consulted holdings of all local libraries and historical societies in close proximity to the twelve complexes and the state historical societies and state historic preservation offices in Illinois, Iowa, and Missouri. They also conducted two to three-hour interviews with eleven of the lockmasters of the complexes, four retired lockmasters, and other lock personnel. Rathbun Associates used the detailed field notes from its 1984 research as a resource for this 1988 report.

The 1987 investigation involved extensive preliminary research in the two-level inventories for collections (where such inventories existed), development of a detailed systematic research design, and field implementation of that plan at the repositories insofar as possible within time and budgetary constraints. In some instances, however, such as that involving the motion pictures, lack of inventories, storage conditions, and the nature of the resource necessitated the use of random sampling techniques. Some collections likely to yield further relevant information, such as Record Group 77 Entries 608, 609, and 610 (collectively total 5 linear feet) at the National Archives in Washington, D.C., and Entry 107 (132 linear feet) at the Washington National Records Center in Suitland, Maryland, were not consulted as a result of time and budgetary constraints. References librarians and archivists at botb the Kansas City National Archives and Records Center and the St. Louis Civilian Records Center informed researchers that it was unlikely that those collections would yield enough relevant information to merit a special trip for research on this project alone. However, future researchers sbould not overlook these resources, if tbey are visiting the repositories for other reasons.

In the fall of 1987, Mr. O'Brien completed the first draft of bis study of Lock and Dam Systems 3-10. Using that work as a model, the materials generated in this research process began being distilled and synthesized into the following history and inventory. Rathbun Associates hopes that it will provide a base on which other historians may build just as Rathbun Associates have built on tbe substantive work done by their predecessors and contemporary colleagues.

DOCUMENTATION OF LOCK AND DAM SYSTEMS 3-10

Mr. O'Brien divided his report into three parts: administrative history, technological history, and individual site inventories. The administrative section includes information that applies to Locks and Dams 11 through 22. These discussions include 1927-1934 public and private opposition to the whole project; Major Charles L. Hall's feasibility studies within that context; political and economic considerations tbat overcame the resistance; and presidential support for the project. The administration, staffing, and operation of the hydraulic laboratory, St. Paul District sub-office, which built and tested all the hydraulic models for all of the locks and dams; the safety programs; and the documentation are all important to the project as a whole, not just the St. Paul District. However, district administrative adjustments apply only to the St. Paul District. Individual lock and dam construction details, while concurrent with Rock Island construction, are site specific. Mr O'Brien concluded this section by identifying project results: improved waste water treatment for valley communities, additional recreational opportunities, and, most notably, a dramatic increase in commercial tonnage carried on the river.

The technological history stresses how project research led to the development of elliptical Tainter gates which made roller/Tainter gate combinations for movable dams obsolete. However, the obsolete type is identified as the most notable feature to evolve from tbe project. Recent German engineering technology provided important features of the project, but Corps designers made many innovations and modifications, particularly in gate designs. Mr. O'Brien detailed various tests and experiments which provided valuable research and formed the basis for improvements and innovations. He identified new technologies resulting from the project's construction. Finally, Mr. O'Brien dealt with the evolution of the architectural components of the project and established basic pier house typologies. Using construction start-up dates as a base, he identified a basic design change in 1936.

ADMINISTRATIVE HISTORY

The U. S. Army Corps of Engineers' Nine-Foot Channel Project represents the culmination of a 100-year effort to improve the navigability of the Upper Mississippi River between the mouth of the Missouri River and Minneapolis, Minnesota. This specific project arose as a response to the farm crisis of the 1920s. Proponents of the New Deal adopted the project and speeded its construction as a means of providing public employment during the Great Depression. By the 1940s, the completed project had converted over 650 miles of free flowing river into a series of interconnected reservoirs which ensured enough water for fully-loaded modern boats and barges to navigate the system. Although a significant environmental alteration of river, the project brought economic benefits and new recreational opportunities for the entire region.

In 1920, farmers remained the country's single largest social and economic group. Their spokesmen constituted the most powerful and consistently successful group in Congress during the entire decade from 1919 to 1929. A significant percentage of America's farmers lived in the Upper Mississippi River drainage. From its source in northern Minnesota, the Upper Mississippi flows south about 1,215 miles, forming all or part of the boundaries of five states: Minnesota, Wisconsin, Iowa, Illinois, and Missouri. The river drains about 171,500 square miles. In the 1920s, the economic condition of this vast domain--a region as large as the nations of Germany, France, Italy, and Great Britain combined--depended primarily upon the prices obtained for food commodities and the consequent buying power of its farmers.[1]

Between July 1920 and March 1922, agricultural prices plummeted throughout the nation. The revival of European agriculture and the development of new agricultural exporters, such as Argentina, Australia, and India, cut domestic and foreign demand for American farm products as American per acre yields increased. In addition to the dramatic drop in farm prices caused by over-production, farmers' expenses mounted.

Although all the nation's farmers suffered during this crisis, the farmers of the Upper Mississippi Valley faired worse than most. So long as full-season, commercial, through navigation remained impossible on the Upper Mississippi, the valley remained effectively landlocked. After World War I, reduced intercoastal shipping rates on both land and sea reflected the Corps of Engineers' 1914 completion of the Panama Canal. Simultaneously, rail rates in the interior of the country increased. High rail rates effectively reduced the already-low commodity prices for this area's farmers to less than those received by farmers in the rest of the country, while greatly increasing the cost of needed products.

Under the influence of their Secretary of Commerce, Herbert Hoover, both U.S. Presidents Warren G. Harding and Calvin Coolidge opposed direct aid to agarian interests from 1921 to 1929. They believed a healthy economy needed free competition and felt direct aid to agriculture would eliminate such competition among farmers. Congress attempted to aid farmers indirectly by regulating railroad rates, grain exchanges, commission merchants, and stockyards; exempting farm cooperatives from the anti-trust laws; easing agricultural borrowing; and approaching waterway improvement more systematically. Of these, Hoover most strongly supported waterway improvement.[2]

During the 1920s, most American waterway improvement proponents focused on the Mississippi system. Three major tributaries--the Upper Mississippi, the Ohio, and the Missouri--form the Mississippi River.

In its natural form, the Upper Mississippi was a shallow, relatively gentle river filled with shifting sand bars. It had low banks, but was never subject to floods as deep, extensive, or frequent as those on the Ohio or on the main trunk of the Mississippi. The Upper Mississippi was obstructed by the Des Moines Rapids and the Rock Island Rapids. The first set, extended 11.25 miles upstream from the Des Moines River at Keokuk, Iowa, consisted of a strata of hard rock. It was extremely difficult, if not impossible, to navigate the long stretch of shoal during low water stages. There was no channel. The Rock Island Rapids, extended 13.75 miles from the foot of Rock Island, Illinois', Arsenal Island to Le Claire, Iowa. It differed from the Des Moines Rapids. Fingers or chains of rock stretched out from each shore with deep pools or channels of water twisting from one shore to the other. Strong currents flowed around the chains and across the channels and pools.

These rapids began to impede navigation in the 1820s, when steamboats began to ply the Upper Mississippi. In 1829, the U. S. Army Corps of Engineers conducted a study of the river and concluded that it would be useable by steamboats eight months a year if channels were blasted through the Des Moines and Rock Island Rapids. In 1837, Congress authorized the Corps to study the Upper Mississippi further and develop specific improvement plans. Lieutenant Robert E. Lee and Second Lieutenant Montgomery Meigs, acting as Lee's assistant, carried out this charge. In 1838 and 1839, Lee and a new assistant, Horace Bliss, supervised underwater blasting to create a 200 feet wide and 5 feet deep channel, the length of the Des Moines Rapids. The Corps continued to work sporadically throughout the 1840s and 1850s. In 1954, the Corps began deepening, widening, and straightening the main channel of the Rock Island Rapids. Although neither project was completed, the Corps ceased work on both in 1856 and did not resume work on the Upper Mississippi River until after the Civil War.[3]

In 1866, renewed federal attention to waterway improvements resulted in a $400,000 appropriation for a Minneapolis to St. Louis four-foot channel. The Des Moines Canal Bullnose at Lock and Dam Complex 19 is a remnant of this project. It was a downstream end of the last of the three 1870-1874 locks, serving the Des Moines Rapids lateral canal built between 1867 and 1870 to allow circumnavigation of these rapids.[4]

In 1878, before the four-foot channel was complete, Congress authorized the Corps to work towards a 4-1/2-foot channel in the Upper Mississippi River from St. Louis to St. Paul. By the early twentieth century, waterway transport proponents saw this goal as inadequate to facilitate river traffic. In 1907, Congress authorized the Corps to construct a six-foot channel in the Upper Mississippi from the mouth of the Missouri River to Minneapolis. The auxiliary lock at Lock and Dam Complex 14 is a remnant of this project. The Corps built the Le Claire lock between 1921 and 1924. It, along with a lateral canal allowed river traffic to bypass the Le Claire section of the Rock Island Rapids.[5]

By this time, waterway improvement proponents had been arguing for over 50 years that a viable water route from the Upper Midwest to the Gulf would reduce rail rates and provide additional cargo capacity. The Upper Mississippi River presented an opportunity to create a modern water link between the Upper Midwest and New Orleans, a port offering excellent access to the Central and South american export market. Many leading international trade theorists of the 1920s saw the great undeveloped continent to the south much as their counterparts of the 1980s viewed the Pacific rim, as the major hope for the future of the American export business.[6]

Congress had mandated a 1922 deadline for completion of the Upper Mississippi six-foot channel. However, the 15-year-old project remained less than half complete at the end of that year. Pressure to force the Corps to complete the project began to mount. In 1924, Congress responded to this pressure. By then, the concept of transforming America's interior waterways into consolidated, interconnected transportation systems as an approach to federal economic development or assistance was popular again. The first session of the 68th Congress proved particularly momentous for all major waterways of the Midwest. Representatives from 16 or 17 states, in an ad hoc commission headed by Herbert Hoover, advocated the creation of a St. Lawrence River-based waterway the Great Lakes and the Atlantic Ocean. William E. Hull of Illinois introduced a bill to create a nine-foot channel from the Great Lakes to the Gulf of Mexico by way of the Chicago, Illinois, and Mississippi rivers. Most importantly for this study, Cleveland A. Newton of Missouri introduced a bill calling for the completion within five years of all the already-authorized improvement projects for the Mississippi system's major northern components.[7]

The Newton bill hoped to ensure a dependable, adequately deep channel for modern navigation north of Cairo, Illinois. Specifically, it called for the Corps of Engineers to complete by 1929 four previously-authorized but as yet incomplete projects: (1) a nine-foot channel in the Ohio, from Pittsburgh to Cairo, as authorized in 1910; (2) a six-foot Missouri River channel from Kansas City to the Upper Mississippi, as also authorized in 1910; (3) a nine-foot channel from Csiro to the Illinois River, an amalgamation and updating of an eight-foot project and a six-foot project, both also authorized in 1910; and (4) a six-foot channel in the Upper Mississippi River from the Missouri River to Minneapolis, a project which Congress had authorized even earlier, in 1907.[8]

When this bill passed, the Corps was preoccupied by a struggle to insure its continued existence. This struggle had begun about 1915 as an internal Army contest for control of military construction. By the 1920s, the recently matured, private, engineering industry had begun lobbying against retention of engineering responsibilities by Army engineering units. The non-military federal engineers in the Department of the Interior's Reclamation Service and the Department of Agriculture's Forest Service supported these moves. During the early 1920s, Herbert Hoover, whose first professional engineering jobs were with the Department of the Interior's Geological Service, spearheaded the drive for a civilian-engineer-dominated national public works department. As waterway improvement became increasingly important, the pressure to take civil works functions away from the Corps increased. Throughout the 1920s, the Corps was in danger of losing its civil works function to a civilian department and its military construction functions to another branch of the military.[9]

The Newton bill and the subsequent Rivers and Harbors Act of 1925 reminded an embattled, understaffed, and overcommitted Corps that the political decision had been made sometime before to create a dependable six-foot channel in the Upper Mississippi River. These also served notice that, in light of the farm crisis, Congress had renewed its commitment to this project and would require the Corps to follow through.

While calling for increased channel depths between Cairo and the Illinois River, Congressman Newton did not raise the issue of increasing the Upper Mississippi River channel to nine feet. His concern with the Upper Mississippi project centered on the fact that the project was only 53% done, despite 17 years of work on it. Newton did not accept the traditional argument that every bit of the completed work made the river easier to navigate. He did not see the improvement as useful until it was entirely completed. The relative paucity of long distAnce shipping on the river supported his position.[10]

The concept of the Upper Mississippi nine-foot channel waa, however, introduced into the official records of the discussion of the improvement of the river during the hearings on the Newton bill. Halleck W. Seaman, a railroad magnate from Clinton, Iowa, testified that he "did not know what is the matter with my friend Cleveland Newton that he did not make it 9 feet, as it is down below." The chairman of the House Rivers and Harbors Committee, S. Wallace Dempsey of New York, pointed out that a study would then be required which would further delay rather than accelerate progress. Seaman then withdrew his suggestion, explaining that a formal change was unnecessary. He was sure that the Corps would create a nine-foot channel while creating the six-foot one, whether it wanted or was authorized to or not.[11]

Seaman and other Upper Mississippi River boosters wanted the river the same depth as the main trunk of the Mississippi system to allow shippers to use the same equipment above as below St. Louis. Barge fleet operators ascending the Upper Mississippi either had to use smaller boats or unload and transfer cargos in the Cairo/St. Louis vicinity before proceeding upstream. Either action involved time and money. At St. Louis, many reloaded their cargos onto trains, which could go to any location landlocked or not, for the remainder of their northward journey rather than reload onto smaller craft.

Even before the March 1925, River and Harbors Act, which included Newton's demands, the Corps began giving serious technical consideration to a dependable six-foot channel on the entire Upper Missiasippi. In February 1925, the new Chief of Engineers, Major General Harry Taylor, questioned how best to secure such a channel between Minneapolis/St. Paul and the Chippewa River. He asked the River and Harbors Committee to authorize a re-examination and survey of this section of the river with a view towarda construction of a slack-water navigation system. The Rivers and Harbors Act of 1925 included this authorization. The St. Paul District conducted this study in 1925 and 1926 on funds advanced by the Upper Mississippi River Barge Lines Company. In December 1926, the Corps recommended the construction of a lock and dam at Hastings, Minnesota.[12]

Once the Corps admitted the need for a lock and dam there to achieve a six-foot channel, it appeared the engineers would have to admit the necessity elsewhere on the Upper Mississippi. At times, there was as little as 4.3 feet of water in the 2.5 mile section of channel between the Moline Lock and the foot of the Rock Island Rapida. To solve this problem, the Corps either had to build a lock and dam and blast a very deep, wide, and expensive channel through 2.5 miles of rock. The prospect of several new lock and dam complexes at various intervals along the 658-mile navigation channel encouraged consideration of a nine-foot channel. If a series of locks and dams were to be constructed, why not consider building a few more and making them a little bigger in order to create a aignificantly more useful waterway. On April 26, 1926, in a hearing before the House Committee on Rivers and Harbors, Congressmen William W. Chalmers of Ohio and Chairman Dempsey pressed Chief of Engineers Taylor hard on the implication of a lock and dam at Hastings. They forced General Taylor to admit that it would be possible to build enough locks and dams to give the Upper Mississippi a nine-foot channel. General Taylor refused, however, to say if this could be done at a cost commensurate with the resultant increase in freight. In January 1927, Congress authorized the Corps to build a lock and dam at Hastings and to "examine the Upper Mississippi River with a view to securing a channel depth of nine feet at low water with suitable widths.[13]

When the Corps received this authorization, Major Charles L. Hall was in the second year of a probably three-year tour in the Chief of Engineers' office. Major Hall, a 1908 West Point graduate, was just turning 40 and had served in the Corps for 19 years. He was an experienced officer with significant exposure to the political realities of military decision-making under Major Generals John J. Pershing, Lansing H. Beach, and John L. Hines. Hall was with the Punitive Expedition into Mexico and on the General Staff, First Army, American Expeditionary Forces. In 1920, Hall was assigned to the Office of the Chief of Engineers. From 1924 to 1926, be was a member of the War Department General Staff. In 1926, he returned to the Chief of Engineers' office. In August 1927, he became Rock Island District Engineer and assumed responsibility for conducting the initial Upper Mississippi River Nine-Foot Channel feasibility study. Presumably, the high command, including the 1926-1929 Chief of Engineers Lieutenant General Edwin Jadwin, was aware of the kind of approach Hall would take to his study, the way his mind worked on such problems, and the probable results of a study conducted by Hall when they cut short his tour of duty in Washington and gave him this assignment.[14]

As judged by his February 1929 report, Hall, just as Chief of Engineers Taylor reported in 1926, approached the economic issues associated with the project from a much more narrow perspective than contemporary politicians. Hall argued that the existing government-subsidized, limited barge traffic did not indicate that a viable barge industry would develop even if a nine-foot channel were created. Thus, he judged the project was not economically advisable. Moreover, he also recognized that tbe only feasible way to provide a nine-foot channel was through a series of locks and dams transforming the river from a free-flowing stream into a series of interconnected lakes. Hall echoed the concerns of midwestern conservationists when he expressed fear that these slack-water pools would create vast swamps of stagnant and polluted water. He also contended that the project would drastically change the wildlife of the region.[15]

Before Hall's report was complete, however, political events had moved a long way. By the time Herbert Hoover (a national waterway system advocate) was elected president in November 1928, it was clear the project would be built. There would be a nine-foot channel in the Upper Mississippi River. The Corps' 1927 engineering decision to use locks and dams to create a six-foot channel, had lead Congress and tbe President (both still responding to the continuing farm crisis) to make commitments to create the nine-foot channel. Politicians interpreted the same facts Hall was studying differently. The limited navigation for its economic recovery and growth. The state of the river precluded such navigation. Increased navigation would follow removal of this obstacle and would vitalize the region, thus providing the economic justification for the project. The politicians left it to the engineers to deal with stagnant and polluted water and to keep the fish and birds alive. They saw these as merely technical problems which could be overcome. By the time, Hall made his report, some important elements of the Corps had either decided in favor of a nine-foot channel or come to see it as inevitable since the Corps designed the Hastings Lock and Dam to accommodate that depth.[16]

Therefore, it is not surprising that although not "convinced of the advisability of the improvement," Hall recommended a survey to determine the cost of providing a dependable nine-foot channel, 200 feet wide in the straight reaches and at least 300 feet wide at bends, between the mouth of the Illinois River and Minneapolis. It is significant that the Special Board of Engineers that conducted this survey beginning on May 29, 1929, included from the very start Lieutenant Colonel George R. Spaulding. As Louisville District Engineer, Spaulding was familiar with the Ohio River project which created a nine-foot channel on that river through locks and dams. That project was coming to a close just then. The Corps completed the last lock and dam in the Ohio River project in August 1929. Spaulding could have seen the potential for its very experienced and capable engineering team to be used on a similar project on the Upper Mississippi River project. Besides Spaulding and Hall, the initial board included Lieutenant Colonel Wildurr Willing, St. Paul District Engineer; Major John Gotwels, St. Louis District Engineer; and Brigadier General Thomas H. Jackson, Western District Engineer and Hall, Willing and Gotwel's immediate supervisor.[17]

In the fall of 1929, before the study team completed its report, the Corps reorganized and began to re-structure for a massive Upper Mississippi River project. On August 7, 1929, Brigadier General Herbert Deakyne became Acting Chief of Engineers, replacing General Jadwin. A little over a month later, on September 9, 1929, General Deakyne removed General Jackson from the Special Board of Engineers conducting the nine-foot channel study. Less than a month later, on October 1, 1929, Major General Lytle Brown was appointed Chief of Engineers. Nine days after that, on October 10, 1929, the Corps created a new Upper Mississippi Valley Division (U.M.V.D.) to supervise the St. Louis, Rock Island, and St. Paul District, which it removed from the Western Division. Colonel Spaulding was named the new Division Engineer and William H. McAlpine, who had been his principal civilian assistant in Louisville, became his head engineer in St. Louis.[18]

Although ultimate leadership responsibility in the U. S. Army Corps of Engineers' civil works and civilian construction units rests with their military officers, these units were largely civilian organizations. The normal, stabilized tour of duty for Corps military officers was three years. Consequently, a district or a division's top management changes frequently, and is generally composed of men from outside the local area. A district or division's long-term civilian employees save it from the consequences of a loss of continuity and lack of site specific experience. It has always been the rule rather than the exception for key employees to remain with the Corps, if not a specific district or division, for most of their careers. William McAlpine, an 1896 Massachusetts Institute of Technology graduate, had joined the Corps in 1899 and served as principal civilian assistant to all the Louisville District Engineers since 1912. Thus, he had provided technical leadership continuity on the Ohio River Project for 17 of its 19 years.[19]

On October 15, 1929, Colonel Spaulding removed Major Hall from the Special Board of Engineers planning the Upper Mississippi River Nine-Foot Channel Project, but retained him in his position as Rock Island District Engineer until December 13, 1930, by which time he had served a full three-year tour of duty. McAlpine assumed Hall's seat on the special board. Just eight days after Spaulding made this shift, On October 23, 1929, President Hoover gave a speech in Louisville, Kentucky, where much of the Corps' Ohio River team was headquartered, announcing that the Federal Government would complete the entire coordinated Mississippi River system (presumably including the Upper Mississippi) within five years. By November 30, 1929, Spaulding and McAlpine had hand-picked and begun to transfer in a divisional design team from their old Ohio River team. Both Lenvik Ylvisaker and Edwin E. Abbot were in this group. Ylvisaker, a foreigner who like McAlpine had a degree from the Massachusetts of Technology, had been McAlpine's right hand man in Louisville. Abbot was Ylvisaker's assistant.[20]

On December 29, 1929, General Brown departed from ordinary practice by making an advance report on the as-yet-incomplete survey. He later claimed that he only did this "on the urgent request of interested parties....[and because the project] was very important and being urged at that time by many people, beside the people on the Mississippi River." But by December 1929, the President, the Secretary of War, and General Brown had all personally assured congressmen that it was their intention to ultimately build a nine-foot channel in the Upper Mississippi River. The official advance report, published on February 15, 1930, as House Document 290, affirmed that the Special Board of the Engineers, the Corps National Board of Engineers for Rivers and Harbors (BERH), and the Chief of Engineers all agreed that the six-foot channel was "self-limiting" and not adequate to build up a commerce which would justify the necessary expenditures for its completion and maintenance. It also recommended that the six-foot project authorization be modified at once, so all further permanent work could be built in such a way that it could be enlarged in accord with a nine-foot channel project, should such a project ever be authorized. The report spurred Congress to go even further than this. After a brief two-day hearing in March 1930, Congress authorized the Upper Mississippi River nine-foot channel, described in House Document 290. This was in the Rivers and Harbors Act of July 3, 1930, and preceded the final survey report and project plan by over a year and a half, a phenomena virtually unheard of for Corps waterway projects.[21]

However, unusual as this was, the Corps was already prepared to begin active project work. The new Upper Mississippi Valley Division (U.M.V.D.) had been in place for nearly nine months. The members of the new divisional design team had been in St. Louis for about six months, applying their ideas and experience to the task of creating a nine-foot channel in the Upper Mississippi River. While retaining most project planning responsibilities at the division level, Colonel Spaulding had already decided to delegate most project implementation responsibilities to the districts. He divided the project into three geographically-defined administrative units tied to the Corps district which included that reach of the river. He thus placed the stretch of the project between St. Louis and Clarksville, Missouri, under the St. Louis District; that between Clarksville and the Wisconsin River under the Rock Island District; and that from the Wisconsin River to Minneapolis under the St. Paul District. Under this arrangement, the Rock Island District included Lock and Dam 10 at Guttenberg, Iowa. The U.M.V.D. transferred this complex to the St. Paul District in 1936; it is not covered in this documentation except in the discussion of district work load between 1929 and 1936. The Rock Island District has had continuous responsibilities at all the other complexes assigned to it in 1929.[22]

From that point on, the three districts were responsible for some of the less critical design work, estimating and contract administration, direct supervision of construction, and operation of the sites within their respective project administrative units. To do these things, the districts not only needed to expand their technical engineering expertise, and increase their contract administration sections, but also add resident engineers for each complex under simultaneous construction within their jurisdiction, plus the necessary on-site supervisory, administrative, and inspection staffs for those engineers. Finally, all three of the districts needed to establish operations divisions to handle their continuing responsibilities at the complexes as they were placed in service.

Major Hall began this expansion process in the Rock Island District, but it escalated under his successor, Major Glen E. Edgerton. Edgerton, a classmate of Hall's at West Point, served as District Engineer from December 14, 1930, until August 31, 1933. Major Edgerton, as well as Hall, had served under General Pershing in the Mexican expedition and later in the War Department. His 1923-1929 assignments as Assistant and then Chief Engineer of the Federal Power Commission, as well as earlier 1908-1916 experience with the Isthmanian Canal Commission during the construction of the Panama Canal, served him well in transforming the Rock Island District into a complex modern organization.[23]

The first job Colonel Spaulding assigned to the District was a design task. Lock and Dam 15 was the first nine-foot channel project complex designed and built. Sited in the heart of the quad-cities of Moline and Rock Island, Illinois, and Davenport and Bettendorf, Iowa, extensive mitigation work was required to protect existing facilities in this urban area. The U.M.V.D. retained responsibility for the design of the locks, dam, and power house--the most critical components of the complex. Lenvik Ylvisaker signed the contract drawings for the locks in January 1931, and for the dam and power house in July 1931. However, Colonel Spaulding delegated the design of the seawall, levees, intercepting sewers, and extension of the intake pipe to the Rock Island District. The district designed these remedial works during the first half of 1931. The Corps avoided such costly remedial measures in future complexes by locating them upstream from major urban areas.[24]

To design these structures, the district did not need a greatly expanded engineering staff. Since 1920, Richard A. Monroe, serving as Principal Civilian Assistant to the District Engineer, had provided technical engineering leadership continuity in the Rock Island District. By 1931, this 64-year-old structural engineer had alreAdy served the district for 37 years. On November 1, 1929, shortly after the U.M.V.D. had been created, Monroe was promoted to the newly-created post of Senior Engineer. In April 1930, Herbert G. McCormick, a Virginia Polytechnic Institute graduate, transferred into the Rock Island District after more than 20 years service with the Corps on the Ohio and Lower Mississippi rivers. At Ohio River Dams No. 45 and 46, where he had served as Assistant Engineer, McCormick had gained national recognition for his use of a plan for placing concrete through chutes from a movable concrete mixer mounted on rails. Once McCormick transferred into the Rock Island District, he did more of the engineering design work for the Nine-Foot Project, while Monroe, who remained head civilian engineer in the district until his retirement in 1937, concentrated on operational issues and problems for which his more general background made him more suited.[25]

In 1931, McCormick not only designed the remedisl works at Lock and Dam 15, but, using Lenvik Ylvisaker's January 1931, contract drawings for the locks at complex 15 as a prototype, he also did the contract drawings for Lock 20 and its incomplete adjoining auxiliary lock.[26]

However, even before its first plans were complete, the district had to assume contract administration duties. As soon as Engineer Ylvisaker completed the contract drawings for the two locks at complex 15 in January 1931, the Rock Island District began soliciting and evaluating bids. By March 25, 1931, the district had selected its first general contractor, Merrit-Chapman and Whitney Corporation of Duluth, Minnesota. On april 7, 1931, the Rock Island District entered into a contract with this firm to construct the locks at complex 15. The existing district contract administration staff handled this work.[27]

However, construction supervision required changes. John H. Peil transferred from the Louisville District and work on the construction of the Ohio River Project to become, just seven years after his graduation as a civil engineer, resident engineer in charge of the construction of Lock and Dam 15. On April 12, 1931, Peil and his Lock 15 field office staff moved into newly-renovated facilities in an abandoned storehouse on Arsenal Island. Just a few hundred feet from the construction site, this storehouse was known locally as the Clock Tower Building. Peil's facilities included two offices, a drafting room, a concrete laboratory, two instrument and miscellaneous storage rooms, and a lavatory. The field headquarters continued to grow as the project got underway.[28]

Although work continued on the construction of Lock and Dam 15 throughout 1931 and early 1932, the district let no other new construction contracts and design work at both the U.M.V.D. office in St. Louis and in district office in Rock Island slowed down. By late 1931, the Special Board of Engineers and the U.M.V.D. staff had completed the survey begun in May 1929, and prepared a detailed site-by-site project plan published in January 1932, as House Document 137. However, neither the St. Louis or Rock Island office completed contract drawings for any major structures in the Rock Island District in 1932. Lack of funds accounted for part of this slowdown. The July 1930 act authorizing the project had not appropriated enough funds to complete the project. Simultaneously, a number of railroad companies, seeing both a long range threat to their freight transport business from increased river commerce and an immediate menace to their riverside properties, began working together to fight the project. This brought things to a virtual halt for several months. Then, the Depression, national politics, the railroads, and conservationists opposed to the project called the project into question. Work only resumed in earnest during the second half of 1933 after some major changes in approach.

Beginning in 1931, the railroads used the property damage they could anticipate suffering as a basis for legal action. The pool expected to form behind Lock and Dam 15 did not threaten railroad property. The remedial work in the quad-cities and the un-urbanized and un-industrial nature of the riverside upstream of these prevented this. However, both railroads and Corps expected the St. Paul District Lock and Dam 4 pool to damage railroad property. This was the only other project complex with completed contract drawings in 1931. That year, the Chicago, Burlington, and Quincy Railroad (CB&Q) filed suit against the government. In their arguments before the U. S. District Court, the CB&Q's attorneys did not ask for a financial settlement or mitigation of damages, rather they asked that the government be barred from building Lock and Dam 4, pointing out that in 1930 Congress had only authorized the Corps to build the system described in House Document 290. The Corps' 1931 plans were quite different; they included non-navigable rather than navigable dams. The railroad's attorneys conceded and the court agreed in early 1932 that this change constituted a radical difference in nature and kind. The court enjoined the Corps from building Lock and Dam 4. It was clear that if the survey report and plans published in House Document 137 were followed, the railroads could get similar injunctions at most, if not all, of the other proposed lock and dam complexes in the system. The Corps needed an amendment to its 1930 project authorization to preclude the railroads from pursuing this strategy and to legalize the structures under construction and the overall plan contained in House Document 137.[29]

Congress and President Hoover acted quickly with a joint resolution signed into law on February 24, 1932. This legislation gave the Corps the right, at its professional discretion and without additional approval, to make changes in the type and location of the lock and dam systems it had recommended in its 1929 report. By March 4, 1932, the Corps was using this amended authorization to get the Lock and dam 4 injunction lifted and the project underway again.[30]

However, this restart was slow due to the lack of funds and, in the Rock Island District, the engineers, during hiatus, discovered problems in the complex locations specified in House Document 137. It was not until September 1932 that the Emergency Relief Appropriation gave a new infusion of funds. Using these, the District contracted the construction of Lock 20 in November 1932, the same month in which Franklin Roosevelt resoundingly beat Herbert Hoover, the project's most visible supporter, at the polls. Peil assumed, in addition to his responsibilities at Lock and Dam 15, responsibility for construction of Lock and Dam 20 in November 1932. Peil remained resident engineer at Lock and Dam 20, when it was placed in operation on November 20, 1935. He only left in February 1936, when the complex was almost totally completed. He moved to the Rock Island District headquarters office to become head of the District's construction section, a position he held until August 1940, by which time all of the Rock Island District's Upper Mississippi River Nine-Foot Channel Project locks and dams (except for the new Lock 19) had been completed.[31]

Because the authors of House Document 137 were well aware that the July 1930 authorizing act had not appropriated sufficient funds to complete the project, they had developed a plan for the progressive implementation of the nine-foot channel as funds became available. They placed each project complex in one of four groups. The U.M.V.D. scheduled the complexes in the first group for immediate construction because these were necessary to facilitate existing commerce. The board judged the complexes in the second group slated for construction as necessary for a six-foot channel. The third and fourth group included the additional works eventually necessary to secure a dependable nine-foot channel. The U.M.V.D. scheduled these groups last.[32]

The immediate construction project group only included two Rock Island District complexes: Locks and Dams 15 and 20. The Rock Island Rapids from the Moline Lock to the food of the rapids was still extremely hazardous to navigate. Navigation was also hampered at the Moline and Le Claire locks because the lock were so small (80 feet by 300 and 320 feet, respectively). Operators had to break tows into "lockable" pieces and then reassemble them. Lock and Dam 15 would solve these problems up to the Le Claire Lock. House Document 137 declared that complex 20 was "of the highest priority because of the difficulty in maintaining suitable depths below the Keokuk Dam, where dredging in rock ia difficult and had already caused a lowering of the lower water plane."[33]

Even before House Document 137 was published, the Corps was aware the plan it contained would possibly need modification, particularly in the downstream sections of the project. Even the BEHR review pointed out that, during construction, continued study would provide many opportunities for improvement of all the components. House Document 137 recommended exact locations for complexes without the benefit of detailed site specific surveys. The engineers began to identify problems with sitings even before the December 1931 BERH review. The U.M.V.D had distributed initial plans or Lock and Dam 15 for public review and comment by December 1930. A variety of concerns were aired at a December 22, 1930, public meeting. Officials of the city of Rock Island expressed concern that if the complex was built in its proposed location, the city would have to draw its water from the pool behind the dam rather than from the river. This raised the specter of health problems. The officials also objected to the position of the lock and guidewall because it would "have the effect of putting Rock Island in the backyard of the Mississippi River." Moline officials were afraid their industrial areas would be flooded. Serious opposition came from U. S. Army Ordnance Colonel D. M. King, who expressed official concern that the proximity of the locks and dam to the government bridge from the Rock Island Arsenal to Iowa would significantly impact access to that installation, as the swing span would have to be open much of the time. The Corps took this national defense issue seriously.[34]

By April 1931, the Corps and political authorities were satisfied with the complex site, but with a modified orientation and the addition of the remedial works. The original plan called for the dam to be perpendicular to the lock walls. However, after preliminary borings, the Corps determined this siting to be inadequate from a structural point of view. The initial site also included insufficient spillway capacity. By moving the dam a little, to a site with better foundation conditions, the Corps placed the dam at a slightly wider spot on the river and thus increased the dam's spillway capacity. It further increaaed this capacity by locating the dam at a 16.5 degree angle to the normal channel. This allowed the engineers to stage the arrangement of the rollers to permit a 37.5 reduction in pier widths. These changes allowed the placement of an additional 100-foot gate. Unlike many other dam projects, land acquisition was an unfeasible approach to mitigation of the adverse impacts from Pool 15. The dam had to be located at the foot of the Rock Island Rapids. This put the complex in the heart of the quad-cities. It also adjoined the northwest tip of Arsenal Island, home of the U.S. Army's Rock Island Arsenal. The Corps decided to build a 2-mile-long reinforced concrete seawall with an integral, intercepting sewer and a 4.5-mile-long earthfill levee enclosing the continuation of this intercepting sewer along the Davenport and Bettendorf waterfronts as part of the project. It also decided to build a raised and strengthen a levee along a portion of Arsenal Island, an intercepting sewer for Arsenal Island, and an extension of the water supply intake pipe for the city of Rock Island. As discussed above, the Rock Island District designed these remedial works during the first half of 1931.[35]

The studies which resulted in these changes also included consideration of the House Document 137 location of Lock and Dam 14. One of the questions examined was whether Lock and Dam 14 could be moved upstream or eliminated. These options could be considered if the water depth above Locks and Dam 15 could be increased sufficiently to submerge the Le Claire section of the Rock Island Rapids. The studies, however, indicated that increasing the depth of Pool 15 this much was not practical.[36]

Complex 16 was the only complex in the District in the second group. There were narrow, tortuous, rock-bedded reaches in the channel between Lock and Dam 15 and Buffalo, Iowa. During low water, the channel became more restricted and more hazardous. Hence, work began on aspects of Lock and Dam 16 as soon as the respective sections of Locks and Dams 15 and 20 were complete. Thus, problems with its proposed siting were discovered early, in 1931 and 1932. The Special Board of engineers had located complex 16 near the downstream end of Muscatine, Iowa, about 2,500 feet below the Muscatine vehicular bridge. Construction of the lock and dam at this site would 1) have placed the Muscatine vehicular bridge in the upper pool, thus limiting vessel height, 2) have an adverse effect on drainage and sewers in the city of Muscatine, 3) flood existing industrial complexes in low land along Mad Creek in the upper limits of the city, and 4) place at least 17 feet of the complex on a shale formation which would be an unsatisfactory foundation. Because Lock and Dam 15 and the Keokuk Lock and Power Dam (which became Lock and Dam 19 in the Nine-Foot Project sequence) already fixed the ends of the reach of the river which was to contain Locks and Dams 16, 17, and 18, the Corps had to study not only the location of complex 16, but also those of priority group three complexes 17 and 18 to determine if and where it could move any of them. While these studies were underway, the Corps discovered that the rock conditions underlying the initial site (5.3 miles below Hannibal, Missouri) for fourth priority group complex 22 were very poor and instituted new surveys to find a better location. Beginning in 1932, the Corps also conducted additional studies on the best locations for priority group three Locks and Dams 10, 11, 12, 13, 13A, and 14.[37]

As a result of these studies, by November 1933, the Corps had relocated Lock and Dam 16 two miles upstream at the foot of Geneva Island (the remaining unsubmerged portion of which is now known as Hog Island and is part of the Lock and Dam 16 complex) and Lock and Dam 18 five miles downstream from its original site. The Special Board of Engineers had originally located complex 18 2.8 miles upstream from Burlington, Iowa; in 1933, the Corps relocated it to a site near the mouth of the Henderson River. These relocation decisions meant that the Rock Island District not only had to develop detailed plans for the diversion of Henderson River, so that it entered the Upper Mississippi immediately below Lock and Dam 18, but also had to redesign both dams. Complex 17 remained in its proposed location. The Corps determined that by moving Lock and dam 22 2.5 miles downstream, the complex could be constructed on a foundation upon which it would be economically feasible to build while securing equal advantages to navigation. The Corps also moved complexes 10, 11, 12, and 13 and eliminated 13A from the plan. However, the 1929 and 1931 decisions to locate complex 14 at Smith's Island was again revalidated. The site for Lock and Dam 10 was moved from Cassville, Wisconsin, to Guttenberg, Iowa. Chief of Engineers Lytle Brown announced the relocation of Lock and Dam 10.5 miles downstream from a site .7 miles above the village of Sprecht's Ferry, Iowa, to a site adjacent to Dubuque, Iowa, on September 28, 1933. Although the same studies lead to the relocation of Lock and Dam 12 from above the Galena River near Gordon's Ferry, Iowa, to downtown Bellevue, Iowa, the Corps was still having site work done at the original complex 12 location a month after its Lock and Dam 11 relocation announcement. The Corps delayed even longer in announcing its new site for Lock and Dam 13. Although the decision to move this complex 13 miles downstream from a site about 1,800 feet above the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at Sabula, Iowa, to a site just upstream from Clinton, Iowa, and Fulton, Illinois, and relocate the lock from the Iowa to the Illinois side of the river was made as a result of the same study which relocated Locks and Dams 10, 11, and 12. The Corps did not announce the complex 13 relocation until 1935, two years after the Corps announced the relocation of Lock and Dam 12. Research to date has not altogether clarified the reAsons for these delays. It is likely, however, that they had to be with the new, post-1933, non-navigational improvement project emphasis.[38]

The Great Depression reached its nadir during the winter of 1932-1933. The national political mood was clear; all civil works projects which could not be modified to serve a major relief work purpose would be abandoned. The Nine-Foot Channel Project came under cancellation consideration during the special session of Congress which Roosevelt called part of his "First 100 Days." Representative Edward C. Eicher of Iowa introduced a bill for the abandonment of the project and, at a four-day May 1933 Congressional hearing, the continuation of the project was debated in conjunction with consideration of railroad concerns about inland waterway improvement proposals. Representative Fred Bierman of Iowa and A. C. Willford, a congressman from Iowa and a national and statewide director of the Izaak Walton League, led the opposition to continuation of the project at these hearings. They did not argue the project's potential for employing significant numbers of people in an area with an acute unemployment situation or the few industries which the Federal

Government could work to revive, so as to provide increased employment opportunities. Rather, they opposed the project on environmental grounds, Progressive grounds, and recovery approach grounds. They were concerned that the project would flood most of the 90,000-acre Upper Mississippi Wildlife Refuge, created by President Calvin Coolidge in 1924 as the result of a fight between conservationists and developers. They attacked it on the basis of what historians such as George E. Mowry and Richard Hofstadter and those who have expanded and built on their theses would refer to as classic Progressive grounds ("If this project is adopted, the good of it...is this: that it will make possible the establishment of industries along the Mississippi River, make it easier to have factories and cheaper transportation. But has it occurred to you gentlemen that there is a grave danger in the U.S. of over industrializing?"). They claimed that significant waterway improvement on the Upper Mississippi was in direct opposition to the first New Deal recovery approach represented by the National Industrial Recovery Act being simultaneously debated in Congress. They were concerned that an existing, locally important, tax-paying industry, the railroads, would be depressed rather than revived by the competition that an improved, not directly taxable river would offer. The railroads' workforce and payrolls would be jeopardized rather than enhanced.[39]

A. C. Wiprud, General Counsel for the Upper Mississippi Waterways Association of Minneapolis (the successor organization to the Upper Mississippi River Barge Lines Company), and Governor Floyd B. Olson of Minnesota were the key witnesses in favor of continuing the project. Wiprud, claiming the railroads were behind all opposition to the project, based his support for the project on its ability to employ large numbers of people. Olson saw the principal potential benefit of the project as lower rail rates. Chief of Engineers Lytle Brown, in a masterly demonstration of studied, official neutrality, limited his remarks to the engineering feasibility of the project--what he termed the Corps' real area of expertise. He specifically refused to comment on economic benefits which might be gained by completing the project (either in terms of rail rates, emergency employment opportunities, industrial revival, or industrial development) and only tangentially dealt with the environmental issues raised when he argued that siltation would not be a problems once the dams are in place. Although no specific legislation or direct congressional orders came out of these hearings, people and agencies apparently arrived, as they so frequently do, at a consensus out of public sight. The project could and should be converted from one whose primary purpose was navigation improvement to one whose purpose was the employment of the maximum numbers of people for the money expended.[40]

That certainly seems to be the decision General Brown began implementing as soon as the hearings were over. Transformation of the project from a navigation to a "make work" project did not involve the Corps in the direct supervision of federal relief workers, but it did mark the Corps' entry into the federal employment relief arena on a large scale. This move was the first significant step in a process which culminated in a late 1938 presidential decision, ending the threat to the Corps' continued existence (a threat the Corps had been under since before World War I) and ushered in what might be called the Corps of Engineers' twentieth century golden age--the period of its greatest organizational security, its highest volume of work, its largest area of responsibility, and its maximum power.

General Brown had explained at the hearings that he could employ the most people by starting all 23 as-yet-unstarted project complexes simultaneously. His assistant, Brigadier General George B. Pillsbury, had further announced that if given adequate appropriations the Corps could have all 23 started within four months. In order to honor these public commitments, Brown and Pillsbury had to decentralize the project as much as possible, so that the maximum number of tasks could be undertaken simultaneously. The logical level to decentralize to was the district level, the smallest Corps' civil works unit routinely commanded by a military officer. Individual construction projects, no matter how big, as witnessed by the then-ongoing Locks and Dams 15 and 20 projects, were generally overseen by a civilian. Moreover, the districts were already responsible for some of the less critical design work, estimating and contract administration, direct supervision of construction, and operation of the sites within their respective jurisdictions. All Brown and Pillsbury had to do was transfer survey and land acquisition and the rest of the design work from the U.M.V.D. to the districts to complete the decentralization process.[41]

In an apparent first step of this process, within days of the May 1933 hearing, the U.M.V.D. got its first new commander in almost four years. Lieutenant Colonel R. C. Moore was acting division engineer from May 19 to July 29, 1933, when Colonel Spaulding resumed command until November 27, 1933. Although General Brown was no longer chief of engineers by this time, having been replaced by Major General Edward M. Markham on October 1, 1933, the reorganization was far enough along that, befitting the reduced importance of the division, General Markham chose not only a lower ranking but also a less prominent officer, Lieutenant Colonel Edmund L. Daley, to replace Spaulding. Daley served as division engineer until August 19, 1935, when Colonel John N. Hodges became U.M.V.D. division engineer. He served in this position until March 1, 1938, when Lieutenant Colonel Malcolm Elliot assumed command of the division. Except for a brief period between May 1 and June 8, 1939, when Lieutenant Colonel Phillip B. Fleming was acting division engineer, Elliot served as division engineer for the rest of the project duration.[42]

Not only did Colonel Spaulding leave the division in 1933, but head division engineer William McAlpine accepted a transfer to head the Engineering Section of the Office of the Chief of Engineers and his right-hand man Lenvik Ylvisaker resigned from the Corps. Ylvisaker's assistant Edwin E. Abbott, transferred from the St. Louis office to the Rock Island District office. Neither a new head engineer nor designers and technical engineering specialists auch as Ylvisaker and Abbott were assigned to the St. Louis Division office. Rather, during Colonel Daley's tenure, a new administratively-oriented position of assistant division engineer was created. Major William A. Snow, who served from December 1, 1933, until Auguat 24, 1935, became the first U.M.V.D. assistant division engineer. Immediately prior to that, he had aerved from November 4, 1930, to December 1, 1933, as St. Louis district engineer. Major Bartley M. Harloe, who served as an U.M.V.D. assistant diviaion engineer from July 22, 1935, until August 31, 1936, also had been St. Louis District engineer immediately prior to assuming this position. However, neither Captain Emmerson C. Itschner (a later Chief of Engineers at the very early stages of his career) who served in the poaition in August 27, 1937, and aaw the project to completion served as St. Louis District engineer prior to assuming the assistant division engineer poat. Prior to becoming division engineer in 1939, Colonel Elliot had, however, served as an assistant division engineer in the U.M.V.D. for four yeara.[43]

While the status, responsibilities, and technical engineering expertise of the division was reduced, those featurea of the districts were increased. General Brown began this proceaa at the command level also. On August 31, 1933, Major Edgerton completed his atandard three-year tour of duty as Rock Island district engineer. Captain John M. Silkman, Chief of the Rock Island District Engineering Division, served as acting Rock Island district engineer until a suitably capable and illustrious officer became available to assume this now much more important position. Major Raymond A. Wheeler, an Illinois native who had graduated fifth in the West Point class of 1911, was that up and coming officer. Being the only later chief of engineers to have directly commanded a unit of the Upper Miasissippi River Nine-Foot Channel Project, Wheeler served as Rock Island district engineer from September 22, 1933, until October 3, 1935. Prior to coming to Rock Island, Wheeler participated in the Vera Cruz Expedition, commanded the Fourth Regiment of Engineers in Germany during World War I, served as Newport, Rhode Island, district engineer, Assistant Engineer of Maintenance of the Panama Canal Zone, and Wilmington, North Carolina, district engineer.[44]

Simultaneoualy, the district staff was enlarged in order to effectively carry out its new and increaaed responsibilities. Both a Diatrict Counsel position and a Real Estate Division were established within the Rock Ialand District. Carelton E. Kelley, a graduate of the University of Wisconsin admitted to the Bar and to the Supreme Courts of Wisconsin, Illinois, and Iowa, as well as U. S. District Court of the Western District of Wiaconsin, the Northern District of Illinoia, and the Southern District of Iowa, transferred to the Rock Island District from the Chicago District office to become the first Diatrict Counsel and the first Chief of the Real Estate Division. He held this combined position from 1933 until 1968, serving as an advisor to 16 district engineers aa well as guiding and directing the acquisition of about 300,000 acres of land.[45]

The district also reorganized and greatly enlarged its engineering staff in 1933. It was now responsible for designing and preparing the contract drawings for all the project structures in the district. During the three years, it took the district to complete this task, both Senior Engineers Monroe and McCormick remained with the district. However, after Lock and Dam 15 went on line in 1934, Monroe took over the primary responsibility for the operation of the facilities, serving as chief assistant to the district engineer in the Operations Division, while McCormick continued to specialize in design and construction, serving as the Principal Assistant to the District Engineer on Engineering Matters. Captain Silkman was the officer in charge of the Rock Island District Engineering Division, when the district assumed its new responsibilities in 1933. He was succeeded by Captain R. E. Coughlin and then Captain Henry Berbert. Edwin E. Abbott, the transferee from the original St. Louis design team, served as chief civilian assistant to all three of these officers and signed the contract drawings for the ten locks (all those in the district except 15, 19, and 20 plus Lock 10 in the St. Paul District), 11 dams (all those in the district except 15 and 19 plus Dam 10 in the St. Paul District), and 3 central control station (those at complexes 13, 14, and 17) designed by the Rock Island District in these three years. As early as the summer of 1933, 200 draftsmen working out of a large drafting room on the second floor of the Clock Tower Building were assisting Abbott in the production of these drawings. The district engineering staff modeled all of its locks closely on Ylvisaker's 1931 Lock 15 prototype. However, the dams which the district designed in this same period show considerable evolutionary change. James Reeves and Edwin Franzen supervised the overall design of these dams, while Frank W. Ashton, another new district employee, designed the dam gates. Ashton, a Clinton, Iowa, native, was only three years out of the University of Iowa civil engineering program when he joined the district in 1933. However, he had spent two of those intervening years as a structural engineer with the American Bridge Company of Gary, Indiana, when the firm was serving as the contractor for the service bridge at Dam 15, a subcontractor for parts on Lock 20 and contractor for service bridge and Tainter gates at Dam 20.[46]

The district also dramatically enlarged its contract administration and construction supervision staffs. Within five months of Major Wheeler's assumption of command the Rock Island District had to solicit and evaluate bids, select general contractors, and award six major project contracts. By February 1934, eight complexes were under simultaneous construction in the district. During the course of the project, the district administered 36 major project contracts. For contract purposes, each lock and each dam constituted a separate project as did the power, control, and lighting of each lock and dam system. J. B. Alexander, the senior engineer in charge of the construction office of the Rock Island District Engineering Division, clearly had his hands full as did John H. Peil when he finished on-site construction and became head of the district's construction section in 1936. When Peil arrived back in Rock Island, the district had ten lock and dam complexes under simultaneous construction.[47]

Peil was not the only engineer from the Corps Lock and Dam 20 construction team to transfer to district headquarters in 1936. Robert E. Clevenstine, a Rock Island, Illinois, native with an electrical engineering degree from the University of Illinois, began his 40-year Rock Island District career as an inspector of concrete materials at Lock 20. He was promoted to office engineer, then assistant resident engineer, and then (when Piel moved up to the Rock Island office) resident engineer overseeing the very final touches on Dam 20 and the water supply and sewer system and power and lighting contract at Lock and Dam 20. Clevenstine also supervised the installation of the water supply systems at both Locks and Dams 21 and 22. In 1936, he followed Peil to the Rock Island District office, assuming responsibility for estimating and construction contract administration. In 1938, he worked on the mechanical design of lock and dam machinery, including a preliminary design of machinery for the new Lock 19. In the 1950s, Clevenstine supervised the construction of that large and distinctive lock, the last major Upper Mississippi River Nine-Foot Channel structure to be built in the Rock Island District.[48]

As early as 1932, the District contract administration and construction supervision staff began to amass extensive experience with unemployment relief. The construction of Lock and Dam 20 was financed with emergency relief funds that year. Beginning in mid-1933, the amount of emergency relief money the district staff was involved with jumped dramatically. These funds had special employment, recruitment, and labor requirements which greatly complicated not only the work of the construction contractors, but also that of the district staff working directly with them. All became deeply embroiled in interpreting and then working within the elaborate rules and regulations which many contractors resented as obstructions to the efficient, timely and profitable completion of their contracts. In 1935, at the height of its involvement with emergency relief monies, the Rock Island District had 11 National Industrial Recovery Act, Public Works Act, Emergency Relief Appropriation Act, and/or Works Progress Administration-funded projects underway. Because of their river channel locations, each project was in the jurisdiction of two National Reemployment Labor Offices, each part of a different state bureaucracy. There were usually two general contractors at work at each location and numerous subcontractors. In aggregate, these contractors employed over 10,000 men. This clearly placed the Rock Island District in the forefront of Federal relief work administration units. Harry Hopkins acknowledged this expertise in 1935 when he was organizing the Works Progress Administration (WPA). In October 1935, Major Wheeler's tour as Rock Island District Engineer was cut short and he was assigned to serve as Chief Regional Administrator of the WPA. This was another important step in ending the threat of the 1920s and 1930s to the existence of the Corps. The extent of Wheeler's influence in getting the WPA, as of 1936, to do and fund flood control construction work under the supervision of the Corps of Engineers is speculative at this point. However, it is not speculative that the WPA flood control work was important to Franklin Roosevelt's 1938 support of the addition of all WPA construction projects to the Corps' workload. This, in turn, figured prominently in Roosevelt's subsequent decision to support the Corpa' retaining all of ita traditional civil work functions, thus ending for over ten years the threats to remove civil works functions from the Corps.[49]

Major Earl E. Gesler was acting district engineer from Wheeler's asaumption of his new post until August 12, 1936, when Gesler was promoted to lieutenant colonel and appointed district engineer. He held the poat until August 4, 1939, by which time all the District's Upper Mississippi River Nine-Foot Channel Project locks and dams, except for new lock 19, were complete.[50]

Under both Wheeler and Gealer, the Federal relief work rules with which the district was gaining experience were geared to employing the most people, rather than serving the efficiency needa of the contractors. This led to problems related to compliance with the rules. These problems included time delays, contractors working men overtime despite rulea disallowing this, contractor claims of changed conditions, and so on. For example, at Lock and Dam Complex 12, both the major general contractors as well as several subcontractors on both the lock and dam elements of the project sued the government in the Court of Claims for the money they felt was due them because the government had not provided enough skilled and unskilled labor for them to hire from while limiting where they could secure workers. The contractors argued that these actions by the government had resulted in much hardship and cost for the contractors. The enormity of the problem is reflected in the size of the claims. The James Stewart Corporation's claim against the government, in relation to the construction of Lock 12, was $314,114.66, a sizable figure considering that the corporation's contact with the government was only for $1,346,720.83. The corporation's claim of excess costs came to the equivalent of almost 25% of its total contract. Not surprisingly, the James Stewart Corporation did not build any other project structures in the Rock Island District.[51]

The design for complex 12'a esplanade also provoked controversy, although it was not aa costly for the Corps. At least one local citizen, Joe A. Young, and his repreaentative in Congress, W. S. Jacobsen, questioned the need to include the lockmaster's and assiatant lockmaster's houses in the esplanade area. They wanted the esplanade to aerve as an unobstructed park in the center of the main waterfront of downtown Bellevue and recommended moving the houses. Colonel Gesler argued that dwellings for the responsible personnel at the lock and dam site were a fixed and indispensible part of the permanent installation. He, however, promised to make the houses and entire esplanade area as nice as poasible within budget. This did not satisfy Young and Jacobaon who objected to the houses facing away from town which would prevent the esplanade from being an asset to the downtown. The issue was only finally settled in 1939 by the chief of engineers, Major General Julius L. Schley, when he personally took a stand in support of Colonel Gesler and the standard esplanade design. Although the two houses which caused all this trouble were removed from the site in the mid-1970s, when the houses at all the complexes were moved, one physical remnant associated with them does remain on site--the frame two-car garage which served the two houses.[52]

Maxon Construction Company, the general contractor for Dam 12, sued not only for excess costs there, but on its Lock 18 contract also. Despite the firm's having only been organized six years before, Maxon Construction's president, G. W. Maxon, had over 25 years experience, of which all but 2 or 3 years were river work for the Corps of Engineers. He was thoroughly familiar with established Corps of Engineers practice and the classification of men for lock construction. However, just as the managers of the James Stewart Corporation, Maxon was not prepared to deal with Federal relief work rules. He felt that the people supplied by the government employment agencies were not qualified to do the work he needed done. So, he employed other people. The government felt this was inappropriate and withheld payment to Maxon for work done by these employees. Maxon argued that using the people provided by the government resulted in substantial unanticipated costs to him because poor workers increased accidents which increased liability insurance premiums and caused him to miss project deadlines. Just as with the James Stewart Corporation's claims at Lock 12 and Maxon's own claim at Dam 12, the issue at Lock 18 ended up in the U. S. Court of Claims. Maxon's claim against the government in relation to his work at Lock 18, a claim which the court awarded him, was in excess of $100,000, an amount equal to about 7% of his total contract on this project. Unlike the James Stewart Corporation, Maxon did continue to work on projects in the District. However, his efforts were plagued by misfortune. A section of the cofferdam he built to protect his work at Dam 11 failed three times and then, in April 1936, was overtopped while permanent work was in progress behind it. Then, Maxon's cofferdams failed two years later at his Dam 17 construction project. Only his first project, construction of Lock 20, went relatively smooth.[53]

Maxon was not, however, the only contractor to sue twice over Federal relief work rule-related excess costs. Joseph Meltzer, Inc., general contractor for Locks 21 and 22, sued on both projects. Meltzer insisted upon working people more than 30 hours a week, despite relief rules prohibiting this. He had a series of conflicts with the unions involved in the projects. He was dissatisfied with the people supplied by the government employment offices, he felt (as Maxon had) they were not qualified to do the work that need to be done. And he interpreted the rules on the proper wages to be paid to various types of employees to be different than the government did. In 1937, two years after completing Lock 21, Meltzer brought suit against the government for money which the government had not paid the firm in response to bills it had submitted on its Lock 21 contract. Meltzer ended up in court over $300,000 on its main Lock 22 contract also. But, in this case, not only was Meltzer suing the government, but various subcontractors were suing Meltzer. For example, as early as 1935, the Independent Bridge Company of Pittsburgh, Pennsylvania, and Century Electric Company of St. Louis, Missouri, were both planning on suing Meltzer for their money.[54]

In retrospect, the fact that the construction of Lock 22 was going to be aggrevation-ridden was obvious from the beginning. On January 9, 1934, Alex J. Anderson of Davenport, Iowa, who had the contract to build the temporary buildings at Lock 22, arrived on site to start work. But he was told by the contracting officer not to do much because there was some question about whether or not the government had legal possession of the site (it was on railroad land). On January 10, 1934, the contractor was told to go ahead. Two weeks later, the contractor was asked not to build the chimney and other fixtures on the building, so that it could be moved to a site adjacent to government land. The government arranged for the lock contractor, Joseph Meltzer, Inc., to move the buildings. The method Meltzer chose delayed Anderson because Meltzer had put the building on skids 12 days before moving it. This raised the structure considerable and made it necessary for Anderson to build extra scaffolds and to work under adverse condition in continuing to build the temporary buildings. Naturally, because of all of this, Anderson and Meltzer put in claims for extra fees.[55]

Of course, contractors caught up in the "make work" nature of the project were not the only disgruntled ones who sued the Corps. Merritt-Chapman and Whitney Corporation, the general contractor for Locks 15, also sued the government over their payments. This, perhaps, explains why this firm, like the James Stewart Corporation, did not build any other project structures in the Rock Island District.[56]

These kinds of complications indicate the massive nature of the Rock Island District's administrative task in relation to the Upper Mississippi Nine-Foot Channel Project. The district's accomplishment for the bulk of this task within seven years: simultaneously conduct detailed surveys of virtually all of both riverbanks between Clarksville, Missouri, and Guttenberg, Iowa; acquire tens of thousands of acres of land; directly supervise construction of 36 major projects; design 21 of the project's major structures; and operate and maintain each of the 12 complexes as they went on line, as well as the other waterways under its jurisdiction. This was a tribute to the organizational abilities of the Corps of Engineers and the Rock Island District.

SUMMARY

The Upper Mississippi River Nine-Foot Channel Project was the latest in a series of waterway improvement projects that began in the 1820s on this river. Snagging and dredging were supplemented by channel contraction that worked toward first a 4, then a 4-1/2-foot channel. However, by the turn of the century, water navigation on this river had become unimportant to the region's economy. Regional advocates saw waterway improvement as a valuable tool in reviving the region, particularly after the onset of the 1920s' farm crisis hit the upper midwest so hard. Waterway improvement was seen as a way to revitalize the region by decreasing rail rates and providing cheap bulk cartage. These factors would encourage industry and exports. Although direct governmental aid was an anathma to the conservative Harding and Coolidge administrations of the time, waterway improvements were seen as an acceptable way to promote the general good. Legislative attempts to create a viable six-foot channel water route from the twin cities to St. Louis through contraction and lateral canals seemed doomed. Only through locks and dams could a modern dependable waterway become a reality. The six-foot channel fell by the wayside, replaced by the concept of a nine-foot channel.

In 1929, with the blessings of President Hoover and the instruction of Congress, the U. S. Army Corps of Engineers began to prepare for one of the most concentrated waterway construction projects of all time. Engineers and administrators from the Ohio River project transferred to St. Louis and began the enormous design and organizational effort needed to convert one of the world's largest rivers into a staircase of lakes cutting across almost half a continent. To design and build this truly phenomenal system, the Corps of Engineers created the Upper Mississippi Valley Division over the three districts effected by the project. The Rock Island District was one of these. In the first phase of construction between 1929 and 1932, work proceeded at a measured pace, controlled and produced out of the Division. However, in 1933, national political changes affected and endangered the project. Its focus changed in response to the changed philosophy of government aid to the general welfare. The Great Depression had installed in office those that believed in more direct aid to those in need. The project, instead of being scrapped, now provided real assistance to the thousands that could be employed in construction. This goal moved much of the project's control out of the Division and into the Rock Island, St. Paul, and St. Louis districts. Many aspects of project implementation fell to the district. New work rules made life difficult for old Corps employees and contractors. However, the job got done and done well.

HISTORY OF TECHNOLOGY

The Upper Mississippi River Nine-Foot Channel Project inaugurated a new development in slack-water navigation system dam practice in the United States: the adoption of a non-navigable dam incorporating both roller and Tainter gates. Prior to the Corps' 1930 decision to build non-navigable dams on the Upper Mississippi River, U. S. Army Engineering practice had, nearly universally, been to construct navigable dams, permitting open-river navigation at higher river stages. By 1930, European engineers had been using roller gates in dAma extensively for over 25 years. However, only ten auch structures had been built in the United States, and these were all located on river reaches where enauring navigability of any aort was not a design concern. It wAs not until 1925-1926 that civilian engineers in the United States pioneered the use of roller gates in combination with other typea of gates. Most of the Corpa' Upper Mississippi River project dam designs expanded upon this development, incorporating both roller and Tainter gatea. The Corps' shift from navigable to non-navigable dams demonstrates the influence of shipping techniquea on navigable waterway improvement technology. It also exemplifies the cautioua nature of American Army engineers' response to changes in shipping. The Corpa' choice of this particular type of non-navigable movable dam illustrates the influence of the hydraulic characteristica of individual rivers on the selection of waterway improvement technologies. It also evidences the manner in which critical engineering design developments are diaseminated and become accepted.[57]

Ironically, the Upper Mississippi River Nine-Foot Channel Project also reaulted in the obaolescence, by the project's end, of combination roller and Tainter gate dama. Technological advances resulting from the research and development incidental to the design and construction of the 26 lock and dam systems in thia project enabled U. S. Army Corpa engineers to develop both aubmersible and non-submersible Tainter gates which nearly matched the capabilities of the roller gates. Once these less expensive and easily operated and maintained gatea had been developed, American engineers ceaaed designing or conatructing combination roller and Tainter gate dams. The Corps' creation of a new dam type and its aubaequent obsoleacence during the course of a single project dramatically illuminates the evolutionary nature of American engineering in general and the Nine-Foot Channel Project in particular.[58]

Lock and Dam Systems 11-22 in the Rock Island District evidence specific engineering innovations. Lock and Dam 15's non-navigable roller gate dam served as the progenitor of the project's aubsequent roller-Tainter combination dama. Corps engineera made many of the design contributiona leading to the obsoleacence of roller-Tainter combination dams as part of the development of complexes 11-14, 16-18, and 20-22. Lock and Dam Syatem 19, the twelfth project complex in the diatrict, is unique. It includes rare, intact examples of early, nationally significant hiatoric slack-water navigation system and hydroelectric power generation engineering. The Corps did not build this complex as part of ita 1927-1940 project. However, it is included in this documentation, becauae all 12 Rock Island District complexea are integral parts of the one working aystem. They constitute an important section of the Upper Missisaippi River Nine-Foot Channel, itself a significant engineering resource which reflects the evolution of American river hydrotechnology and hydroengineering.[59]

The Upper Mississippi River Nine-Foot Channel Project created a slack-water navigation system from the mouth of the Missouri River to just below the Falls of St. Anthony in Minneapolis. Within this 658-mile-long reach, the project transformed the Upper Mississippi River into what is essentially a series of interconnected lakes.[60]

River improvement engineers use locks and movable dam systems to build slack-water navigation systems. The dams form a series of pools which are deep enough for navigation throughout their entire length. The movable gates within the dam regulate the upper pool depth, ensuring water for navigation while guarding against flooding. The pools constitute, in essence, a water stairway. In a system with non-navigable dams, such as the Upper Mississippi River Nine-Foot Channel system, vessels travel from one pool to another, exclusively by way of locks.

French and American engineers first began successfully building slack-water navigation systems in rivers in the 1930s. However, American Army engineers did not begin to study such river improvement methods until the 1940s. It was not until 1878 that the U. S. Army Corps of Engineers began building its first experimental bank-to-bank structure on the Ohio River just below Pittsburgh, Pennsylvania. The Davis Island Lock and Dam initiated what became, until the Upper Mississippi River Nine-Foot Channel Project, traditional American practice for slack-water navigation systems. The dam was a navigable movable structure: a masonry sill set into the bed of the river with gates or wickets superimposed on it (based on designs originally conceived by Frenchman Jacques Chanonine in 1952). During the relatively long high-water stages on the Ohio, the Chanonine wickets in the dam's 559-foot-wide navigable pass lay flat across their sills on the riverbed, permitting open water navigation over the dam. The staff raised and lowered the wickets to regulate the upstream water level.[61]

In the immediate post-Civil War period, western rivermen, hard pressed by the altered economic conditions created by the railroads, developed the barge system. Coal shippers used the barge system extensively in the Ohio River Valley and its tributary region from 1866 on. The leading mining companies of the Upper Mississippi River Valley and its tributary region also used the barge system; and it was not long before grain haulers began using the system to haul bulk agricultural products out of the Upper Mississippi region. Fleets of eight to twenty ore or grain barges, bound to a steam towboat by a complex system of cables and chains, were a common site on the Upper Mississippi after 1870.[62]

The upriver lumber industry also had a particular need for open river navigation. From 1870 until about 1905, logs were a major commodity carried on the Upper Mississippi. Logging was the largest industry in the Upper Midwest during this period. The lumber companies floated many of the logs harvested in the forests of Wisconsin and Minnesota down the Upper Mississippi to markets and sawmills as far south as St. Louis. For most of the years between 1875 and 1900, more than 100 special steamboats--called raftboats because they pushed massive log rafts down river--traveled the Upper Mississippi. While steamboats rarely exceeded 100 feet in width and 300 feet in length, raftboats with their log rafts tied to their bows were often 300 feet wide and 1,500 feet long. They needed as an an unobstructed area of river as possible in which to move. Neither barge/towboat units nor raftboats could be operated economically in a non-navigable dam system with a deep but narrow channel and a number of locks, because they would have had to be broken up and then reassembled repeatedly. Packet operators carrying passengers, mail, and valuable or special freight also opposed non-navigable slack-water navigation systems. Packets operated on tight schedules competing with railroads. Numerous lockages would have drastically reduced their ability to compete [63]

The Upper Mississippi navigation improvement projects the Corps designed and built concurrently with the Ohio River Davis Island Lock and Dam project also provided for open water navigation. Although the Corps had seriously considered a slack-water navigation installation on the Upper Mississippi as early as 1867, it did not build any such installations then or as part of the 4-1/2-Foot Channel Project (1878-1907). However, in 1903, Montgomery Meigs, a Rock Island District civilian employee, endorsed, on the Corps behalf, the Keokuk and Hamilton Water Power Company's 1901-1902 plan to build a bank-to-bank structure including a non-navigable dam at the foot of the Des Moines Rapids on the Upper Mississippi River, in the very heart of the navigable section of the river.[64]

The complex proposed by the Keokuk and Hamilton Water Power Company could not include a navigable wicket dam, permitting open water navigation at high water stages, because the proposed dam would create a 40-foot difference in water elevation. Forty-foot wickets were not technologically possible in 1901-1903. The Water Power Company could not reduce the size of the dam in order to reduce the difference in pools to one manageable by a wicket dam because the company needed adequate water and fall, or "head." The 40-foot head achievable and maintainable at Keokuk was one of the prime attractions of the site for hydroelectric power interests.[65]

Meigs concluded that the construction of a non-navigable slack-water navigation installation at Keokuk would benefit the navigation of the Upper Mississippi River, while allowing effective use of the river for hydroelectric power generation. He acknowledged 15% of the downstream river traffic went directly over the rapids rather than passing through the existing bypass canals and locks. Meigs, however, noted that the percentage of traffic using open water navigation to pass the rapids were declining rapidly. He predicted it would continue to do so as the Upper Midwest lumber industry declined and the lumber marketing and processing facilities upstream from Keokuk came to increasingly dominate what was left of the business. By 1902, there was only one sawmill left below Keokuk. Advances in barge and towboat technology had made it possible to haul ore and grain in less-cumbersome fleets. Moreover, long-distance packets had for all intents and purposes totally lost out to railroads and disappeared as a significant user group. Meigs concluded that construction at Keokuk of a non-navigable dam with one lock to replace the three canal locks would save time for the vast majority of river traffic. He estimated that, had the facility existed between 1890 and 1901, river users would have saved 12,000 hours, a savings which would have reduced shipping costs .6 of a cent per ton of freight.[66]

Despite these cost benefits, Meigs would never had endorsed the project, had it not been a hydroelectric power generation project. In 1902, the Corps could not have justified a navigation improvement at Keokuk; too little traffic was using the river to warrant the expenditures involved in such a project. However, the Corps could support a multiple-use project where the builders of the navigation improvement could justify building the navigation structures as part of an overall commercial complex with a sound prospective future.[67]

In February 1905, Congress authorized the Keokuk and Hamilton Water Power Company to build its dam and power plant. However, the government required the company to replace the Des Moines Canal facilities and the Rock Island District dry dock which would be submerged by the dam. The government also required free power to operate both the new lock and dry dock. Fishways, satisfactory to the U. S. Fish Commission, were also required. The structures which the compsny built as a result of this authorization still exist and are part of the Lock and Dam 19 complex. By allowing this project, Congress and the Corps cleared the way for the later Nine-Foot Channel Project. The 1905-1914 Keokuk project established the precedent of non-navigable slack-water navigation structures on the Upper Mississippi and showed that the free flow of the river could be interrupted in mid-stream without unacceptable damage to the river or the surrounding lands.[68]

The Corps did not, however, immediately begin building slack-water navigation structures on the Upper Mississippi River. The next major structure the Corps built on the Upper Mississippi was the Moline Lock, 123 river miles upstream from the Keokuk installation. Designed between 1902 and 1905, this structure was specifically geared to open water navigation. The Corps situated the lock well to the side of the middle stretch of the Rock Island Rapids. The two concrete dams which extended out from the lock to contract or funnel the river towsrds the Moline side did not extend all the way across the river. These structures, completed in 1908, were replaced by Nine-Foot Channel Lock and Dam 15.[69]

Similarly, in 1913 when the Corps developed plans for a lateral canal and lift lock to allow circumnavigation of the LeClaire section of the Rock Island Rapids as part of the Six-Foot Channel Project (1907-1930), it continued to ensure the availability of open water navigation. Congress authorized construction of the project on March 5, 1914. However, the outbreak of war in Europe dashed any hopes for a quick construction start-up. When, by the summer of 1920, construction had still not begun, the Corps took the opportunity to re-examine and revise the designs for the canal and lock in light of recent developments in waterway technology. Interestingly, the Corps continued its commitment to open water navigation. The 1921-1924 construction of the Le Claire Canal and its appurtenant structures in no way hampered open water navigation.[70]

The Corps remained committed to open water navigation on the Upper Mississippi in 1925. However, the Hastings, Minnesota, lock and dam (built 1928-30) did not leave as much room for open water maneuvering as the Moline and Le Claire structures. This complex, now known as the Upper Mississippi River Nine-Foot Channel Lock and Dam 2, only included a 100-foot-wide navigable pass adjacent to the lock. It also include 20 Tainter gates. In narrowing the space reserved for open river navigation and utilizing Tainter gates for the first time on the Upper Mississippi River, the Hastings Lock and Dam acted "as a sort of engineering link" between the Corps' Six-Foot Channel structures and philosophy and its mature Nine-Foot Channel structures and philosophy.[71]

As late as December 16, 1929, the Corps was committed to navigable dams on the Upper Mississippi. The Corps' interim Nine-Foot Channel Project survey report of that date called for movable dams with navigable passes and Chanonine or Boule type weirs for regulating the pool and facilitating the operation of the passes. These dams would have permitted greater areas for open water navigation during high-water river stages and would have offered less obstruction to the passage of water during floods than the Hastings structure, since all their movable parts could have been laid down on the bed of the river.[72]

However, even before this report was published on February 15, 1930, as House Document 290, the Corps reconsidered its commitment to ensuring open water navigation on the Upper Mississippi. Within days of the issuance of the report, members of the new U.M.V.D. design team began to arrive in St. Louis. The team concluded almost immediately that open river navigation on the Upper Mississippi during the relatively short periods of high-water levels was not significant enough to rule out the need of non-navigable dams.[73]

Non-navigable dams offered advantages not available in navigable wicket dams configurations. Non-navigable dams' higher sills function as weirs, ensuring a minimum pool level above the dam at all times. This was a decided advantage in a shallow river such as the Upper Mississippi. In some places, such as the Hastings site had been, maintaining a deep enough pool for fully loaded modern boats and barges to navigate was difficult, even during high water stages. The new design team was probably more familiar with the conditions at Hastings than they were with any other site on the Upper Mississippi. Claude I. "Pete"

Grimm, the chief of the Corps' Central Engineer Division's Engineering Design Force in Cincinnati, Ohio, had been in charge of the design of the Hastings structure from 1927 until 1930. During these years, many of the members of the new Upper Mississippi River design team had been part of the Ohio River design team working under Grimm's direct supervision. As a result, they were probably aware that he had chosen to replace the standard Ohio River's Chanonine or Boule weirs with a non-navigable section with a Tainter gate crest because of the need to hold a pool above the Hastings dam even during flood times.[74]

Navigable dams, often called pier, or crest, dams because a crest of movable gates erected between the piers is superimposed on their sills, could be operated from fixed service bridges. Although initially more expensive to build, pier dams with gates operated from a fixed bridge are easier, cheaper, and less hazardous to operate than dams with wicket gates. Wicket gates have to be operated from a maneuver boat and require a greater number of skilled operators, often working under hazardous conditions. Pier dams with gates operated from a fixed bridge also are more dependable, allow more accurate control of pools, and are more readily repaired with less hindrance to navigation than wicket gates. For example, the space between the piers can be blocked off with bulkheads and dewatered for easy repair of both the crest gates and the sill. Wicket gates can be repaired rather easily, but repair of their sills is very difficult or impossible without interrupting navigation. Gates operated from a fixed bridge can also be opened part of the way; wicket gates on dams are either open or shut. Therefore, a little water can flow over a whole pier dam rather than a lot of water over a few parts of the dam. This not only increases the operator's ability to fine-tune water releases, it also protects the dam from erosion or scour from the water pouring through its gates in a very concentrated flow. On the Upper Mississippi, where so many structures would have to be built on a sand foundation, this was another decided advantage.[75]

The engineering theory of the 1930s indicated that it was practical to build dams operated from fixed service bridges on the Upper Mississippi River, whereas it had not been on the Ohio, due to flood heights. Engineers acknowledged not only the feasibility of building fixed service bridges high enough to be clear of the highest floods on the Upper Mississippi, but also of installing movable gates which could be raised clear of these floods.[76]

The idea of non-navigable dams on the Upper Mississippi River Nine-Foot Channel Project was far enough advanced by February 1930 that members of the design team, accompanied by the Rock Island District Engineer Hall, visited newly constructed non-navigable movable dams. These visits were followed by consultation with companies manufacturing movable gates for these dams. By March 1930, the idea of changing the type of dams proposed in House Document 290 was so far advanced that William I. Nolan, Representative in Congress from Minneapolis, proposed legislation giving the Corps the right to make changes in the type and location of the dams recommended in House Document 290. Although this clause was not in the final July 1930 act, by which Congress authorized the Corps to construct the project, the Corps had decided to change to non-navigable dams on the Upper Mississippi project by December 1930. The U.M.V.D. design team was so far advanced in its planning that it had selected one of the kinds of movable gates to be used in these dams. Indeed, the team had the design of Dam 15 (a non-navigable roller gate dam) far enough along to distribute it to the general public for review and comment.[77]

M. Karstanjen developed roller gates for use in dams in Norway and Sweden about 1900. European engineers adopted the design almost immediately. Two German companies, the Krupp Company and the Machinenfabrik Augsburg - Nurnberg A.G. (commonly referred to in America as the M.A.N. Company), controlled basic patents for the gate. By 1902, a Krupp roller dam had been built on the Main River nrst Schweifurt, Germany. Soon, roller gates predominated on both the Main and the Neckar rivers. The roller dam at Kibling, Germany, built before 1915, involved a particularly remarkable use of the technology. This dam had one 28-foot-high roller providing a 46-foot clear span. Another interesting pre-1915 example is a dam near Stuttgart, Gaermany, which had two 92-foot by 12-foot spans.[78]

Roller gates are very strong, because the main body is a trussed cylinder. This gives the gates superb rigidity along their longitudinal axes. A curved shield, or apron sector, secured to tangentially disposed struts, extends from the cylinder. There is a sprocket on each end of the gate. These sprockets engage inclined racks attached to the concrete piers at either end of the gate. This, too, increases the strength of the gate, as it allows bearing on the broad end of the cylinder rather than on a small pivot. The gate is rolled up and down between the piers by means of a chain mechanism attached to one end of the drum. This chain hoist is operated by a motor housed above the pier closest to the end of the cylinder to which it is attached. When in the lowered position, the shield extending from the main cylinder bears on a concrete sill to form the bottom seal. The end seals are flexible steel shields , the linings of which fit the slightly inclined plane of the face of the pier. Thus, water pressure keeps the end shield tight against the piers, and yet clearance between the linings and the pier faces is ensured as soon as the roller has risen a few feet.[79]

By 1911, American civilian engineers had introduced roller-gate technology to the United States. The Washington Water Power Company began installing a rolling crest on its Long Lake spillway that year. Located near Spokane, this dam used three 65-foot wide roller gates, each 19 feet high. Shortly thereafter, the United States Reclamation Service, a part of the Department of the Interior's Geological Survey, installed a small roller crest, 30 by 8 feet, in conjunction with its Boise project.[80]

With its second roller crest dam, the Grand Valley Diversion Dam at Palisade, Colorado, the Reclamation Service established the basic form for American roller gate dams. This dam was a clear progenitor of dam 15 on the Upper Mississippi River. In September 1913, the Reclamation Service decided to have the M.A.N. Company design and fabricate roller gates for its Grand River diversion dam. By May 1914, the company had developed a set of plans and fabricated some of the parts in Germany. After World War I broke out in early August 1914, however, the M.A.N. Company announced its inability to proceed with the work. At that point, F. Teichman, a designing engineer for the Reclamation Service, reworked the German designs to conform to American practice. The dam, completed in 1916, included seven roller gates: one 60 feet wide by 15 feet 4 inches high and six 70 feet wide by 10 feet 3 inches high. Elevations and sections of the Grand Valley Diversion Dam show not only the basic forms of the piers and the fixed service bridge connecting the piers to be the same as those in Dam 15, but also the architectural style of the roller gate piers are clearly direct precursors of the roller gate piers used in the first Upper Mississippi River structures 15 years later.[81]

In 1925-1926, ten years after the combined efforts of German and American government engineers produced the final Grand river structure design, private-sector engineers carried the American end of the design process one step further. German engineers had been using roller gates in combination with other gates for some time. American engineers apparently placed greater value on uniformity of operating machinery and believed that water levels could be more effectively regulated and debris deposits sluiced out more efficiently, if only one type of gate was used in any given installation. The New England Power Association's engineers broke with this pattern. The new plant they designed for installation on the Connecticut River at Bellows Falls, Vermont, utilized two 115-foot roller gate sections and three sections equipped with flashboards. The flashboard sections ranged in length from 100 to 121 feet. The flashboards were operated by a 25-ton hoist traveling by trolly along a fixed service bridge. This bridge spanned not only the flashboard sections of the dam, but connected that portion of the dam to the pier houses containing the motors used to operate the roller gate hoists. The bridge also connected the pier houses to one another. The S. Morgan Smith Company, the firm with the American rights to produce the version of the roller gate covered by the M.A.N. Company's patent, fabricated the roller gates for this dam.[82]

As early as December 1928, the Corps considered the possible installation of roller gates in some of its structures. It sent Claude I. Grimm, the engineer in charge of the design of the Hastings, Minnesota, lock and dam, to inspect roller gates in operation at the Electric Bond and Share Company's Wallenpaupack Plant at Hawley, Pennsylvania. Grimm did not, however, consider these gates for use in his Hastings structure. He did consider them for two Kanawha River dams he was working on simultaneously. These two dams eventually included roller gates. However, the design for these were not finalized until after the Corps of Engineer's National Board of Engineers for Rivers and Harbors (BERH) had evaluated and approved the use of roller gates in the Upper Mississippi River Nine-Foot Channel Project. This did not happen until late 1931.[83]

In 1930, a variety of movable crest gates operable from fixed service bridges were available for use: vertical lift gates, Tainter gates, sector gates, and roller gates. The Upper Mississippi river Nine-Foot Project design team chose to include roller gates in its dams for a variety of reasons. The inherent strength of the roller gate drum permitted construction of long gates with an economic use of metal. As of 1930, roller gates allowed for successful construction at lengths greater than any of the other types of movable gates suitable for pier dams. This greater length allowed maximum clear openings between piers to pass running ice and drift and to provide capacity for the greatest discharge of floodwaters of any pier dam. It also reduced the number of piers to a minimum. Piers themselves were obstacles to the free passage of ice, drift, and flood waters. Achieving the most free flow possible was important on the Upper Mississippi. Winter temperatures on the Upper Mississippi resulted in ice gorges which posed a serious threat not only to the dams, but also to private property along the riverbank. Later in the spring, the river's flood waters carried much heavy drift. Passing the maximum amount of flood water quickly was necessary because the Upper Mississippi's banks were low, the bottoms densely farmed, and towns and railroads located close to the river. Designers could not allow the dams to increase natural flood levels more than 12 inches.[84]

As discussed above, the need to refrain from increasing the depth of the flood waters was particularly pressing in the case of Lock and Dam System 15, the first of the Nine-Foot Channel Project complexes to be designed. The water level could not be raised too high because of the effect that it would have on industrial areas and the sewage systems of Davenport and Bettendorf, the Rock Island Arsenal, and the water intake facilities for the city of Rock Island.

The massive construction of roller gates and their operating machinery were additional factors in the designers' choice. The ruggedness of the gate and operating machinery assured positive operation under severe physical and climatic conditions. The design considered the operation of gates in freezing weather. Roller gates offered better assurance of operating under freezing conditions than the other types of gates, especially Tainters, which bear on a relatively small pivot. The design of the seals, both side and sill, also meant that rollers were less likely to leak than other movable gates. The U.M.V.D. engineers also perceived the roller gate design as lending itself to relatively inexpensive provisions for heating both the gate and the side seals for operation during freezing weather. Unfortunately, their subsequent experience with roller gates in operation at Dams, 15, 20, 16, 18, and 11 belied this perception. Though the designers removed all projections on the end discs of the roller gates and simplified removal of the end disc plates and heater elements in February 1937; the heater units of the few roller gates built subsequent to that were still inefficient. No lock and dam personnel in the Rock Island District recall using the heaters on any dam. They just do not work well enough.[85]

Initially, the roller gates' ability to raise up to allow flood waters, ice, and drift to pass below them was an important factor in their selection. Because their sills did not have to be large enough to accommodate the gates in a submerged position, the use of roller gates allowed the designers to minimize the height of the sills and thus maximize the flow of ice and drift and the discharge of flood waters. Engineers were very leery of submergible gates, such as some types of sector gates, because they were concerned about making the excavation in the riverbed into which these sector gates were lowered. They expected these excavations to fill up with sediment, making it impossible to move the gates out of the way of the flow of waters.[86]

Although they did not change their minds about sill height, Upper Mississippi River project designers changed their attitudes towards submergible gates. Construction of Dam 15 began in February 1932 and, by 1933, enough gates were in operation for the engineers to learn that floating ice could not be passed underneath the gates unless they were raised approximately half the distance from the sills to the surface of the upper pools. To open the gates this far during freezing temperatures, when the Upper Mississippi is usually low, lowered the upper pool below the desired level. Moreover, opening the gates that much produced a very concentrated flow. Such a flow would cause serious erosion on the many dams to built with sand foundations. The Rock Island District completed the designs for Dam 20 in August 1933 and for Dam 16 in September 1934, using the original German designed roller gates. However, the district design team began work on modifying this design.[87]

They were not alone in this effort. Following the 1931 BERH report recommending non-navigable roller and roller-Tainter dams for the Upper Mississippi River Nine-Foot Channel Project, the Huntington District of the Corps of Engineers finalized its plans for two roller dams on the Kanawha River. The designers of this project had been considering using roller gates in the structures since at least 1928. By the fall of 1933, the Corps' Kanawha River project staff had developed a design for a submergible roller gate with a hinged flap on the bottom side. This design was, however, not used in the Kanawha dams because the Dravo Contracting Company of Pittsburgh, Pennsylvania, the contractor building both of the Kanawha river roller dams, submitted an alternate design acceptable to the Corps. This design provided for a smaller drum with a hinged flap on the top side. This flap could be folded down over the drum to create a five-foot deep floodway over the gate. Flap-type roller gates were also discussed for use in Upper Mississippi River Nine-Foot Channel Project Dam 4 in the St. Paul District. However, they were not built. The first use of a new submergible roller gate design developed by the Upper

Mississippi design team was at Dam 4, construction of which began in November 1933. St. Paul District Dam 4 includes roller gates submergible to a depth of three feet.[88]

Rock Island District engineers designed their first submergible roller gates for Dams 11 and 18 in May and July 1955, respectively. The sills for all previous Rock Island District roller gates had only one basic level and the gates closed against the sills, forming bottom seals. The newly-designed sills for the submersible roller gates had two levels, a higher upstream level and a lower downstream level joined by a curved section of concrete. Thus, a gate could be brought to bear on the upstream level of the sill to form a bottom seal or to pass this portion of the sill sliding along the curved section to the downstream level. This permitted the crest of the gate to be lowered eight feet below its normal closed position. Although the submergible roller gates they designed for Dam 12 (the contract drawings of which Senior Engineer Abbott signed in November 1935) were identical to those at Dams 11 and 18, the district engineers were aware by then that this new design had not totally solved the scour or over-lowering of the upper pool problems which had manifested themselves at Dam 15. The design they completed in September 1935 for Dam 21 attempted to further mitigate these problems by reducing the depth to which the gates could submerge. The roller gates at dam 21 only submerge to a depth of 4.67 feet. However, the engineers were still dissatisfied with this solution. They returned to roller gates submergible to a depth of 8 feet in their April 1936 design for Dam 22. In this design, however, the Rock Island District engineers incorporated a Poiree dam trestle the same height as the downstream fender on the adjoining piers. Set immediately downstream from the downstream level of the sill, these units acted as weirs. They mitigated the problems enough that, in 1937, the Rock Island District hired the Worden-Allen Company of Milwaukee to furnish and deliver enough Poiree dam trestles to retrofit the dams in all three districts built prior to Dam 22. Despite use of these devices as retrofit solutions, the Rock Island District design team was not happy enough with the solution to include it in its new designs. For its last three dams (14, 13, and 17, with completed designs by September 1936), the team once again reduced the submergible depth. These roller gates can only be submerged to a depth of 4.67 feet. Despite this, there were still scour problems with the district's submergible roller gates in 1939. The St. Paul District Sub-Office Hydraulic Laboratory at the University of Iowa in Iowa City, Iowa, conducted model studies on Dam 22 which led to the design of stilling basins for the roller gate sections of the dams. Stilling pools, or water cushions, are enlargements and deepenings of the river at the foot of dam spillways to lower the speed of flow and reduce scour.[89]

While it was developing and refining new submersible roller gate designs, the Rock Island District design team began to incorporate Tainter gates into its designs. The team included both roller and Tainter gates in Dam 20, the first dam it designed, not the U.M.V.D. staff. As in subsequent designs, Rock Island

District engineers limited their use of roller gates to the middle of the movable gate section of this dam. They had discovered that three or four 100-foot wide roller gates situated in the thread of the stream were all that were really necessary in order to pass ice, drift, and floodwaters satisfactorily.[90]

A Tainter gate consists of a segment of a cylinder with triangular arms extending from each end to a pivot. These arms pivot on pins attached to the supporting piers. North American hydraulic engineers had been using radial gates based on the same principals as the Tainter gate for over a hundred years by the time the Upper Mississippi design team began incorporating them in the designs for its project dams. As early as 1827, when Captain Marshall Lewis applied for a patent on his semi-circular, cast-iron gates turning on pivots connected to the gate by arms, he admitted he had not designed a new type of gate, but merely made some important improvements in what was already known as the "common paddle gate." Refinements in design continued throughout the nineteenth century. In 1840 and 1841, George W. Hildreth of Lockport, New York, and George Heath of Little Falls, New York, patented such similar refinements in the design that a series of court cases and state legislative actions ensued. By 1853, the noted French hydraulic engineer Poiree (for whom the dam trestles that district engineers applied to their submergible roller gate problems), had adapted a similar segmental arc gate for use in movable dams. Later in the century, Wisconsin lumberman Theodore Parker made further refinements in the basic design as used in dams. Parker sold his rights to Jeremiah Burnham Tainter who patented the gate system in 1886. In 1889, Major William L. Marshall became the first Corps officer to use Tainter gates, adopting a manually-operated version of them for use on a movAble dam across the Rock River between Rock Falls and Sterling, Illinois. [91]

Despite their extensive use, there was still room for improvement in Tainter gates, when the Upper Mississippi River Nine-Foot Channel Project design team began incorporating them into its designs in 1932 and 1933. The team improved the basic gate design and means of operation, developed submersible Tainters, and ultimately created Tainter gates of unpredecented length.

Prior to this project, it appears Tainter gates, like the original German-designed roller gates, could only rest against the concrete sill of the dam or be raised. The district design team's work on submersible and overflow technology for roller gates yielded results in terms of Tainter gates as well. Dams 20 and 16 included both non-submergible and submergible Tainter gates. The non-submergible Tainters on these two dams were very standard; steel skin plates only on the water side of the curved water face of the gate. The main water face of the submergibles were identical to that of the non-submergibles; however, the submergibles had an additional overflow plate arching back downstream from the top of the gate face.

These first submergible Upper Mississippi River Tainter gates are forerunners of more sophisticated non-submergible and submergible Tainter gates. Rock Island District engineers initiated new kinds of submergible Tainter gates, along with submergible roller gates at Dam 18 in May 1935. Steel skin plates, similar to those used on roller gates, totally surround a steel truss frame in these new submergible Tainter gates. The frame was the shape of a three-quarter ellipse. According to Major Wheeler, district engineers took the final step from a drum-type submergible Tainter, in which there were steel skin plates only on the water side of the curved water face, to truss-type Tainter gates totally surrounded by steel skin plates, because model studies indicated that the drum-type submergible Tainter "develops a negative pressure on the crest which may cause vibration and excessive fatigue, or corrosion of the metal."[92]

Manufacturers found these new gates objectionable as originally designed. They were difficult and expensive to build. The truss framing shown on the contract drawings required the distortion of certain connection angles. In August and September 1935, Rock Island District designers revised the framing, substituting a girder frame for the truss frame. The September 4, 1935, finalized drawings for Dam 11 in the Rock Island District are the first representation of mature elliptical Tainter gate design.[93]

Despite having scour problems with these submergible gates similar to those they were having with submergible roller gates, Rock Island District engineers incorporated this elliptical Tainter gate in the five dams founded on sand, which they designed after Dam 18. However, just as they attempted a new solution to their problems with submergible roller gates in their April 1936 design for Dam 22, they tested also new approaches to Tainter gates design there. The one submergible tainter gate the Rock Island District design team included in Dam 22 was a variant of the elliptical Tainter design evidenced at Dams 11-13, 17, and 21. The engineers added elliptical shields on either end of the elliptical Tainter gate. When the gate was closed or submerged, these prevented water from seeping between the main body of the gate and the piers from which it was suspended. However, their more important Tainter gate innovation at Dam 22 was the introduction of a new non-submergible Tainter gate. This gate, like their 1935 submergible Tainter, was a truss-type Tainter. However, these non-submergible gates were arch shaped, not elliptical. The Rock Island District design team apparently wanted the improved longitudinal rigidity, increased strength and ruggedness of the elliptical Tainter gate, but did not need, at a dam founded on bedrock, the scour dimunition offered by the submersible gate, especially since creating the necessary two level sills in bedrock would have been very expensive. This is apparently the reason that the district used these new non-submergible Tainter gates exclusively in its design for the bedrock-founded Dam 14, completed four months later in August 1936.[94]

The Corps also followed up on the district's submergible Tainter gate experiment at Dam 22. In 1939, the Corps' Hydraulic Laboratory at Iowa City made 19 models of this gate and conducted 157 tests on them, in order to develop a satisfactory stilling basin for submersible Tainters and a design for improved Tainter gate hoisting machinery and operation. Operating methods had also evolved significantly as the Upper Mississippi River Nine-Foot Channel Project progressed. The Rock Island District originally designed all 40 Tainter gates in Dam 20, to be operated from specially-designed locomotive hoist cars running on the dam's service bridge. However, the district later modified the design for two of the Tainter gates. The engineers designed these two to be operated individually , using line shafts and motors housed in installations above each gate. As Colonel Wheeler explained at the time, these installations were intended "to show the practical and economic advantages of this system" over the hoist system included in the original design. The gates, as built, were "an experiment which will be applied to all others in the system if it works." The Tainters in Dam 16 (final design in September 1934) and all subsequent project dams utilized line shafts and motors housed in installations above each Tainter gate to individually operate those gates. Although each gate operates independently of the others, they could be operated simultaneously as well. As the designers continued to modify the basic Tainter gate, they could be operated simultaneously as well. Once elliptical Tainter gates had been developed, substantial changes had to be made to operating equipment. The Tainters chattered and vibrated during operation tests on the first two sets of elliptical Tainters installed, those in Dam 11 and 18. Insufficient rigidity and the relatively large circular pitch of the jack gear caused these problems. In January 1937, the Corps decided to change to heavier gears with increased diametral pitch. In the case of dams where the operating machinery had already been installed, the Corps removed and replaced it after the dams were complete.[95]

Rock Island District engineers refined other auxiliary parts of the gate systems after completing the contract drawings for Dams 11 and 18. After using the emergency bulkheads for the roller gates at Dam 15, the district realized that considerable silt accumulated inside the units, increasing their weight as well as making them more expensive to clean. Consequently, the Rock Island design team modified the plans for the roller gate bulkhead units to provide for end guide and reaction rollers, buffer blocks, molded rubber end seals, more efficient curb plate splices, a better pickup device, and projecting angles in the bulkhead recesses against which the end seals bear. The engineers also studied and investigated improving the Tainter gate emergency bulkheads for these dams. As a result, the design team substituted riveted units for welded ones and reduced the number and costs of the units. The new Tainter gate bulkhead units were stiffer and more stable. They had less of a tendency to bend when placed. The hazard due to defective welding was reduced, as were the numbers of seals and the maintenance costs. Both the roller gate and Tainter gate bulkhead unit designs, as modified at Dams 11 and 18, became the standard units used in the rest of the Rock Island District dams.[96]

As a result of design research, the Upper Mississippi River Nine-Foot Channel Project design team succeeded in building Tainter gates to unprecedented lengths. Prior to the project, most American Tainter gates averaged 30 to 35 feet in width. The first Tainters the team built in the Rock Island District, those at Dams 20 and 16, were 40 feet wide. By 1935, when it had completed the design for the next dam (Dam 18), Rock Island District engineers were designing 60-foot-long Tainters. The steel girder frames in both the post-1935 submersible elliptical Tainter gates and the post-1935 non-submersible arched Tainter gates supported the construction of gates at this unprecedented length. It was this development which made roller gate technology obsolete and effectively brought to an end the short history of combination roller-Tainter gate dam construction in America.[97]

The Upper Mississippi River design team employed the Tainter gate principle not only in the dams, but also in the locks. The four valves in each lock are actually Tainter gates located in wells in the lock walls. These wells connect to a system of cast-in-place tunnels within the walls. The gates operate by cable drives run by electric motorized assemblies remotely controlled by switches in weatherproof cabinets on the lock walls.[98]

In most regard, the Upper Mississippi River Nine-Foot Channel Project locks expanded on well-established design tradition. One example rest in the massive fixed sides of the locks which were standard concrete masonry. Major William L. Marshall, the same officer who had pioneered Corps use of Tainter gates, conducted the Corps' first "great experiment in river construction," using poured Portland cement rather than traditional cut stone to construct lock walls in 1891 on the Illinois and Mississippi Canal (the same project on which he introduced the Corps' use of Tainter gates).[99]

The Upper Mississippi Nine-Foot Channel Project design team did make some engineering contributions to concrete masonry lock design. Many of these related to foundations and counteracting stresses and thrusts from forces not integral to locks. Foundation construction was not a particular problem for the four Rock Island District lock and dam systems sitting on bedrock: 14, 15, 20, and 22. However, the Corps built seven other systems on silty, sandy riverbed, 11, 12, 13, 16, 17, 18, and 21. These structures rest on concrete foundations set on sealed timber pile configurations. By 1934, district engineers had come to realize that the land walls of the locks resting on the piling configurations did not have adequate stability to resist the horizontal thrust imposed by the back filling necessary to create the lock esplanades. So, they added a series of reinforced concrete struts to the foundations to the lock chambers. The top of these struts were at the level of the lock floor. Thus, a portion of the horizontal thrust imposed on the landwall by the esplanade fill carried to the riverward wall of the lock. They also required struts between the land walls and the riverward wall of the lock upstream from the upper miter sill and downstream from the lower miter sill.[100]

Similarly, Rock Island District engineers redesigned the foundations of the guidewalls of several of locks. The Upper Mississippi River design team departed radically from standard practice in designing the foundations for the lock guidewalls for this project. Past practice keyed these guidewalls to rock foundations where such foundations existed. During this project, guidewalls were constructed on timber cribbing partially filled with rip-rap, concrete being supported on timber stub pilings either placed directly on rock or driven to refusal. The substitution eliminated the necessity of expensive cofferdams for this portion of the work.[101]

The guidewalls at several of the locks resting on pilings had the same weakness to backfilling as the land walls. The Corps held an inter-district conference and came up with a solution to the problem. Struts could not be used since no riverwalls existed to absorb horizontal stress. The conferees decided that batter piles with a wider crib and some additional vertical piles would give the necessary support.[102]

It is somewhat unusual that the Corps built foundations for and portions of a third lock wall built at each Upper Mississippi River Nine-Foot Channel complex. This section of wall, lying riverward of the main lock, included the upstream riverward gate recess for an auxiliary lock. The Corps only completed one auxiliary lock in the Rock Island District, that at Lock and Dam 15. After that auxiliary lock was completed on November 14, 1931, the rest of the auxiliary locks were left incomplete, providing only flexibility for future expansion or easily secured alternate navigation passage facilities, should the main lock need to be out of service for any considerable period of time.[103]

Although it did not complete the auxiliary locks, the Corps installed their upstream gates. The upstream auxiliary lock gates, like the two sets of gates enclosing the main lock chamber, are standard steel skin-plated miter gates. However, the auxiliary gate set are only 100-feet-wide, while those on the main lock are 110-feet-wide. With the exception of Lock 15, the Corps did not install the machinery to operate the auxiliary lock gates. The main lock gates are electrically-operated, motor assemblies housed in machine pits in the lock walls, adjacent to each gate leaf, power arms and gears which open and shut the gates. The two leaves in each set of gates are hinged panels balanced on steel pintels embedded in the lock floor and attached at their quoin ends to the lock walls. When closed, the miter cut ends of the two leaves toe together in the center of the chamber, forming a "V" configuration pointing upstream. The lock staff operates each pair of gates independently by remote control switches located in weatherproof cabinets on the lock walls.

Miter gates are the most traditional type of gate used to enclose lock chambers, having been used for hundreds of years on canal locks. There were few problems involved in designing miter gates when the locks they enclosed were 18 feet wide, an average mid-nineteenth century size. In the 1870s, it was not unusual for locks to be 80 feet wide. Major Amos Stickney counterbalanced the stresses generated by the 40 feet of lock gate hanging suspended from each lock wall on the Des Moines Canal locks with iron cables that ran to a spar, or pole. The pole was supported by cables anchored away from the lock walls. This arrangement served to reduce the effective weight of the gates, kept the lock gate from tearing loose from its anchorages in the wall, reduced the wear on the pintel, kept the lock gate from sagging in the middle, and made the gates easier to operate. However, when the Corps faced designing 110-foot mitering gate for the Davis Island Lock and Dam, its Ohio River design team concluded that such lock gates could not be built with available materials. This ushered in a 30-plus year period, in which Corps designers either restricted their structures to an obsolete 80-foot width, as in the case of the Rock Island District's Moline (1905) and Le Claire (1913) locks or experimented with innovative lock gate designs.[104]

By the time Hugh L. Cooper, working closely with Montgomery Meigs, designed the Keokuk lock gates (probably between 1908 and 1910), engineers had almost worked their way back to miter gates. The lower gates at Keokuk (still extant, but not operated since 1977) span a 110-foot-wide lock chamber and are almost identical to the steel skin-plate miter gates, which were the final outcome of this particular evolutionary process. However, the upstream faces on the lower Keokuk gates are not flat, rather they are curved to make use of the strength of an arch. They also have an interior framing which allowed their lower thirds to serve as buoyancy chambers which reduced the friction and wear on the pintels and to make the gates easier to operate. In 1913, the Louisville District engineering staff, under William H. McAlpine who later played such a significant role on the Upper Mississippi River Nine-Foot Channel design team, finally solved the engineering problems inherent in developing a standard shaped 110-foot-wide mitering gate. The Louisville District team melded the interior bracing frame surrounded by steel-skin plates of gates, such as those at Keokuk with the flat-leaf form of the traditional miter gate. The resulting gate was strong enough to do its job well, yet light enough to be easily operated.[105]

In 1920, the Corps brought this Ohio River design to the Upper Mississippi. As part of the re-examination and revision of the designs for the Le Claire Canal and Lock, the Cincinnati Division of the Corps of Engineers, which was concurrently churning out the designs for the 110-foot 1913-style miter gates for the continuing Ohio River Nine-Foot Channel Project, designed an 80-foot-wide steel skin-plated lock gate for the Le Claire lock.[106]

Although the basic miter gate used on the Upper Mississippi Nine-Foot Channel locks has been developed by 1913 and used on the Upper Mississippi aince the Hasting Lock, completed in 1930, the Corps engineers did continue to perfect the design during the course of the project, as they learned more and more from the construction of each complex. For example, at Lock 20 (the first district design by district staff), the contractor had considerable trouble in erecting the miter gates. The difficulty centered on filling up the vertical water seal. Engineer McCormick had deviated from the conventional wood-on-concrete seal at the quoin end of the gate. Instead, he had substituted a rubber seal on the quoin post of the gate, sitting on a stainless steel plate embedded in the masonry. The design did not prove effective. When the gate was closed, the pintel was pushed upstream on its seat from 1/8-inch to 1/4-inch, resulting in a corresponding opening between the bottom seal and the miter sill. The district engineering staff decided to replace the rubber seals at Lock 20 with oak seals. However, they remained convinced that the rubber seals offered decided advantages and recommended specific design changes in them, so that they could be used on all future installations. When made, these changes kept the problem that had occurred at Lock 20 from re-occurring. The Rock Island District design team successfully used rubber seals, modified as a result of the Lock 20 experience, on all its subsequent locks.[107]

The Corps also corrected problems in lock gate operating machinery at Lock 20. McCormick incorporated changes in Lock 20 that emerged from their experience at Lock 15. The original design of the Lock 20 gate operating machinery called for single speed motors which gave one minute operating time for opening and closing the gates. Before these machines were installed at Lock 20, operating experience with one minute cycle at Lock 15 showed this speed to be too great for safe operation. Thus, the district had the motors for the lock gates at 20 reworked to give two-speed operation. The high speed winding developed 25 hp at 1200 rpm resulted in a closing time of one minute. The low speed winding developed 5 hp at 300 rpm for closing time of four minutes. These reworked motors served the lock effectively and efficiently for over 50 years.[108]

The district did not correct some of the problems uncovered as the complexes came into operation, until the whole project had been completed. Upon completion of Lock and Dam 20, in 1935, the design team became aware of a problem that had not affected Lock and Dam 15. Strong outdrafts made navigation into and out of the upstream end of Lock 20 very difficult. In an effort to correct the problem, district engineers ordered Lock and Dam 20's operational staff to keep the Tainter gate closest to the lock closed as much as possible to help cut down on the outdraft. The engineers also encouraged tow operators to hire an extra tow boat at Canton, Missouri, to help hold the head of their tow in. However, two years later, in 1937, Lock and Dam Systems 16, 18, and 11 were completed; all had equally severe outdraft problems. A year later, in 1938, Lock and Dam Systems 21 and 22 went into operation. They, too, had severe outdraft problems. District engineers confronted the fact that the designers had made inadequate engineering assessments. The district staff began trying to come up with design solutions which could retrofit all six locks. They developed a 500-foot, concrete, cell foundation extension to the upstream end of the riverward wall of the auxiliary lock. The foundation cells extend almost to the surface of the upper pool. Only the smallest portion of the wall is under water; it offers virtually no obstruction to the flow of water. Water flows freely under the wall, around the individual foundation cells. By May 1940, Rock Island District engineers had developed detailed plans for this structure and adapted it to each of the individual sites. Contractors completed the structures as Locks and Dams 11, 16, 18, 20, and 21 by 1942 and at Lock and Dam 22 by 1943.[109]

Locks and Dams 13 and 14, which went into operation in 1939, also had severe outdraft problems. However, the district engineers did not apply this solution. They could not do this at Lock and Dam 14. There is no incomplete auxiliary lock riverward of the main lock at complex 14. Consequently, the designers adapted the riverwall extension for application directly to the riverward wall of the lock. They developed a totally different solution for Lock and Dam 13. There, they added a simple, 1,064-foot-long mooring levee extension to the upstream guidewall. With the upstream guidewall extended, boats could be physically held against the guidewall. The Corps added a similar mooring levee extension to the upstream guidewall at Lock and Dam 15. Contractors completed these remedial structures at Locks and Dams 13, 14, and 15 in 1942.[110]

The extensions of the upstream guidewalls at Locks and Dams 13 and 15 proved such a success that the district began preparing to install similar, but smaller, additions to Locks and Dams 11, 21, and 22 before the year was out. In 1941-42, district engineers also added approach flow deflecting dikes at Locks and Dams 11 and 12, where the outdrafts were more severe. They added further extensions to the upstream landwalls at both 11 and 22 again between 1947 and 1950. In 1950, they also added another transitional section of approach dike and a mooring cell to Lock and Dam 13. However, outdraft problems still troubled them at the other nine complexes in the district. By 1951, engineers developed a uniform remodeling program to handle the outdraft problems at all the lock and dam systems in the district. That year, the district added upstream guidewall extensions at Locks and Dams 12, 14, 15, 16, 17, 18, 20, 21, and 22.[111]

Once the district made these modifications, eleven of the Upper Mississippi River Nine-Foot Channel Project Lock and Dam Systems within the Rock Island District reached their mature form. Although alterations have been made since then, the basic form and massing of the structures remained stable until 1986, when the Corps began a new cycle of maintenance and reconstruction. Beginning with Lock and Dam System 20, all of the complexes in the district are presently undergoing major rehabilitation.

The district brought the twelfth system, Lock and Dam System 19, into its mature configuration in 1957 when it completed the new 1,200-foot-long Lock 19. The same act that authorized the Nine-Foot Project in 1930 also authorized the Corps to construct a new, standard 110-foot by 600-foot lock at

Keokuk, but did not authorize the Corps to build a new dam. Planning for this new lock began in 1930, but there were serious problems concerning where to locate it without interfering with the operation of either the commercial power plant or the Corps' dry dock. The Corps settled on a location in 1937, at which time all other structures in the district were already completely planned, if not already under construction. Upon selection of a location for a new Lock 19, the engineers began to tinker with the design. The designers considered deviating from the standard Nine-Foot Channel Project lock design because of the 40-foot lift at Keokuk. However, in 1945, before the engineers had completed detailed plans and specifications and model studies for this lock, Rock Island District planners recommended that the length of the new lock be expanded to 1,200 feet to allow what were becoming standard long tows to pass through the lock as one piece, rather than having to be divided into two lockable pieces as was routine procedure at the other locks in the Nine-Foot Channel System. In 1952, Congress authorized the Corps to build the lock in this enlarged size. The new lock used much of the technology developed in the Upper Mississippi River Nine-Foot Channel Project of 1930-1940, but it also incorporates newer technologies developed in the ten-year interval between the completion of that project and the initiation of this new construction. Other than the actual lock size, the most important difference between this lock and the earlier ones is the gates. The upper gates are single leaf, hydraulically-operated gates and in no way resemble the lock gates built as part of the nine-foot project. Although there are two gates, either one functions to hold back the upper pool. The innermost gate is considered the main gate, with the northernmost gate acting as the guard gate. It differs from the main gate because its size and configuration were designed for it to serve as a vehicular bridge. The lower gates are more standard; however, they use a more modern form a steel framing based on solid "L" irons. The gate arms are arranged and pivoted differently, but still use a series of gears and arms operated by electric motors. Unlike their predecessors, these are located in a room below the deck of the lock. A feature that also makes this lock unique is the system of underground galleries (tunnels) that run under the walls and chamber of the lock. These provide ready access to the electric cables that they house as well as being a means to get to the other side of the lock chamber. The four tainter valves are in much larger uncovered wells with their operating machinery also in rooms below the lock deck. The lockmaster's office and shop were removed from the control station and put in a separate building. A second identical control station was put on the riverwall to improve ease of use. The architecture of the structure and appurtenances reflect the styles of the 1950s. The control stations, tunnel cover structures, and lockmaster's office are all designed in a very muted and understated Art Deco/Art Modern-influenced style that reflects much public architecture of the 1940s and 1950s. The most notable use of this style can be found in State Police headquarters and Transportation Department facilities from that time period throughout the country.[112]

Just as the technologies and engineering design evolved over the 10-year project period, the architectural aspects of the Upper Mississippi River Nine-Foot Project designs also evolved. Yet, interestingly enough, all of the various designs fall into two distinct stylistic categories: those for which the design team completed the plans between July 1931 and June 1934; and those for which the design team completed the plans between August 1934 and September 1936.

By June 1934, the design team completed the designs for the locks, dam, seawall, power house, storage house, and lock tender's shelter house at Lock and Dam System 15; the lock, dam, and power house (now known as central control station) at Lock and Dam System 20; and the central control stations at Lock and Dam complexes 11, 12, 16, 18, 21, and 22. All these structures reflect pre-World War I German engineering architecture. The architectural aspects of the actual lock and dam designs are most conspicuous in the roller gate piers. The machinery housing units (known as pier houses) perched atop these piers are characterized by tile-covered hipped roofs, rubbed concrete wall finishes, multi-pane industrial sash windows, and engaged buttress detailing. They are remarkably similar to the hipped roofed pier houses perched atop the roller gate piers of the 1916 Grand River Diversion Dam. Although American engineers reworked the plans for that dam between 1914 and 1916, the M.A.N. Company developed its initial design and prepared the original plans in Germany between September 1913 and April 1914. It is unlikely that the American engineers reworking the plans redesigned the architecture of the pier houses. They did not want to delay construction any more than necessary and, therefore, would have most likely changed only those aspects of the design which would have made construction or production in the United States difficult. The architectural style of the pier houses would not have been a consideration.[113]

The power house and lock tender's shelter house at Lock and Dam System 15 and the central control stations at Lock and Dam complexes 20, 11, 12, 16, 18, 21, and 22 mirror the architectural aspects of these early pier houses. These nine buildings all have tile-covered hipped roofs, rubbed concrete wall finishes, and multi-pane industrial sash windows. All, except the lock tender's shelter house which, for functional reasons, does not have enough wall surface to accommodate them, also have the engaged buttress detailing.

The U.M.V.D., under Spaulding, McAlpine, and Ylvisaker, developed all these German architectural design-inspired structures and buildings. In 1982, Charles Ross, an engineer who worked in McAlpine's St. Louis office in the 1931-33 period, recalled McAlpine keeping a German draftsman busy translating meters into feet for the American engineers working on the project.[114]

The structures and buildings for which the Rock Island District under Wheeler, Gesler, Silkman, Coughlin, Berbert, and Abbott completed the plans between August 1934 and September 1936 reflect an architectural design philosophy different from the earlier designs. The roller gate piers on Dams 16, 18, and 11 (the plans for which Abbott signed in September 1934, May 1935, and July 1935, respectively) are much more standardized and streamlined. The pier houses are integrated into the overall pier design. Although the wall finishes remained rubbed concrete, the roofs of these more modern style structures are flat with slit, three pane windows and no buttress detailing. These designs were cheaper to construct and just a bit easier for the untrained workers the contractors' employed to build these structures.

The Corps had already finalized the roller gate pier designs for Dam 16, 18 and 11 before it completed development of the submergible roller gate. The design team did not include submersible roller gates in Dam 16. The engineers first used submergible rollers in the Rock Island District in Dams 18 and 11. The new gates required new operating machinery. As the dams were being constructed, the designers made improvements in the chains and the sprocket teeth which accommodated the chains and in the materials requirements.[115]

Thus, it is not surprising that the next six sets of roller gate piers that the Rock Island District team designed were slightly different that these first three sets signed by Abbott. The shape, fenestration, surface finish, and detailing are the same as the first three sets of new modern American-style roller gate piers. However, there is no concrete mass inside the upper half of the oval roller gate track of the roller gate piers at Dams 12, 13, 14, 17, 21, and 22 (the plans for which Abbott signed between September 1935 and September 1936). By November 1936, as Colonel Gesler explained at the time, the district was having the large opening left below the pier house of each roller gate pier filled with a steel diaphragm, in order to improve the architectural appearance of the dams.[116]

Just as the buildings designed concurrently with the old style roller gate piers, the buildings designed concurrently with the new style roller gate piers mirrored some of the architectural aspects of these roller gate piers. The central control stations at Locks and Dams Systems 14, 13, and 17 all have flat-roofs. The massing and proportions of the buildings are also reminiscent of the taller, more streamlined pier structures, as is the modern style. These buildings have a first floor and mezzanine level above the ground, while the earlier-designed buildings have only one floor above the ground. However, unlike the rubbed concrete finish on the piers, the buildings have face brick exterior walls.

The architectural design evolution in the project ended in 1936 when the Rock Island District finalized the last of the exterior plans for buildings and structures. The engineers continued to design the machinery and interior machinery layout for at least two more years. The technological evolution inherent in the project naturally continued as long as this process continued.

Some of the technological developments made in the project grew out of the construction process. For example, since each contractor was responsible for the design of the cofferdams on his work, innovations in cofferdam technology originated with these firms rather than the Corps' design team. Cofferdams were one of the most important and expensive features of the construction process. The contractors built cofferdams as the first step in their construction process. The removal of these dam cofferdams usually signalled the total completion of the project. Failure of a cofferdam could not only destroy the work done during that contract, but also destroy work completed by another contractor under a separate contract. Such failures became the subject of lengthy court battles over who had responsibility for the resulting damage. These court cases went on, in some cases, for years and involved hundreds of thousands of dollars, several contractors, and the Corps of Engineers.[117]

Contractors on the Upper Mississippi Nine-Foot Channel Project built two basic types of cofferdams: timber/crib configurations and steel sheet piling configurations. All the timber/crib cofferdams were Ohio River box-type. This style of cofferdam had been used extensively since the 1870s. Contractors built these by setting wood sheathing vertically inside a frame of horizontal walers and tie rods. Cofferdams made of interlocking-steel sheet piling were first used on a Corps project in 1898 to raise the Maine from Havana harbor. Contractors began using them on the Ohio River in 1917. However, William McAlpine, then supervisor of construction on the Lower Ohio, discouraged their use. He thought the difficulty and expense of removing the piling after work was completed outweighed their advantages. McAlpine apparently continued in this belief despite the reduced first cost of steel sheet piling and its high salvage value. For despite these obvious benefits to them, contractors did not begin to use them on the Upper Mississippi River project until McAlpine's transfer to the Office of the Chief of Engineers removed them from direct supervision of such project details. However, the contractors at both Dams 20 and 16, the first two dams begun after McAlpine's transfer, used steel sheet piling cofferdams. Thereafter, they were in very general use on the project.[118]

Contractors used a variety of configurations for these steel sheet piling cofferdams. For example, in the 1934 project, the S. A. Healy Company built individual circular cells with diameters of 20 to 30 feet and connected them by short arcs of circles to form cofferdam 28 at Dam 20. While, in January 1935, the Central Engineering Company held parallel sides, about 20 to 30 feet apart, with tie rods and walers to form its first Dam 1 cofferdam. These were the two structures that the Rock Island District used in 1935 tests intended to help correlate the most important variable fsctors affecting the use of cofferdams on previous deep streams. The district was always cognizant that their work could have a significant impact on future engineering.[119]

SUMMARY

The design, construction, and present form of Upper Mississippi River Nine-Foot Channel Locks snd Dams 11-22 illustrate significant developments in low head movable dam technology. By far the most importsnt result of this project on future slack-water navigation practice was the U. S. Army Corps of Engineer's abandonment of navigable dams; The most importsnt technological development was improvements in the Tsinter gate. The advancement in both Tainter gate size and strength through innovative design represents a msjor contribution to dam technology that resulted in both the submergible and non-submergible elliptical Tainter gate. The complexes in the district also represent an important page in the history of both roller and Tainter submergible movable dam gates. The continued efforts to improve functional submergibility are amply illustrsted in the gates designed by the Rock Island District staff. The use of Poiree wiers snd stilling basins to make these gate types feasible on sand founded dams is sn integral part of this story. The unique use of a Tainter and roller gate combination slso are an interesting page in the history of movable dam technology, particularly since the combined use is in the project that marks the last important use of rollers. This project msde them obsolete. Another importsnt advancement in gate design was the new Tsinter gate hoisting system the Rock Island District developed.

Although strides in the use of non-nsvigable dams and the specific gate design and construction represent the most significant technological developments demonstrated by these particular locks and dams, there were many more. The emergency bulkheads used to close off individual water channels underwent a significant evolution in this project. The concrete, piling, strut and batter methods used in tying the locks' landwalls to the river walls and in founding the landward guidewalls to resist backfilling represent important advances for this project. One of the major problems that required technological and operational solutions was the upstream outdraft that made nsvigation difficult. The riverwall extensions that were used as the major solution to this problem represent an important development that continued well after the official end of the project. Other important developments include the use of incomplete auxiliary locks and the use of rubber for lock gate water seals.

The district's complexes and history also illustrate a number of standard features and technologies used in modern locks and dams, such things as the lock configurstions, fixed service bridge systems, the variety of cofferdams used in construction, the use of concrete batterwalls and monoliths, lock gates, and lock arrangement. The service buildings used in the complexes provide a good example of the architectural development of styles for utilitarian technological structures.

NOTES

1 Arthur S. Link, "What Happened to the Progressive Movement in the 1920s?", American Historical Review 64 (1959) pp. 833-851 as reprinted in David M. Kennedy, ed., Progressivism: The Critical Issues (Boston: Little, Brown, and Company, 1971), pp. 158-159; U.S. Congress, House, Mississippi River, Between Mouth of Missouri River and Minneapolis, Minnesota (Interim Report), H. Doc. 290, 71st Cong., 2nd sess., 1930 (a lengthy report on the 1927-1929 Corps of Engineers studies of the feasibility and practicality of a 9-foot channel in the Upper Mississippi. Although not published until Feb. 15, 1930, the report was dated Dec. 16, 1929. This report is a seminal document in the study of the history of the Upper Mississippi River Locks and Dams. Hereinafter cited as H. Doc. 290); and U.S. Congress, House, Hearings before the Committee on Rivers and Harbors, House of Representatives, 73rd Congress, 1st Session, on the Subject of Continuing the Improvement of the Upper Mississippi River, and Proposals of the American Railways in Connection with the Improvement of Inland Waterways, Distribution of Expenses for Reconstruction of Bridges and other structures, Proposed Tonnage Tax or Toll Charge, May 2, 3, 4 and 5, 1933 (hereinafter referred to as May, 1933, Hearings), p. 59. There are many good studies of farm politics and the farm plight in the 1920's. This and the following paragraphs draw heavily on the standards Theodore Salontons and John D. Hicks, Agricultural Discontent in the Middle West, 1900-1939 (Madison: University of Wisconsin Press, 1951) and Russell B. Nye, Midwestern Progressive Politics (New York: Harper and Row, 1959), without necessarily accepting their argument that Progressivism is an outgrowth of Populism or that farm interest group politics in the post war years is clearly Progressivism. Much information on the specific situation in the Upper Mississippi Valley is drawn from the arguments offered over and over again in successive Congressional hearings between 1924 and 1934 and in successive Corps of Engineers reports on this project. All these hearings and reports are cited in the bibliography as well as referenced in these notes as appropriate.

2 The fact that these administrations were opposed to direct farm aid does not mean that the idea did not have strong adherents. It was a resident of the Upper Mississippi Valley, George N. Peek, a plow manufacturer from Moline, Illinois, who in 1921 advanced the most famous scheme for direct federal aid to farmers. He proposed that the federal government buy up surplus American agricultural products. In "Equity for Agriculture" Peek suggested that the federal government should by American farmers surplus wheat production. The 1927 McNary-Haugen bill which Coolidge vetoed only to have Congress pass again in 1928 and Coolidge veto again was a variant of Peek's plan. See Gilbert C. Fite, George N. Peek and the Fight for Farm Parity (Norman, OK: University of Oklahoma Press, 1954), passim.

3 The small, light draft craft that plied the Upper Mississippi for nearly 11,000 years prior to the arrical of steamboating were well suited to existing conditions. The first steamboat plied the Mississippi below Cairo, Illinois, in 1811, but it was not until 1820 that Major Stephen H. Long in his Western Engineer, a specially built light-draft U.S. Army Corps of Engineers survey and exploration boat, brought steamboating to the Upper Mississippi. In 1823, the Virgina, a passenger and supply boat was able to pass both the Des Moines and Rock Island rapids and powered commerce had come to the Upper Mississippi.

The Corps 1829 work is reported in U.S. Congress, House, Message from the President of the United States, Transmitting Copies of Surveys Made in Pursuance of Acts of Congress, of 30 April, 1824, and 2nd March, 1829, E. Doc. 7, 21st Cong., 1st sess., 1929 (hereinafter referred to as E. Doc. 7), p. 1-25. See also Roald Tweet, A History of the Rock Island District U.S. Army Corps of Engineers 1866-1983 (Rock Island: U.S Army Engineer District, 1984), (hereinafter referred to as Tweet, Rock Island District), pp. 38-40. Meigs is slightly less well known than Lee; however, he was an illustrious engineer. A West Point graduate, Meigs served as Union Quartermaster General during the Civil War. Later he supervised construction of several important Corps projects including the Capital Dome, the Washington Aqueduct, and the Pension Building in Washington, D.C. The Corps reported Lee and Mieg's 1837 survey work in U.S. Congress, Senate, Report from the Secretary of War, in Compliance with a Resolution of the Senate of the 25th Instant, in Relation to the Rock River and Des Moines Rapids of the Mississippi River, S. Doc. 139, 25th Cong., 2nd sess., 1837. Lee reported on his and Bliss' work in 1838 and 1839 in Robert E. Lee, "Survey Report to Colonel J.G. Totten, Chief of Engineers," Oct. 21, 1839, Record Group 77 (hereinafter referred to as RG77), National Archives, Washington DC (hereinafter referred to as NA). See also, Tweet, Rock Island District, pp. 42-48; Roald Tweet, Taming the Des Moines Rapids: The Background of Lock 19 (Rock Island: U.S. Army Engineer District, 1978), (hereinafter referred to as Tweet, Taming Des Moines Rapids), p. 2. John G. Floyd, the supervisor of the work, reported the Corps 1854-1856 work on the Upper Mississippi in U.S. Congress, Senate, Report of the Secretary of War in Answer to a Resolution of the Senate Relative to the Improvement of the Des Moines and Rock River Rapids, E. Doc. 12, 33rd Cong., 2nd sess., 1854; U.S. Congress, Senate, Report of the Secretary of War, Communicating in Compliance with a Resolution of the Senate of December 26, 1856, Information Relative to the Des Moines and Rock River Rapids, and the Harbor at Dubuque, Iowa, E. Doc. 45, 34th Cong., 3rd sess., 1857; and U.S. Congress, House, Letter from the Secretary of War, Transmitting a Report Furnishing Information in Relation to the Improvement of the Des Moines Rapids, E. Doc. 83, 35th Cong., 1st sess., 1858. See also Tweet, Rock Island District, pp. 57-61; and Roald Tweet, A History of Navigation Improvements on the Rock Island Rapids (The Background of Lock and Dam 15) (Rock Island: U.S. Army Engineer District, 1980), (hereinafter referred to as Tweet, History Improvement Rock Island Rapids), pp. 3-4.

[4] The idea of a lateral canal at the Des Moines Rapids did not originate in 1866. As early as 1829, Lt. Napoleon B. Buford, the officer in charge of the Corps' first study of the Upper Mississippi, considered the possibility of constructing lateral canals around both the Des Moines and Rock Island rapids. He did not, however, recommend it as he saw the problems associated with constructing lateral canals, particularly a lateral canal around the Des Moines Rapids as "almost insurmountable" (E. Doc. 7, p. 20). In 1836, Captain Henry M. Shreve, a famous early engineer who achieved almost legendary status along the Mississippi River and its tributaries and served as Superintendent of Western River Improvements for the U.S. Army Engineers from 1826 to 1841, did recommend that the Corps of Engineers develop a plan to allow circumnavigation of the worst sections of the Des Moines Rapids via a lateral canal along the Iowa shore (Florence Dorsey, Master of the Mississippi, Henry Shreve and the Conquest of the Mississippi (Boston: Houghton, Mifflin, Co., 1941), (hereinafter referred to as Dorsey, Shreve), p. 189; Tweet, Rock Island District, p. 40; and Tweet, Taming Des Moines Rapids, p. 3.). In 1837 Lee and Meigs rejected Shreve's idea (Tweet, Rock Island District, pp. 42-48). In 1853, Long had Lt. Gouverneur K. Warren resurvey the area and re-examine the issued. In his 1854 report, Warren declared that, while a

lateral canal such as Shreve had suggested might eventually become the permanent solution to the navigational problems at the Des Moines Rapids, he recommended that for at least the forseeable future the government restrict itself to continuing to blast a channel through the rock (Tweet, Rock Island District, pp. 54-57.)

Private interests in Keokuk and the state of Iowa refused to let the idea of a lateral canal die. In 1849, the state of Iowa authorized the Navigation and Hydraulic Company of the Mississippi River to acquire the right-of-way for a lateral canal around the Des Moines Rapids. The company's chief engineers was Samuel R. Curtis, a West Point trained waterway improvement engineer who consistently advocated the use of the most innovative technology available, waterway improvement technology which the Corps did not adopt in most cases until 40 years after Curtis experimented with and applied it. Curtis resigned from the service after 1 year of post-school active duty to become in 1832 Chief of Engineer of the Muskingham River Improvement Organization in Ohio. There, Curtis created a slack-water navigation system using a series of locks and dams. In 1847-49 he served as Chief engineer for an Iowa state-created board, attempting to come up with plans for improving the Des Moines River. He recommended a combination of slack-water navigation and lateral canal. In 1849, Curtis recommended a canal be built around the Des Moines Rapids along the Iowa shore from Montrose to Keokuk with one 24-foot lift lock at Keokuk. Curtis recommended that the canal be used as an enormous mill race to generate power. When the Navigation and Hydraulic Company could not raise enough money to execute the plan, it was abandoned until 1856 when Curtis returned to Keokuk, was elected mayor, and refined his plan by increasing the width of the canal he was proposing to 200 feet. For a discussion of Curtis' Des Moines Rapids plans see Tweet, Rock Island District, pp. 90-91.

The actual canal constructed was authorized as part of the 4-Foot Channel Project in U.S. Army, Corps of Engineers, Annual Report of the Chief of Engineers United States Army, to the Secretary of War for the year 1867 (Washington, DC: Government Printing Office, 1868), (Beginning in 1867 the government started printing and binding the Annual Report of the Chief of Engineers as a separate volume. The series has continued to be issued every year since then. Published at the end of each fiscal year, the exact title and format of the series has varied slightly from time to time. Hereinafter all reports from this series will be referred to as Annual Report followed by the fiscal year which the report covers.), p.265. For details on the canal and locks see Tweet, Rock Island District, pp. 91-93; and Ben Hur Wilson, "The Des Moines Rapids Canal," Palimpset V, No. 4 (April 1924), pp. 120-130.

[5] Congress authorized the 4 1/2-Foot Channel in the Rivers and Harbors Act of June 18, 1878. Rivers and Harbors Acts are the basic legislation authorizing Corps of Engineers' (or between 1838 and 1865, the Corps of Topographical Engineers') waterway improvement activities. Since 1824 almost every Congress has passed one or more rivers and harbors acts. The most noteworthy exceptions are the 26th Congress (1839-1841), the 29th through 31 Congresses (1845-1851), the 33rd through 38th Congresses (1853-1865), the 92nd Congress (1971-1973), and the 94th through the 97th Congresses (1975-1983). Each act has two principal parts. One section authorizes the Corps to conduct preliminary examinations and surveys at designated locations. The other major section authorizes specific rivers and harbors projects in accordance with reports previously submitted by the Chief of Engineers. A conveniant printing of much of the legislation relating to Corps of Engineers' waterway improvements is United States Army, office of the Chief of Engineers, Laws of the United States Relating to

the Improvement of Rivers and Harbors, from August 11, 1790, to January 1, 1939 3 vols. (Washington, D.C.: Government Printing Office, 1913 and 1940). No exact page numbers for Rivers and Harbors Acts contained in that volume as well as in the United States, Statutes at Large will be cited herein.

Congress authorized the Corps to create a 6-foot Channel in the Upper Mississippi River between the Mississippi River and Minneapolis on March 2, 1907. The document which underlines this legislation is U.S. Congress, House, Survey of the Mississippi River, H. Doc. 341, 59th Cong., 2nd sess., 1907 (hereinafter referred to as H. Doc. 341). The idea of a lateral canal around the Le Claire section of the Rock Island Rapids (the 3.6 miles from Smith's Island to Le Claire) did not, however, originate in 1907. As early as 1888, the Corps had developed a plan to allow circumnavigation of this stretch of rapids via a lateral canal along the Illinois side of the river. See Tweet, History Improvements Rock Island Rapids, pp. 1-2 and 11; and District Engineer officer to Chief of Engineers, 27 Aug. 1913, RG77, Entry 81, Box 798, National Archives and Records Center, Chicago, IL (hereinafter referred to as NARA-CH).

6 The fact that an Upper Mississippi waterway was perceived as being geared towards Central and South American commerce and expectations for that trade is addressed in the congressional hearings on this project by such individuals as Halleck Seaman in 1924, Herbert Hoover in 1926, and Lytle Brown in 1932. See U.S. Congress, House, Hearings on H.R. 3921 providing for the Improvement and Completion of Perscribed Sections of the Mississippi, Missouri, and Ohio Rivers held before the Committee on Rivers and Harbors, House of Representatives, 68th Congress, 1st session, March 20, 21, 22, 24, 24, and April 4, 1924 (hereinafter referred to as March-April, 1924, Hearings), pp. 101-102; U.S. Congress, House, Statement of Hon. Herbert Hoover, Secretary of Commerce, before the Committee on Rivers and Harbors, House of Representatives, 69th Congress, 1st session, on the subject of the Development of Inland Waterway Systems in the United States, Jan. 30, 1926 (hereinafter referred to as Hoover Statement, Jan., 1926), p. 15; and U.S. Congress, House, Hearings before the Committee on Rivers and Harbors, House of Representatives, 72nd Congress, 1st session, on the subject of "The Improvement of the Mississippi River between the mouth of the Missouri River and Minneapolis," Jan. 25, 26, 27, 1932 (hereinafter referred to as Jan. 1932, Hearings), pp. 40-41.

7 With the Rivers and Harbors Act of June 25, 1910, Congress established a 12 year time limit for completing the Upper Mississippi River 6-Foot Channel project. The Rivers and Harbors Act of Sept. 2, 1922, further amended the 1907 legislation authorizing the 6-foot Channel. This 1922 Act provided for dredging channels to landing places on the main river and subsidiary sloughs. The passage of this legislation did not indicate that other features of the channel were complete. It was not until Nov. 29, 1922, that the Corps open the Le Claire Canal lock, a critical feature of the 6-foot channel, to navigation and did not complete the lock until 1924.

The idea of waterway improvement as a federally sponsored economic development and/or economic assistance tool has deep roots in American history. It can be easily traced in the whig tradition from the 1808 Gallatin report prepared by Thomas Jefferson's Secretary of Commerce through Secretary of War John Calhoun's 1818 report and the debates on Speaker of the House and Presidential Candidate Henry Clay's 1820s "American System" which ushered in the first great era of federal waterway improvement work, and era which ended in the late 1830s. The idea came into vogue again after the Civil War. In this era, unlike the earlier period, the Corps began undertaking waterway improvement projects that did not have the slightest military justification. Regional improvements got a further boost following the "Compromise of 1877" which gave Republican Rutherford B. Hayes the victory in the disputed Presidential election of 1876. Hayes avowed support of internal improvements helped elect him. It was during this period that ideas very similar to those articulated in the 1920s debates about the Upper Mississippi improvements were current. The Select Committee on Transportation Routes to the Seaboard (also known as the Windom Committee) studied the needs of the landlocked regions of the United States. This committee clearly saw federally funded internal improvements creating a system intended to facilitate economic development. It urged railroad regulation and river improvement to central rail rates. Interest in waterway improvement for its economic development or economic assistance potential lasted throughout the "Gilded Age" of the 1880s and 1890s. During these years, waterway improvement projects were exclusively projects intended to aid navigation. The 1890s marked the victory of rail over warterborne transportation for long distance haulage throughout the nation, even west of the Mississippi. In the Progressive Era the idea of multiple use water resource development emphasizing similar aid to navigation, control of floods, and use of stored water to irrigate crops, generate hydroelectric power and provide water for municiple and industrial use gained wide acceptance. The Farm Bloc interests of the 1920s were, however, more concerned exclusively with navigation improvement than their immediate predecessors.

David Burner, Herbert Hoover: A Public Life (NY: Alfred A. Knopf, 1979), (hereinafter referred to as Burner, Hoover), pp. 181-182, gives an interesting account of the ad hoc St. Lawrence Seaway Commission.

Cleveland Newton's 1924 bill which specifically addresses Upper Mississippi River issues is U.S. Congress, House, A Bill Providing for the Improvement and Completion of Prescribed Sections of the Mississippi, Missouri, and Ohio Rivers, H.R. 3921, 68th Cong. 1st sess., 1924.

8 March-April, 1924, Hearings, pp. 1-3 and 24.

9 Lenore Fine and Jessie A. Remington, The Corps of Engineers: Construction in the United States, United State Army, in World War II (Washington, DC: office of the Chief of Military History, 1972), pp. 18-40. Burner, Hoover, pp. 21-22. Hoover's allegiance to the U.S. Geological Survey is shown in its transfer along with the Bureau of Mines from the Department of the Interior to the Commerce Department while Hoover was Secretary of Commerce. Burner, Hoover, p. 169. When Hoover became president in 1928, there was a renewed impetus for the creation of a new, civilian engineer dominated national public works department. To heal the breach with the private sector engineering community, in 1929 Chief of Engineers Lytle Brown announced that all further corps rivers and harbors work would be done by contract except where it was manifestly impracticle or a waste of government funds. Following this action private engineering groups eased their pressure to remove military engineering responsibilities from both the Corps of Engineers and the Quartermaster Corps. Active lobbying to consolidate federal civil works engineering in the Department of the Interior continued. In a final presidential effort in January, 1933, Hoover issued an executive order transferring the civil works functions of the Corps of Engineers to the Department of the Interior. Congress saved the Corps' civil functions by

disapproving this order in 1933.

Pressure continued under President Franklin D. Roosevelt's administration. Secretary of the Interior Harold L. Ickes wanted Interior's Bureau of Reclamation to takeover the Corps' civil works. Harold L. Ickes to Franklin D. Roosevelt 20 May 1939, in Elgar B. Nixon, comp. and ed., Franklin D. Roosevelt and Conservation, 1911-1945, vol. 2 (Hyde Park, NY: General Services Administration, National Archives and Resources Service, Franklin D. Roosevelt Library, 1957), (hereinafter referred to as Nixon, Roosevelt and Conservation), p. 336.

10 The issue of a 9-foot channel in Upper Mississippi was, however, alive enough and had enough support that some such as Marshall Hall, President of the Marshall Hall Grain Company of St. Louis--who testified at the hearings on Newton's Bill bothered to volunteer the information that they did not see any reason to build a 9-foot channel north of the confluence of the Upper Mississippi and the Illinois rivers. March-April 1924, Hearings, p. 37. The degree of completeness of the 6-foot channel in 1924 was repeatedly entered into the record by the Corps of Engineers. See, for example, U.S. Congress, House, Committee on Rivers and Harbors Report on proposed Rivers and Harbors Act, h. rpt. 581, 68th Cong., 1st sess., April 24, 1924, p. 32; ---, Committee on Rivers and Harbors Report on proposed Rivers and Harbors Act, h. rpt. 952, 68th Cong., 1st sess., June 4, 1924, p. 37; ----, Committee on Rivers and Harbors Report on proposed River and Harbors Act, h. rpt. 1053, 68th Cong., 2nd sess., Dec. 17, 1924, pp. 36-37; and ---, Report of Committee of Rivers and Harbors on proposed Rivers and Harbors Act, 68th Cong., 2nd sess., Jan. 9, 1925, p. 35.

11 March-April, 1924, Hearings, pp. 90-94. Although not a well-known figure nationally, Halleck W. Seaman was an influential force in the American transportation industry during the first 30 years of this century. He was so well known enough in the field that he required no introduction to the members of the House Rivers and Harbors Committee when he testified at the 1924 Newton Bill Hearings. Born in Clinton, Iowa, on Sept. 26, 1860, Seaman graduated with a degree in civil engineering from the State University of Iowa at Iowa City in 1882. After this he worked as a civil engineer on the western extensions of the Chicago & Northwestern Railway and the Chicago, Milwaukee & St. Paul Railway. In 1883, he began studying law in the office of Judge George B. Young of Clinton, Iowa, and in 1887 was admitted to the bar. He practiced law in Clinton until 1901 and was director and vice-president of the City National Bank of Clinton for many years, president of the American Wire Fabrics Company of Clinton and the Trojan Mining Company. However, he had his greatest impact in the railroad field. He was involved in building the Ozark & Cherokee Central railway, the Muskogee Southern, the Lorraine & West Virginia railway and the Chicago, Milwaukee & Gary railroads among others. By 1911 he was simultaneously president of 6 railroad companies and director and of the syndicate manager for another. These railroads were the Lorraine and West Virginia Railway Company; Fremont and Gulf Railway Company; Minneapolis and Rainey River Railway Company; Monistie and Grand Rapids Railway Company; Groveton, Lupkin and Northern Railway Company; Gary and Southern Fraction Company; and the Chicago, Milwaukee and Gary Railway. Seaman's major avocational interest was waterway improvement. He was a member of the executive committee of the Mississippi Valley Association, the Upper Mississippi Waterways Association of Minneapolis, and the Inland Waterways Corporation. He wrote many articles on waterways. P.B. Wolfe, Wolfe's History of Clinton County, Iowa (Indianapolis: B.F. Bowen & Co., 1911), vol. 2, pp. 1092-1094; Citizens Historical

Association, "H.W. Seaman, Attorney, Clinton Wire Cloth Company, 509 Weston Building, Clinton, Iowa," entry No. 2D13E23F1JHA/CFD, Nov. 11, 1939, copy in Clinton Public Library; "Halleck Seaman, Man of Vision," Clinton Herald, Centennial Edition, June 18, 1955; History of Clinton County Iowa (Clinton: Clinton County Historical Society, 1976), pp. 173-174. It should be noted that, although Seaman believed that by creating a 6-foot channel a 9-foot channel ultimately would be created, he did acknowledge that even a 6-foot channel could probably not be created in some reaches of the river (for example the area around Lake Pepin) by contraction works alone. He contended, however, that once 6-foot was established a to 9-foot channel could easily be accomplished. March-April, 1924, Hearings, p. 94.

[12] U.S. Congress, Senate, Report on the Proposed River and Harbor Bill (H.R. 11472) S. Rpt. 1143, 68th Cong., 2nd sess., 17 Feb. 1925, p. 15; Rivers and Harbors Act of March 3, 1925, p. 1195. The barge company's advancing the money is covered in Jan. 1932, Hearings, p. 33. A group of Minneapolis businessmen founded the Upper Mississippi Barge Line Co. the summer of 1925 in order to get the Inland Waterways Corporation to extend its service to the Upper Mississippi. During World War I, the railroads inability to handle intra-continental freight was so great that the federal government began operating barge and towboat fleets in order to re-establish waterway commerce. After the war, much of this fleet was transferred to the War Department which continued to offer barge service through its Inland and Coastwise Waterways Service. In June 3, 1924, with sections 201 and 500 of that year's Transportation Act (Public Law 185, 68th Cong.), Congress mandated the creation of the Inland Waterways Corporation, which took over from the Inland and Coastwise Waterways Service on the Mississippi system. By the provisions of this same act, upon application of the water carriers, the Interstate Commerce Commission (ICC) could order all connecting common carriers to set up joint rates. When in June 1924, the ICC ruled that the Upper Mississippi was no longer enough of a competitor to justify the ICC keeping rail rates comparable to river rates, this group of Minneapolis businessmen began to explore how to get the Inland Waterway Corporation to extend its service to the Upper Mississippi. This would mean a viable water carrier, with government subsidized low rates, would be in a position to call upon the ICC to order the railroads to set up joint rates. The men created the Upper Mississippi Barge Line Company, built boats and barges, put them in the river, and forced the Inland Waterway Corporation (by a combination of lobbying and law suits) to lease the fleet from them as of Jan. 1926, and to operate it on the Upper Mississippi. In 1926, even before the boats began operating, the Upper Mississippi Barge Line Co., the Inland Waterway Corporation, and the Illinois Central Railroad had established joint rates under the provision of the Inland Waterways Act of 124. For a fuller account see Jon Gjerde, "Historical Resources Evaluation: St. Paul District Locks and Dams on the Mississippi River and Two Structures at St. Anthony's Falls" (St. Paul: U.S. Army Engineer District, 1983), (hereinafter referred to as Gjerde, "St. Paul District Locks and Dams"), pp. 89-92; Proceedings of the Twenty-Second Convention National Rivers and Harbors Congress, Washington, D.C., December 8 and 9, 1926 (Washington, DC: Press of Randall Inc, 1927), pp. 31-33. Marshall E. Dimock's Developing America's Waterways: Administration of the Inland Waterways Corporation (Chicago: The University of Chicago Press, 1935) is an older treatment of the Inland Waterway Corporation as a whole. Michael C. Robinson's "The Federal Barge Fleet: An Analysis of the Inland Waterways Corporation, 1924-1939" National Waterways Roundtable Proceedings (Washington, DC: U.S. Government Printing Office, 1980), pp. 107-125, though shorter is a useful more modern treatment of the subject. The Corps reported on its 1925-1926 study of the need to use locks and dams to achieve a 6-foot

channel in H. Doc. 583, 69th cong., 2 sess., 14 Dec 1926.

13 U.S. Congress, House, Survey of Mississippi River Between the Mouth of the Missouri River and Minneapolis, H. Doc. 137, 72nd Cong., 1 sess., 1932, (A lengthy report on the 1931 existing situation on the river and provides a site-by-site explanation of the proposed dams, their type and function. Since this is the initial full-scale 9-foot channel plan put before Congress, the report is a seminal document in the study of the history of the Upper Mississippi River Locks and Dams. Hereinafter cited as H. Doc. 137); and War Department, Corps of Engineers, U.S. Army, Mississippi River Lock and Dam No. 15: Final Report Construction, Vol. I: Text (Rock Island: U.S. Engineer Office, Feb. 1935), (hereinafter referred to as Final Report Lock and Dam 15), p. 48, RG77, Entry 81, Box 668, NARA-CH; U.S. Congress, House, Hearings Before the Committee on Rivers and Harbors, House of Representatives, 69th Congress, 1st session on the following subjects: Report on Umqua Harbor and River, Oreg.; Report on Islais Creek, San Francisco Harbor, Calif.; Raising the levels of the headwaters of the Mississippi River; Control of floods on the Illinois River, Illinois; Allowing credit and disbursing officers for Reimbursement of certain subsistence expenses; Acceptance and approval of bids for furnishing materials and labor; Collection of commercial statistics, 26 April 1926, p. 188; and Rivers and Harbors Act of Jan. 21 1927, 69th Cong., 2nd sess., Chapter 47. It should also be noted that in addition to these prospective new dams, the Keokuk Lock and Dam already interrupted the 658 mile long navigation channel.

14 Tweet, Rock Island District, p.378. William Patrick O'Brien's discussion of Jadwin's attitudes is contained in his "Historic American Engineering Record Documentation, Lock and Dam Systems 3-10', Upper Mississippi River 9-Foot Channel Project, U.S. Army Corps of Engineers, St. Paul District," (Denver: National Park Service Service, Rocky Mountain Regional Office, 1987), (hereinafter referred to as O'Brien, "Locks and Dams 3-10"), HAER No. MN-20, pp. 9-10.

15 The Corps did not publish Hall's Feb. 8, 1929, report. It is, however, quoted in H. Doc. 290, p. 7. See also Merritt, St. Paul District, pp. 187-214.

16 It is interesting that the Corps changed the depth which the Hastings Lock and Dam was designed to accommodate without formal action by Congress. Its only authority for this action was a resolution of the House Rivers and Harbors Committee. The Corps had its Central Division (headquarters in Cincinnati, Ohio, and responsible or the Ohio River project from 1901 until 1929) assume responsibility for preparing the plans for the Hastins complex. U.S. Congress, House, Hearings Before the Committee on Rivers and Harbors, House of Representatives, 71st Congress, 2nd Session, on the Subject of the Improvements of the Mississippi River between the Mouth of the Missouri River and Minneapolis, March 18 and 27, 1930 (hereinafter referred to as March, 1930, Hearings), p. 4; Col. C.W. Kutz, Central Division Engineer, Cincinnatti, Ohio, to Chief of Engineers, 2 Nov. 1927, RG77, District Files, 1923-1942, File 2294, Box 62, NA.

17 H. Doc. 290, p. 7; Jan, 1932, Hearings, p. 4.

18 H. Doc 290, p.7; Annual Report, 1930, p. 1188; O'Brien, "Locks and Dams 3-1", HAER No. MN-20, p. 20.

19 Civil Works Study Board, "The Interrelationship Between Civil Works and Military Mission," Annual Report, 1965, pp.27-30; Leland R. Johnson, The Falls City Engineers: A History of the Louisville District Corps of Engineers United States Army (Louisville: U.S. Army Engineer District, 1974), (hereinafter referred to as Johnson, Louisville District), pp.182-183; and O'Brien, "Locks and Dams 3-10," HAER No. MN-20, pp. 20 and 48.

20 H. Doc. 290, p.7. Although Hall was not drummed out of the Corps and kept his District Engineer position for a full tour, his performance there did not advance his career. This may have come as a suprise to Hall considering the tenor in the "head shed" when he took the position in 1927. Unfortunately for him, he did not change as the tenor in that office changed. Hall's post-Rock Island assignments were neither high status nor did they lead to rapid promotion for Hall. Following his Rock Island District tour, Hall taught engineering at West Point for 10 years. In 1941 he was appointed District Engineer of the Ohio District, a position he held until 1945 when he retired from the Corps with a rank of Col. Hall died in March, 1963. Tweet, Rock Island District,p. 378.

It is not clear if Hoover was including a 9-foot or 6-foot Upper Mississippi River channel in his Oct. 23, 1929, committment. Johnson, Louisville District, pp. 187-188. In his famous 1926 statement to the House Committee on Rivers and Harbors, Hoover classified the Upper Mississippi as a lateral as opposed to a main trunk line and declared most laterals should be 6 feet deep. Statement of Honorable Herbert Hoover, Secretary of Commerce, before the Committee on Rivers and Harbors, House of Representatives, 69th Cong., 1st sess., on the subject of the Development of Inland Waterway Systems in the United States, Jan. 30, 1926, p. 2. However, by March 27, 1930, Congressman William E. Hull of Illinois could report Hoover had in a personal conversation with him, declared his intention to see a 9-foot channel built in the Upper Mississippi River. Jan, 1930, Hearings, p. 26.

Ylvisaker and Abbotts transfer approvals are contained in Chief of Engineers Lytle Brown to Col. George R. Spaulding, 30 Nov. 1929, RG 77, District Files, 1923-1942, Box 825, File 2294, NA. Information on Ylvisaker's education and role in Louisville comes from interview Leland R. Johnson and Charles E. Parrish with Oren Bellis, Louisville, KY, 6 June 1986, as cited in Leland R. Johnson to Willaim Patrick O'Brien, 6 Feb. 1988 (1st letter of that date) copy in NPS-Rocky Mt. Regional Office, working files.

21 March, 1930, Hearings, pp. 4 and 26; Jan, 1932, Hearings, p. 36; H. Doc. 209, p. 49; H. Doc. 137. Congress created BERH within the Corps in 1902 to review all prospective Corps projects independent of any local political influence. In theory, BERH only recommends projects which the standing board members from throughout the country, acting as professional engineers not administrators, judge meritorious for construction.

22 George R. Spaulding to Chief of Engineers, 27 July 1931, RG77, Entry 111, Box 985, File 3524-Part 1, Washington National Records Center, Suitland MD (hereinafter referred to as WNRC); Annual Report, 1930, p. 1189; Tweet, Rock Island District, p.273.

[23] Tweet, Rock Island District, p. 379. Unlike Major Hall, Major Edgerton's career prospered after his Rock Island tour of duty. From 1940-44, he served as Governor of the Panama Canal Zone. He then became Deputy Director and still later (1945-46) Director of Material for the War Assets Administration. In 1946 he became Director of the United Nations Recovery and Reconstruction Agency in China, a position he held until 1947 when he became a member of the War Department Board. He also served as President of the Corps' Beach Erosion Board before retiring from the Army in 1949. After retirement Edgerton became Executive Director of the Committee on Renovation of the White House during the Truman Administration. He was president of the Export-Import Bank from 1953 to 1955 and a consulting engineer for the World Bank and director of several corporations. He died in 1976.

[24] Spaulding to Chief, 27 July 1931.

[25] Tweet, Rock Island District, pp. 401-402; Johnson, Louisville District, p. 183; and W.F. Heavey, "Concreting at Ohio River Lock No. 45," Military Engineer 16 (March-April, 1924), pp. 144-146. Not only had McCormick, the southerner (he was born as well as educated in Virginia), already served directly under McAlpine, the Yankee (who was born as well as educated in Massachusetts); but McCormick at 54 was more the 56 year-old McAlpine's contemporary and their professional training and experience drew on the same period and styles of engineering. Monroe represented an earlier era.

[26] U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Locks an Dams 9-Foot Channel (hereinafter referred to as Drawings), number M-L 20 20/1. The original architectural/engineering drawings are the most important source of information on the Corps of Engineers' Upper Mississippi River 9-Foot Channel Project. The dates when the drawings were completed and the individual signing the contract drawings are contained on the drawings. Copies of all the original contract drawings pertaining to each lock and dam complex are on file at that complex and copies of all the drawings relevant to all twelve complexes (11-22) circulate from the central district library vault in the Clock Tower Building Annex in Rock Island IL. The vault copies are frequently checked out of the library and unavailable to researchers. However, the copies at the individual complexes are almost always available for use by researchers, if researchers travel to the complex. The Rock Island District assigned an alphabetic-numeric code number to each original drawing when it was complete. Drawings are easily retrivable at both locations by this code number. At the vault the original contract drawings are organized into structural groups and assigned an operations folio number relative to the structure. Herein all individual drawings will be referred to only by the alphabetic-numeric code number; no reference will be made to the operations folio of which it is a part. Operations folios will only be referred to when the entire folio is being cited.

[27] Final Report Lock and Dam 15, p.16 and 17; Glen E. Edgerton to Chief of Engineers, 25 March 1931, 7 April 1931, and 27 April 1931 and B.A. McGinn to Chief of Engineers, 4 Feb. 1932, RG77, Entry 111, Box 985, File 3524-Part 1, WNRC.

[28] Tweet, Rock Island District, pp. 384-385, 413-414, and 416-418. Piel served the Rock Island District as both a civilian employee and a military officer, from 1931 until her retirement in 1965. From August, 1940, to July, 1942, he was the engineer in charge of the planning section of the District's Engineering Division. In Jut, 1942, he was commissioned as a major in the Corps of Engineers. However, he remained assigned

to his planning section duties in the Rock Island District. In Feb., 1943, Peil was promoted to Lieutenant Colonel and appointed Rock Island District Engineer. He served as District Engineer from Feb., 1943, to April, 1946. In 1946, Peil returned to civilian employe status and became chief of the District's Engineering Division and chief technical assistant to the District Engineer. He held this position for the next 19 years, until his retirement. In, 1965, he returned to the area of Lock and Dam 20, becoming a math professor at Culver Stockton College in Canton MO. He held this position until his second retirement in 1982, 17 years later.

In August, 1931, the district added a photo lab to Peil's initial facilities. In Feb., 1932, the district awarded the contract for the construction of the dam and added four offices, a drafting room, and two lavatories on the second floor of the Clock Tower Building to house Peil's Dam 15 field staff. In Oct., 1932, the district added a concrete the cylinder storage room in the basement of the Clock Tower Building. In 1933 a large drafting room was added on the second floor, but was soon pulled to make room for the district Planning Section as relocated from the main headquarters. The whole headquarters was relocated to the Clock Tower Building in 1934.

[29] Jan. 1932 Hearings, pp. 6-10;U.S. Congress, House, Committee on River and Harbors, Mississippi River to Minneapolis--Decree of Injunction Restraining the Government From Construction of a Lock and Dam at Alma, Wis., H. Doc. 7, 72nd Cong, 1st sess., 1932; and O'Brien, "Locks and Dams 3-10," HAER No. MN-20, pp. 13-15.

[30] U.S. Congress, House, Public Resolution No. 10, H.J. Resolution 271, 72nd Cong., 1st sess., 1932; O'Brien, "Locks and Dams 3-10," HAER No. MN-20, pp. 14-15.

[31] May, 1933, Hearings, p.72; Gen. Pillsbury to U.S. District Engineer Rock Island, 26 Nov. 1932, RG77, Entry 111, Box 993, File 3524, WNRC; Tweet,Rock Island District, p.384.

[32] War Department, Corps of Engineers, U.S. Army, Mississippi River Lock and Dam No. 17: Final Report Construction, Vol. I: Introduction, Lock, and Temporary Buildings (Rock Island: U.S. Engineer Office, March, 1938), (hereinafter referred to as Final Report-Lock 17), p. 3, RG77, Entry 81, Box 666, NARA-CH.

[33] Final Report Lock and Dam 15; p. 4; War Department, Corps o Engineers, U.S Army, Mississippi Lock and Dam 20: Final Report Construction, Vol. I: Introduction and Lock (Rock Island: U.S. Engineer Office, March, 1935), (hereinafter referred to as Final Report-Lock 20), p.2., RG77, Entry 81, Box 666, NARA-CH.

[34] H. Doc. 137 as cited in Final Report-Lock 17, pp. 4-5; "U.S. Engineer Office, Improvement of Mississippi River, Development Near Rock Island, Illinois, Hearing on December 22, 1930," typescript, p. 67, RG77, Entry 81, Box 798, NARA-CH; Final Report Lock and Dam 15, p. 7.

[35] Final Report Lock and Dam 15, p.6.

[36] War Department, Corps of Engineers, U.S. Army, Mississippi River Lock ad Dam No. 14, Final Construction Report, Vol. I: Introduction, Lock, Temporary Buildings (Rock Island: U.S. Engineer Office, Dec., 1939), (hereinafter referred to as Final

Report-Lock 14), p. 2, RG77, Entry 81, Box 666, NARA-CH.

37 War Department, Corps of Engineers, U.S. Army, Mississippi River Lock ad Dam No. 16, Final Report-Construction, Vol I: Introduction, Lock and Channel Excavation as Horse Island (Rock Island, U.S. Engineer Office, May, 1937), (hereinafter referred to as Final Report-Lock 16), pp.2-5, RG77, Entry 81, Box 666, NARA-CH; ----, Mississippi River Lock and Dam No. 22, Final Report Construction, Vol. I: Introduction, Lock, Roadway, and Temporary Buildings (Rock Island: U.S. Engineer Office, July, 1937), (hereinafter referred to as Final Report-Lock 22), pp. 3-4, RG77, Entry 81, Box 669, NARA-CH; -----, Mississippi River Lock and Dam No. 11, Final Report Construction, Vol. I: Introduction, Lock, Roadway, and Temporary Buildings (Rock Island: U.S. Engineer Officer, Nov., 1938), (hereinafter referred to as Final Report-Lock 11), pp. 2-4, RG77, Entry 81, Box 667, NARA-CH.

38 Ibid.; War Department, Corps of Engineers, U.S. Army, Mississippi River Lock and Dam No. 18, Final Report-Construction, Vol. I: Introduction, Lock, Roadway, an Temporary Buildings (Rock Island: U. S. Engineer Office, n.d.), (hereinafter referred to as Final Report Lock 18), p.1, RG77, Entry 81, Box 668, NARA-CH; Final Report-Lock 14, p.2; "May Build River Lock Opposite City of Dubuque," Dubuque Journal, 28 Sept, 1933, p.12. The Pennsylvania Drilling Co. of Pittsburgh PA started drilling a Lock and Dam No. 12's Gordon's Ferry site on 23 Oct. 1933. See R.A. Wheeler to Div. Engineer, 5 Oct. 1933, and R.E. Coughlin to Chief of Engineers, 25 Oct. 1933, RG77, Entry 111, Box 997, file 3408, WNRC; and War Department, Corps of Engineers, U.S. Army, Mississippi River Lock and Dam No. 12, Final Report-Construction, Vol. I: General Introduction and Lock (Rock Island: U.S. Engineer Office, Nov., 1937), (hereinafter referred to as Final Report-Lock 12), pp. 2-4 and 22, and -----, Mississippi River Lock and Dam No. 13, Final Report-Construction, Vol. I: Introduction and Lock (Rock Island: U.S. Engineer Office, Jan., 1938), (hereinafter referred to as Final Report-Lock 13), p. 2, RG77, Entry 81, Box 665, NARA-CH.

39 May, 1933, Hearings, pp. 77, 4-5, and 7. For Mowry and Hofstadter's definitions of classic Progressivism see George E, Mowry, "The California Progressive and His Rationale: A Study in Middle Class Politics," Mississippi Valley Historical Review 36 (September, 1949), pp.239-250 and Richard Hofstadter, The Age of Reform From Bryan to F.D.R. (New York: Vintage Books, 1955). Beginning in April, 1933, various people attempted drafts of what became the National Industrial Recovery Acts. Debate continued throughout April and early May. Roosevelt presented a draft to Congress on May 17. He did not sign the resulting act until June 16, 1933. William E. Leuchtenburg, Franklin D. Roosevelt and the New Deal, 1932-1940 (New York: Harper & Row, 1963), pp. 56-58.

40 May, 1933, Hearings, pp. 25, 44, 61, 51-52.

41 Ibid., pp. 53 and 71.

42 Annual Report, 1933, p. 674; Annual Report, 1934, p. 783; Annual Report, 1936, p. 878; Annual Report, 1938, p. 1047; Annual Report, 1939, p. 1147; Annual Report, 1940, p. 1152. The prominence of the post-1933 Division Engineers is reflected, for example, in Col. Hodges career. A 1905 West Point graduate Hodges served with the 6th Engineering Division of the American Expeditionary Force in France. Between 1920 and 1923 he was District Engineer for the Little Rock ad Memphis districts. From

1928-1931 he was with the Office of the Chief of Engineers in Washington, D.C. For the last two of those years his position in that office was editor of the Military Engineer. Following his tenure with the U.M.V.D. Hodges served in 1943 with the United States Army Forces, Middle East; and as Division Engineer for the North Atlantic Division (1943-44). He retired as a brigadier general in 1944 at the age of 60. He died, at age 80, in 1965. George W. Cullem, Biographical Register of the Officers and Graduates of the U.S. Military Academy from 1802 to 1867 (revised edition, with a supplement, containing the Register of Graduates to January 1, 1979, New York: James Mille, 1879), entry no. 4351.

43 O'Brien, "Locks and Dams 3-10", HAER No. MN-20, pp. 20 and 47-48; Leland R. Johnson to William Patrick O'Brien, 6 Feb. 1988 (2nd letter of that date), copy in NPS-Rocky Mt. Regional Office, working files; "List of Officers and others available for Witnesses," 4 Feb. 1937, RG77, Entry 111, Box 995, File 3524-Part 3, WNRC; "List of Witnesses available to testify on Meltzer Claim Case on Lock 22," 26 May 1941, RG77, Box 998, file 3524, WNRC; Annual Report, 1934, p. 783; Annual Report, 1936, p. 878; Frederick J. Dobney, River Engineers of the Middle Mississippi: A History of the St. Louis District, U.S. Army Corps of Engineers, (St. Louis: U.S. Army Engineer District, 1978), pp. 92-93; Annual Report, 1937,p. 916; Annual Report, 1938, p. 1047.

44 Annual Report, 1934, p. 782; Tweet, Rock Island District, p. 380.

45 Tweet,Rock Island District, p. 409,

46 R.A. Wheeler to Chief of Engineers, 3 May 1934, RG77, Entry 111, Box 977, File 3524, WNRC; "List of Officers and Others Available for Witnesses," 4 Feb. 1937; "List of Witnesses available to testify on Meltzer Claim Case on Lock 22," 26 May 1941; Tweet, Rock Island District, pp. 401, 271, and 416. Once the project was designed, in 1937, Monroe retired from the Corps and McCormick became head civilian engineer in the Rock Island District. McCormick remained in that position until he too retired from the Corps in 1946. However, much of the rest of the engineering staff moved on. By 1941, Silkman was Chief of the Supply Section of the Office of the Chief of Engineers and J.B. Alexander was in Denison, Texas, working on high dams, while Abbott was working for the Corps in the Canal Zone. Abbot later transferred back to the Ohio River and became Chief of Engineering at the Ohio River Division in Cincinatti. He finally retired from the Corps in 1970. (Johnson to O'Brien, 6 Feb. 1988-2nd letter of that date, p.2.)

47 "List of Officer and Others Available for Witnesses," 4 Feb. 1937; "List of Witnesses available to testify on Meltzer Claim Case on Lock 22," 26 May 1941; Tweet, Rock Island District, p. 384.

48 Tweet, Rock Island District, p. 407.

49 In 1938, Harry Hopkins came up with a plan for the WPA to do the construction associated with preparedness and rearmament. In attempting to keep the work from going to the WPA, the officers in charge of the Quartermaster Corps made an issue of who controlled emergency construction. In this situation, the proponents of the transfer of all military construction to the Corps of Engineers struck. By late 1938 President Roosevelt had come to favor the transfer of all military construction to the Corps of Engineers, if the transfer of responsibilities could be accomplished without a

fight with Congress which might jeopardise his other programs. As part of these negotiations, the Corps agreed to have the WPA actually do, under the Corps' supervision, some of the construction associated with preparedness and rearmament. After all since the May, 1933, redefinition of the Upper Mississippi River 9-Foot Channel Project, relief workers employed by private contractors had been building waterway improvement structures under Corps supervision. Since the Flood Control Act of 1936 the WPA had been doing and funding flood control construction work under the supervision of the Corps of Engineers. These precedents paved the way for the President's late 1938 decision to support the addition of the supervision of all WPA construction projects to the Corps work load. Once he had made this decision, Roosevelt rapidly came to support the Corps' retention of all its traditional civil works functions. Roosevelt's reluctance to give all water resource development to the Corps revolved around the Corps lack of experience in planning comprehensive programs. Roosevelt to Senate, 13 Aug 1937, in Nixon, Roosevelt and Conservation, p. 102. However, once Roosevelt had made his decision it ended the 1920s and 1930s threat of removal of civil works functions from the Corps.

[50] Annual Report, 1937, p.916; Annual Report, 1940, p. 1152; Tweet, Rock Island District, p. 381. Following his Rock Island tour, Gesler was in charge of the Contract and Finance Section of the Office of the Chief of Engineers. He served as Mid-Atlantic Division Engineer from 1943-1946. He was Philadelphia District Engineer in 1949 and 1950. He died in 1958.

[51] RG77, Entry 111, Boxes 977 and 978, file 3524, WNRC; and transcript of Case No. 45051, Court of Claims of the United States, James Stewart Corp. vs the United States (Lock 12), RG77, Entry 111, Box 673, WNRC (a duplicate copy is available in RG77, Entry 81, Box 678, NARA-CH).

[52] Green Construction started building esplanade 12 and its residential structures on 15 Sept. 1938 and were done on 10 Dec. 1938. J. H. Grove to Chief of Engineers, 1 Jan. 1939, RG77, Entry 111, Box 978, file 3648, WNRC. For controversy see Joe A. Young to E.E. Gesler, 14 Oct. 1938; Gesler to Young, 18 Oct. 1938; Gesler to Young, 15 Nov. 1938; Young to Gesler, 2 Dec. 1938; Young to W.S. Jacobson, 31 March 1939; an J.L. Schley to Jacobson, 24 April 1939, RG77, Entry 111, Box 979, File 6740, WNRC.

[53] R.A. Wheeler to Chief of Engineers, 13 Nov. 1933 and 18 Jan. 134, RG77, Entry 111, Box 990, File 3408, WNRC; R.A. Wheeler to Chief of Engineers, 8 Jan. 1934 and 19 March 1934, RG77, Entry 111, Box 989, File 3344, WNRC; E.L. Daley to Chief of Engineers, 14 Feb. 1934, RG77, Entry 111, Box 990, File 3408, WNRC; G.E. Edgeton to Chief of Engineers, 22 Oct. 1934, RG77, Entry 111, Box 993, File 3524-Part 1, WNRC; R.A. Wheeler to Chief of Engineers, 7 Jan. 1935, RG77, Entry 111, Box 993, File 3524-Part 1, WNRC; and transcript of Case No. 45262, Court of Claims of the United States, Maxon Construction Company vs. the United States (Lock 18), RG77, Entry 111, Box 685, WNRC.

[54] RG77, Entry 111, Box 994, File 3524, WNRC; transcript of Case No. 43489, Court of Claims of the United States, Joseph Meltzer Inc. vs. the United States (Lock 21), RG77, Entry 111, Box 688, WNRC; E.E. Gesler to Chief of Engineers, 24 Dec. 1935, RG77, Entry 111, Box 998, File 3524-Part 2, WNRC; RG77, Entry 111, Box 998, File 3524-Part 3, WNRC; and transcript of Case No. 45452, Court of Claim of the

United States, Joseph Meltzer, Inc. vs the United States (Lock 22), RG77, Entry 111, Box 691, WNRC.

[55] R.E. Coughlin, "Finding of Fact," 9 March 1934; R.A. Wheeler to Chief of Engineers, 19 March 1934; and J.S. Bragdon to General Accounting Office, 29 June 1934, RG77, Entry 111, Box 997, File 3344, WNRC.

[56] RG77, Entry 111, Box 680, WNRC.

[57] "Roller-Gate Dams for Kanawha River," Engineering News-Record 111, No. 12 (Sept. 21, 1933), pp. 337-338; Leland R. Johnson, The Davis Island Lock and Dam 1870-1922 (Pittsburgh: U.S. Army Engineer District, 1985), (hereinafter referred to as Johnson, Davis Island Lock and Dam), p. 162; Tweet, Rock Island District, p. 265; and "New Power Plant Replaces Old Waterwheels," Engineering News-Record 99, No. 23 (Dec. 8, 1927), 908.

The Corps of Engineers' Ohio River Canalization Project, completed in 1929, is a good example of United States Army engineering practice prior to the Upper Mississippi River 9-foot Channel Project. A typical navigation works in the Ohio River project included a lock, a navigable section of Channonine wicket dam, a non-navigable wier section with beartrap gates and wickets, and a fixed section. The Ohio River dams differed from the Upper Mississippi structures in this fundamental way. However, the Ohio River project had such a great influence on the Upper Mississippi Project that knowledge of the Ohio River project is very important to an understanding of this project. For detailed information on the Ohio River Canalization Project see both Johnson, Louisville District pp. 155-190; and Michael C. Robinson, History of Navigation in the Ohio River Basin: National Waterways Study: U.S. Army Corps of Engineers Water Resource Support Center, Institute for Water Resources--Navigation History NWS-83-5 (Washington DC: Government Printing Office, 1983), passim.

Although all the Upper Mississippi 9-Foot Channel Project dams constructed between 1930 and 1940 differed from these pre-1929 Ohio River dams in that they were non-navigable dams, not all were combination roller-Tainter dams. Upper Mississippi River Dams 3 and 15 included only roller gates.

The first American dam to use rollers in combination with another type of moveable gate, in this case a flashboard wier, was the New England Power Association's Bellows Falls, VT, power plant spillway. It was also very important to this project as is discussed below. The best coverage of the structure itself is the Engineering News-Record article cited above.

[58] In fact, after 1937 (once all the designs for the Upper Mississippi River 9-foot Channel Project dams considered in this study were complete) engineering students began to be taught that they should not design dams utilizing more than one type of gate if they could avoid it. See, for example, Inq. Dr. Tech. Arim Schoklitsch, Hydraulic Structures: A Text and Handbook, translated by Samuel Shulits, Vol. 2 (New York: American Society of Mechanical Engineers, 1937), (hereinafter referred to as Schoklitsch, Hydraulic Structures) pp. 638-656, 679-691.

[59] Lock and Dam 19's independent significance is reflected in its listing on the National Register of Historic Places independently from all the others in the system.

Larry McClean, "Keokuk Lock and Dam, " National Register of Historic Places Inventory-Nomination Form (1976), (hereinafter referred to as McClean, "Keokuk Lock and Dam"). None of the other 11 complexes in the Rock Island District have either been listed on the National Register or formally determined eligible for the National Register. However, if viewed collectively and only when viewed collectively, they could be determined eligible. Telephone interview with Beth Grovner Boland, Office of the Keeper of the National Register, Washington DC, 11 May 1988.

Because the Corps did not build Lock and Dam complex 19 as part of the 1927-1940 Upper Mississippi River 9-foot Channel Project, all aspects of that complex's history and significance are not addressed in this narrative. Much of this information not included in the following text is, however, included in notes 4 and 64. The Rock Island District distributes a brief booklet just covering this complex: Roald Tweet's Taming Des Moines Rapids cited above. See also Rathbun Associates, "Historical-Architectural and Engineering Study Locks and Dams 11-22, Nine-Foot Navigation Project, Mississippi River" (Rock Island: U.S. Army Engineer District, 1985), (hereinafter referred to as Rathbun Associates, "Locks and Dams 11-22"), pp. III-32-37 and V-4-12. Phillip V. Scarpino also offers some interesting information and insights in his Great River: An Environmental History of the Upper Mississippi, 1890-1950 (Columbia: University of Missouri Press, 1985), (hereinafter referred to as Scarpino, Great River).

60 Although immediately contiguous to the 9-Foot Channel, neither the upper lock nor the lower lock and dam at St. Anthony Falls are, or ever were, part of the 9-Foot Channel system. Congress authorized the first two locks and dams at St. Anthony Falls were built in 1894 as a special 5-Foot Navigation Project while the Corps was still working on the 4 1/2-Foot Project on the rest of the river. However, they were not built until the 6-Foot Project era had commenced on the rest of the river. The current structures are products of the 1950s and 1960s. See Gjerde, "St. Paul District Locks and Dams", passim.

61 The moveable dam was the key to the successful use of slack-water navigation systems. Although moveable dams have existed in a rough form since ancient times, the modern moveable dam is usually traced to the series of systematic improvements in moveable dams technology which began in 1832 when Thenard, an officer in the French Corps of Engineers, devised a system for raising panels in a dam with chains attached to a winch moving along a footbridge. For a discussion of the French developments see Johnson, Davis Island Lock and Dam, pp. 34-36. Although later American slack-water navigation systems drew on these moveable dam innovations, earlier American moveable dams drew on native innovations such as the beartrap dam gate invented by Josiah White in 1818 for use on the Lehigh River. See Johnson, Davis Island Lock and Dam, pp. 25-26. These early experiments with moveable dams did not, however, produce slack-water navigation systems as they are defined today for the structures did not include locks as well as dams. Traffic passed the over the dams or was flushed through the dams by way of gates in the dams themselves. Some of the first American slack-water navigation systems built on rivers, including locks as well as dams, were those on the Muskingum River in Ohio begun in 1832 and on the Green River in Kentucky begun in 1833. One of the the first American Army engineers to study the applicability of this technology was Captain George W. Hughes who studied the advisability and feasibility of constructing a slack-water system on the Ohio in 1842-43. For a treatment of the extended controversy which ensued see Mary Yeater Rathbun, The United States Army Corps of Engineers in the Little Rock District (1987

draft manuscript on file with the Office of History, Office of the Chief of Engineers, Fort Belovir VA), (hereinafter referred to as Rathbun, Little Rock District), passim. For general information on the application of slack-water navigation systems technology see Johnson, Louisville District, pp. 98-99, 142-143, and 147-148; Johnson, Davis Island Lock and Dam, pp. 8-9, 13, and 16; and Louis Hunter, Steamboats on the Western Rivers, An Economic and Technological History (Cambridge MA: Harvard University Press, 1949), (hereinafter referred to as Hunter, Steamboats), pp. 206-212.

The Davis Island Lock and Dam was designed between 1874 and 1878 by the staff of the U.S. Army Corps of Engineers' Office of Ohio River Improvements under the direction of Col. William E. Merril. It was completed in 1885. For full information on the Davis Island Lock and Dam system see Johnson's Davis Island Lock and Dam.

[62] Hunter, Steamboats, pp. 566-584.

[63] There were so many raftboats plying the Upper Mississippi in the later part of the nineteenth century that they presented a hazard to other traffic. In 1900 Congress passed legislation making it illegal to operate these raftboats in streams or rivers also navigated by steamboats in such a way as to "obstruct, impede, or endanger navigation" by the steamboats. Rivers and Harbors Act of 1900. For more general information on log and raftboat movement on the Upper Mississippi River see Tweet, Rock Island District, p.238-243; William J. Peterson, "Rafting on the Mississippi: Prologue to Prosperity," Iowa Journal of History, 58, No.4 (1960), pp. 289-320; Robert F. Fries, Empire in Pine: The Story of the Lumbering Industry in Wisconsin, 1830-1900 (Madison: State Historical Society of Wisconsin, 1951), pp.8-59; Agnes M. Larson, History of the White Pine Industry in Minnesota (Minneapolis: University of Minnesota Press, 1949), pp. 3-70; and Charles E. Twinning, Downriver Orrin H. Ingram and the Empire Lumber Company (Madison: State Historical Society of Wisconsin, 1975), passim (primarily for excellent photographs).

Each lockage would have taken a fleet of barges or a raftboat 40 to 50 hours, while a packet would have needed only an hour or less per lockage. However, in some ways the hour or less was just as critical for the packets in their competition with the railroads as the 40 or 50 was to the barges and raftboats.

[64] Congress authorized the 4 1/2-foot Channel in the Rivers and Harbors Act of June 18, 1878. The passage of both the Upper Mississippi 4 1/2-Foot Channel legislation and the Davis Island Lock and Dam authorization are associated with Rutherford B. Hayes' 1876 commitment to support regional internal improvements. This campaign promise had helped produce the "Compromise of 1877" which resulted in Hayes' election so he had to honor it. Both projects also reflect pre-existing Congressional support for internal improvements, a support shown in such things as the Congressional allies Hayes won on the basis of his 1876 commitment and the 1874 Windom Committee Report. See above note 7.

The Corps first considered a slack-water navigation installation at Keokuk as part of the 4-foot channel project authorized in 1866. Colonel James H. Wilson, the officer in charge of the improvement of the Des Moines Rapids, recommended a lateral canal. The Chief of Engineers, Major General Andrew A. Humphreys, agreed with Wilson and forwarded his report on to Congress. The House had no problem with Wilson's plan. However, there was considerable discussion in the Senate of the fact that most previous Corps reports had specifically rejected the idea of a canal as a solution to this navigation problem. The final Congressional appropriation was contingent upon a special board of engineers re-examining the issue. The board General Humphreys appointed to study the issue consisted of Wilson, Maj. Gouverneur K. Warren, Capt. Thomas J. Cram, Col. John N. Macomb, Capt. Peter C. Hains, and W. Milnor Roberts. The board considered many alternatives, including (not suprisingly since Roberts, the distinguished civilian engineer who had been advocating the use of locks and dams all he way across the Ohio River since 1857, was on the board) the possibility of creating a slack-water navigation system out in the river itself. However, after all its discussions, the special board of engineers studying the improvement of the Des Moines Rapids recommended in 1867 a plan almost identical to Wilson's original plan except for a few changes in dimensions. See Tweet, Rock Island District, pp. 91-93; Annual Report, 1867, p. 265.

The bulk of the work the Corps undertook in the 4 1/2-foot channel project was limited to snagging, dredging and the construction of contraction works. However, after 1882 the Corps began a series of dams on the headwaters to help improve the navigability of the Upper Mississippi. These dams created reservoirs whose waters were released to supplement the natural flow of the river south of Minneapolis during periods of low water. Because the dams were not located in navigable reaches of the river they were in accord with the idea of keeping the navigational areas of the river as free from obstructions as possible. See Merritt, St. Paul District, pp. 69-93; and Ellis Armstrong, et. al., History of Public Works in the United States 1776-1976, (Chicago: American Public Works Association, 1976), (hereinafter referred to as Armstrong, Public Works, 1776-1976), p. 35.

The Corps' commitment to approaches ensuring open water navigation was also acknowledged in 1894 when the Corps began the first two locks and dams spanning the Upper Mississippi. These two locks and dams did not really impair open water navigation anywhere that such navigation was already being practiced. Both of these locks and dams were between St. Paul and Minneapolis, that is, at the head of navigation. Thus, they impaired very little traffic and in fact opened a whole new stretch of the river to any kind of substantial navigation for the first time. See Gjerde, "St. Paul District Locks and Dams", pp. 117-119; and Merrit, St. Paul District, pp. 141-146.

The Keokuk and Hamilton Water Power project had its roots in an 1899 meeting of about 25 residents of Keokuk, Iowa, and Hamilton, Illinois, the small town directly across the river. The purpose of the meeting was to discuss once again an idea which had been the subject of many discussion since at least 1836: developing the water power available at the foot of the Des Moines Rapids for the use of men. In 1900, the group of people who had rekindled this discussion in 1899 incorporated under Illinois law as the Keokuk and Hamilton Water Power Company. In 1901, the federal government authorized the company to build a wing dam on the Illinois side of the river and the company hired Lyman R. Cooley, a hydraulic engineer from Chicago, to make a survey and develop specifications for its power generation project. Cooley pronounced a wing dam impractical and informed the company it would need to erect a dam all the way across the river, if it was to effectively generate enough hydroelectric power to be a commercial success. The installation Cooley suggested included a navigation lock and thus would solve the navigation problems associated with the Des Moines Rapids. Water would be back up behind the dam Cooley was suggesting. The water would be 40 feet deep right behind the dam and would gradually taper off, until it reached its natural depth about 54 miles upstream. Thus, the whole 11+ mile stretch of rapids immediately behind the dam would be submerged in deep water and made navigable for all ice-free seasons of the year. Navigation at the dam site would be ensured by the lock. The Keokuk and Hamilton Water Power Company informed the Corps of Cooley's recommendations and the Corps agreed to study the issue further, if so authorized by Congress. In June, 1902, by way of that year's River and Harbor Act, Congress authorized the Corps to determine if a structure such as Cooley was suggesting at the foot of the Des Moines Rapids would be a benefit or an impediment to the navigation of the Upper Mississippi River. See Nelson C. Roberts and S. W. Moorhead, Story of Lee County Iowa (Chicago: The S. J. Clarke Publishing Company, 1914), (hereinafter referred to as Roberts and Moorhead, Lee County), pp. 243-245; Tweet, Rock Island District, p. 245; and Rivers and Harbors Act of June 13, 1902. Montgomery Meigs report, although completed in 1903, was not published until 1916. See "Report of Mr. Montgomery Meigs, U. S. Civil Engineer," Annual Report, 1916, vol. II, p. 1509 (hereinafter referred to as "Meigs Report").

Montgomery Meigs was the son of the famous engineer by the same name who had, in 1837, assisted Robert E. Lee in resurveying the Upper Mississippi River rapids and recommending an improvement plan. See above note 3. The Meigs who studied and then endorsed the Keokuk and Hamilton Water Power Company project was not as well known nationally as his illustrious father, but he was a very distinguished and widely known engineer. He received his engineering degrees from Harvard University and the Royal Polytechnic School of Stuttgart, Germany. He joined the Rock Island District in 1874, when he was 27 years old. For the first few years of his employment there he did survey work and helped develop the plan for the wing dams for the 4 1/2-foot channel project. In 1881, he was given charge of the Des Moines Rapids Canal. He remained the principal Corps of Engineers engineer in its Keokuk office from that point until his retirement in 1926--45 years later. In addition to supervising work on the successive structures at Keokuk, Meigs worked a great deal with steam boat design. His interest in photography and model building had a lasting impact on District policy. However, his most lasting claim to fame, aside from his involvement with the Keokuk structures probably lay in his originating the idea of oiling country roads to improve them. This 1898 idea was adopted throughout the United States. For a fuller biography of Meigs see Tweet, Rock Island District pp. 357-358.

[65] For information on what was technologically possible with wicket dams see Johnson, Davis Island Lock and Dam, p. 135.

[66] "Meigs Report", p.1509.

[67] Multiple-purpose water resource development had been gathering adherents throughout the country since the 1880s. Leaders of the emerging Progressive an conservation movements fostered an awareness that America's waterways should be developed not only to aid navigation, but also to control floods, use stored water to irrigate crops, generate hydroelectic power, and provide water for municipal and industrial use. Simultaneously navigation faced a crisis. The 1890s marked the victory of rail over water-borne transportation for long-distance hauls throughout the country. In ever increasing numbers water transport boosters jumped on the multiple-use bandwagon. A multiple-use improvement would often be cost effective where a navigation improvement alone would not be.

The most prominent author tracing the development of multiple-purpose water resource improvement projects and linking the development of the progressive and conservation movements is Samuel P. Hays in his Conservation and the Gospel of Efficiency: The Progressive Conservation Movement 1890-1920 (Cambridge, MA: Harvard University Press, 1959, reprinted with a new preface by the author, New York: Antheneum, 1974), (hereinafter referred to as Hays, Conservation and Efficiency).

It is probably not purely coincidental that in 1902, the year Congress authorized the study Meigs was conducting of this most "progressive" Keokuk waterway projects, the leaders of the Progressive conservation movement achieved two other major victories in Congress. Representative Theodore E. Burton, chairman of the House Rivers and Harbors Committee, and President Theodore Roosevelt moved decisively to end the pork-barrel era of the Gilded Age as it affected the Corps of Engineer. In 1902, Congress created BERH. See above note 21. This attempt to remove water resource management decisions form the traditional political process, was an attempt to realize the Progressive conservation movement principle that decisions about water resource development should be made by technicians not politicians. Lobbying, pork-barrel Congressional politics, and partisan debate did not lead to rational scientific decision making. Once President Roosevelt had thrown his weight behind the idea in 1901, Congress also passed the Reclamation Act in 1902. By providing for federal planning, construction, and development of irrigation works, this act significantly enlarged the area in which federal water resource development programs could legally be pursued. Prior to 1902, the only legal water resource development goal any federal agency could work towards was aid to navigation and only the Corps of Engineers could do it. Congress did not make the Reclamation Service a part of the Corps of Engineers. Congress made the Reclamation Service part of the Geological Survey of the Department of Interior; thus setting up a rivalry which exists to this day, although now focused on other issues. The Geological Survey had been building a staff geared for producing comprehensive, multiple-use plans for the development of both land and water resources since its creation in 1879. Almost from its beginning, the Reclamation Service staff succeeded in pushing a broader goal than just irrigation for developing western water resources. As early as 1903, while Meigs was still studying the Keokuk proposal, the Reclamation Service began designing and building high dams which stored massive amounts of water and had the potential for generating hydroelectric power. For information on these 1902 events see Johnson, Louisville District, p. 170; Hays Conservation and Efficiency, pp. 93-94; and Rathbun, Little Rock District, pp. 120-122. Histories of the U.S.Reclamation Service are abundant. George Whaton James's Reclaiming the Arid West: The story of the United States Reclamation Service (New York: Dodd, Mead, and Company, 1917) and the Institute for Government Research's The U. S. Reclamation Service: Its History, Activities and Organization (New York: D. Appleton and Co., 1919) are readily available in general circulation libraries. Alan R. Dickerman, George E. Radosevich, and Kennet Noble's Foundation of Federal Reclamation Policies: An Historical Review of Changing Goals and Objectives (Fort Collins, CO: Department of Economics, Colorado State University, 1970) offers a more modern treatment. Hays, Conservation and Efficiency also deals extensively with the issue.

Support for generating hydroelectric power was strong in Keokuk also. Meigs held a public meeting at the Keokuk Engineer Office on April 24, 1903, to receive objections to the proposed lock and dam. Despite the implications of the plan for open river navigators, no one brought a single objection to Meigs. Soon thereafter Meigs concluded that the project would effectively and simultaneously use the Upper Mississippi for hydroelectric power generation and navigation improvement. "Meigs Report," p. 1509; and Tweet, Rock Island District, p. 246.

68 "Meigs Report," p. 1509; and Tweet, Rock Island District, p. 246. Once it had received its Congressional authorization for construction in 1905, the Keokuk and Hamilton Water Power Company prepared a prospectus stating its need for capital with which to build he complex and a competent engineer to take charge of the undertaking. Hugh L. Cooper, an engineer who already had a worldwide reputation for his achievements in Jamaica, Brazil, and in designing the hydroelectric generating facilities at Niagara Falls, and McCall's Ferry, Pennsylvania, began to raise capital in response to this prospectus. Unable to raise sufficient capital himself, Cooper allied himself with Stone and Webster, a Boston, Massachusetts, based construction company which agreed to undertaking the financing. On September 5, 1905, the committee in charge of the Keokuk and Hamilton Water Power Company entered into a contract with Cooper by which the stock and franchise of the company were turned over to his syndicate on the condition that the dam and power plant to completed by February 10, 1915, and that navigation not be delayed while construction was in progress. Roberts and Moorhead, Lee County, p. 246.

Throughout both the design and construction phases of the project Hugh Cooper worked closely with Montgomery Miegs. At times it is difficult to determine what is a Cooper design and what is a Meigs design. However, it appears Cooper had a freer hand on the dam and power plant while Meigs' role was more important in the design of the navigation structures and the dry dock. It is also difficult to identify clearly the full extent of Stone and Webster's influence on the project. As the securers of the capital necessary to build the project, they obviously played a major role in defining the project. Their subsidiary, Stone and Webster Engineering Corporation of New York City, served as the general contractor for the project; and, as anyone knows who has been around many construction projects, the contractor and its personnel can, and usually do, have a major influence on the finished product. The parent firm of Stone and Webster also had other substantial interests in Keokuk. In 1914, it owned and operated the Keokuk Electric Company as a separate entity from the now renamed Mississippi River Power Company which had built the dam, power plant, and navigation structures. Stone and Webster Management Association, another separate entity which managed more than 50 public utilities throughout the country, managed the Keokuk power plant for the Mississippi River Power Company of which the parent Stone and Webster Company still continued to own a sizable chunk. Stone and Webster even had a private club, The High Tension Club, for its employees in Keokuk. Lee County, p. 249; Tweet, Rock Island District, p. 246; Montgomery Meigs and Family Papers, 1866-1931, Illinois State Historical Society Library, Old State Capital, Springfield, Illinois; Keokuk Industrial Association, "A Survey of the City of Keokuk, Lee County, Iowa," (typewritten manuscript, 1914), hereinafter referred to as Keokuk Industrial Association, "1914 Survey"), pp. 41 and 54, copy in Iowa State Historical Society Library, Iowa City, Iowa.

Despite being designed by a private engineer, the influence of Corps designed projects was strong, the Ohio River and Panama Canal locks served as the most direct antecedents for the technology of the Keokuk lock. In the 1905 enabling legislation the government called for the lock to be 90 feet by 400 feet. But, during the course of the design process the width was changed to 110 feet, the same width as the locks on the Ohio River and the Panama Canal. Tweet, Rock Island District, p. 249.

There are, however, significant differences between the Keokuk Lock and those in the Panama Canal and on the Ohio River. Although in direct proximity to the major midwestern hydroelectric source, the Keokuk lock machinery was operated by air pressure. Two factors probably accounted for this: even as late as 1910 electricity was not seen as dependable, and the upper gates, as designed, needed to be operated by air. There are two identical upper gates for the lock; the upstream one, called the guard gate, allowed for repairs to the upper service gate. A similar gate was used for the dry dock. These gates were very different from standard lock gates. The gates, when open, fit into large slots in the floor of the upper breast wall of the lock, allowing boats to pass over them into the lock. They were closed by air pressure piped to the site through pneumatic tubes which ran through elevated towers adjacent to the gates. The air pressure lifted the gates to the level of the lock walls. Catches then engaged them in place. The tops of the gates are quite wide enough, when up, to serve as service bridges, giving access to the commercial power plant.

The air pressure required for the operation of the various parts of the lock was generated by a turbine that powered double air compressors located in the lock power house, just to the east of the lock gates and within the wall that connects the lock to the commercial power plant extension wall. The operations of the lock were controlled from the operator's house located on top of the lock wall just north of the lock power house. Lever switches allowed an individúal to open the gates and to operate the valves from this one central location.

The lock was rehabilitated in 1934 so it could serve as part of the 9-Foot Channel Project, but in 1957 it was superceeded by a new lock. At 400-feet in length, rather than the 600-foot standard for the rest of the locks in the system, the Keokuk lock was causing a bottleneck for traffic. Modern tows had to be broken into three to six sections to pass through the lock. This resulted in a two to eight hour delay for each tow. Mississippi River Lock and Dam No, 19; Repairs to Keokuk Lock Miter gates (Rock Island: U.S. Engineer Office, March, 1934), p.1, RG77, entry 81, box 666, NARA-CH; Completion Report New lock 19, p. 1.

[69] Tweet, Rock Island District, pp. 142-144; Rathbun Associates, "Locks and Dams 11-22" pp. II-11-12. The Corps built these to accommodate open water navigation even though, by 1902, sawmill operators such as the Weyerhaeusers had already moved their headquarters north from Rock Island-Moline to Minnesota and begun exploring investment opportunities in the far west because the source of logs for Rock Island-Moline operations were almost used up. Charles E. Twinning, Phil Weyerhauser Lumberman, (Seattle: University of Washington Press 1985), p.7.

[70]The 1913 Corps plan (in line with the 1907 conceptual plan, H.Doc. 341, see above note 5) for a lateral canal along the upper portion of the Rock Island Rapids underlies the pertinent provisions of the Rivers and Harbors Act of 5 March 1915. The 1920 revisions are dealt with in Richard Monroe to H. Burgess, 9 June 1920, and H. Burgess to Div. Engineer 24 July, 1920, RG77, Entry 81, Box 798, NARA-CH. Construction is covered in Annual Report, 1924, p. 1090.

[71] Gjerdes "St. Paul District Locks and Dams," p. 125

72 H. Doc. 290.

73 H. Doc. 137; and "Roller-Gate Dams for the Kanawha River," pp. 338 and 340.

74 It was difficult to maintain sufficient depth for navigation in some places on the Upper Mississippi even during high water because the banks of the river were so low and the valley so wide. The water would spread out rather than backing up in the comparatively shallow floods on the Upper Mississippi. Grimm's role on the Hastings lock is covered in Col. C.W. Kuntz, Central Division Engineer, Cincinnati OH, to Chief of Engineers, 2 Nov. 1927, RG77, District Files, 1923-1940, Box 62, File 2294, NA. It appears that Grimm had no direct role in the subsequent design of the Upper Mississippi River 9-Foot Channel structures. He remained with the Central Division through 1928 and 1929. In 1930 he transferred to the Pacific Engineer Division at San Francisco. He died in 1942. For fuller biographical information on Grimm see Johnson to O'Brien, 6 Feb. 1988 (2nd letter of that date).

75 H. Doc. 137, pp. 2, 21, 68, and 95-96; "Roller-Gate Dams for the Kanawha River," pp. 338 and 340; Charles P. Gross and H.G. McCormick, "The Upper Mississippi River Project," The Military Engineer 33, No. 190 (July-Aug., 1941), p. 313.

76 Ibid. By the time the Corps developed its Ohio River Navigation Modernization plans in the early 1950s, engineers had abandoned the idea that dams with fixed service bridge were not practical on the Ohio River. Structures such as the Markland Lock and Dam near Cincinnati clearly illustrate this change is philosophy. For a full treatment of the Ohio River Navigation Modernization Project see Leland R. Johnson, The Falls City Engineers: A History of the Louisville District Corps of Engineers United States Army 1970-1983 (Louisville: U.S. Army Engineer District, 1984), (Although this volume continues the story contained in Johnson's almost identically Louisville District an additional 13 years, it should not be confused with it), pp. 28-47.

77 George R. Spaulding to Chief of Engineers, 8 Feb. 1930, RG77, District Files, 1923-1942, Box 825, File 2294, NA. This letter deals with sending McAlpine, Ylvisaker and Col. Hall to the New England Power Association's new power plan on the Connecticut River at Bellows Falls VT. The Bellows Falls Dam, though under construction, was not complete in Dec. 1927, when the article on it appeared in Engineering News-Record. It was completed by Dec., 1928, just a little over a year before the team's visit. "New Power Plant," pp. 910-911. Ylvisaker and Abbott visited S. Morgan Smith in York PA in April, 1931, in regard to the proposed dam at Rock Island. Spaulding to Chief of Engineers, 11 April 1931, RG77, District Files, 1923-1942, Box 825, File 2294, NA. This firm manufactured the roller gates for the Bellows Falls dam. Nolan's legislative proposal is covered in March, 1930 Hearings, p. 20. For the full and exact wording of the 1930 authorization see the Rivers and Harbors Act of 15 July 1930. The Dec., 1930, state of the team's design is evident in "U.S. Engineer Office, Improvement of Mississippi River, Development Near Rock Island, Illinois, Hearing on December 22, 1930."

78 "Roller-Gate Dams for Kanawha River,", p.338; "Building the Rolling-Crest Dam Across Grand River," Engineering News 76, No. 2 (July 13, 1916), p. 60; Johnson, Davis Island Lock and Dam, p. 162; P.S. Reinecke, "The Rhine and the Upper Mississippi," The Military Engineer 30, No. 171 (May-June, 1938), p. 170; and F.

Teichman, "Large Roller-Crest Dam, Grand Valley Project, Colorado," Engineering News 76, No.1 (July 6, 1916), p.4.

79 O'Brien, "Locks and Dams 3-10," HAER No. MN-20, p.27; "U.S. Engineer Office, Improvement of Mississippi River, Development Near Rock Island, Illinois, Hearing on December 22, 1930," p. 67; Leland R. Johnson, Men, Mountains and Rivers: An Illustrated History of the Huntington District, U.S. Army Corps of Engineers (Huntington: U.S. Army Engineer District, 1977), (hereinafter referred to as Johnson, Huntington District), pp. 137-138; Johnson, Davis Island Lock and Dam, p. 162.

80 Teichman, "Large Roller-Crest Dam," p.4; undated newspaper clipping from Davenport (WA) Times and historic photograph caption cited by Rory Vincent, Journeryman Operator, Long Lake Power Plant, Ford, WA, in telephone interview, May 27, 1988.

81 Teichman, "Large Roller-Crest Dam," pp.2-4; and "Building Rolling-Crest Dam Grand River," pp. 60-61.

82 On tributaries of the Rhine, German engineers sometimes used a vertical lift type gate, called a "plunging roller", in conjunction with ordinary roller gates. Reinecke, "The Rhine and the Upper Mississippi," p. 170. Although the idea that one type of gate should, if at all possible, be used exclusively in a structure circulated in the first two decades of the 20th century, it was not dogmatized in engineering texts used in America until 1937. See, for example, Schoklitsch, Hydraulic Structures, p. 638. The specifics of the Bellows Falls dam are contained in "New Power Plant," pp. 910-911.

83 Col. Harley B. Ferguson, Central Division Engineer, Cincinnati, OH, to Chief of Engineers, 11 Dec. 1928, RG77, District Files, 1923-1940, Box 62, File 2294, NA. Grimm had obviously completed the design for the Hastings Lock and Dam (now known as Lock and Dam 2) by December, 1928, for construction of the complex began earlier that year.

84 "Roller-Gate Dams for Kanawha River," p. 339. Tainter gates are discussed below. Vertical lift gates' name explains their technology well. The rectangular sliding gates at Dam 19 on the Upper Mississippi are a form of vertical lift gate (see individual outline, HAER No. IA-27, appended in this report). Sector gates are roller gates in which the roller is a sector of a circle instead of a cylinder. John S. Scott, A Dictionary of Civil Engineering, 2nd ed., (Baltimore, MD: Penguin Books, 1965), p. 270.

85 H. Doc. 137; "Roller-Gate Dams for Kanawha River," p. 338; and Teichman, "Large Roller-Crest Dam," p. 4; and E.E. Gesler to Chief of Engineers, 10 Feb. 1937, RG77, Entry 111, Box 982, File 3524 - Part 1, WNRC.

86 "Roller-Gate Dams for the Kanawha River," p. 340; H. Doc. 137; Rathbun Associates, "Locks and Dams 11-22," p. II-27.

87 The original German designed gates that the Corps started with at Rock Island were those covered by the M.A.N. Company patent as fabricated by the S. Morgan Smith Company. They were almost identical to those used at the New England Power Association's Bellows Falls dam. H. Doc. 137, p.97. Discussions relevant to

reasons for the modifications in these original designs are included in Gross and McCormick, "The Upper Mississippi River Project," pp. 315-316; "Roller-Gate Dams for he Kanawha River," p. 340. Standard roller gate construction process is covered in "Building Rolling-Crest Dam Grand River," esp. pp. 61-63. Construction dates on Dam 15 are covered in Final Report Lock and Dam 15, p. 60. The dam was completed on March 31, 1934. Thus, it was halfway done in 1933.

88 "Roller-Gate Dams for Kanawha River," p. 337. As noted above, it was in connection with the designs of these Kanawha River dams that Claude I. "Pete" Grimm, Chief of the Central Divisions Engineering Design Force, visited the Electric Bond and Share Company's Wallenpaupack plant in PA. Col. Harley B. Ferguson to Chief of Engineers, Dec. 1928, RG77, District Files, 1923-1942, Box 621,File 2294, NA. The flap type rollers at Dam 4 are discussed in O'Brien, "Locks and Dams 3-10," HAER No. MN-20, pp. 27-28 and his individual outline HAER No. WI-47, p.8.

89 Gross and McCormick, "The Upper Mississippi River Project," p. 316; E. Gesler to Div., 9 Oct. 1937, and E.E. Gesler to Chief, 12 Nov. 1937 and 28 May 1938, RG77, Entry 111, Box 998, File 3524-Part 2; and RG77, Entry 111, Box 197, Envelope 7245.

90 Gross and McCormick, "The Upper Mississippi River Project," p. 314.

91 "Patent Lock Gate," The Farmer's Journal, Welland Canal Intelligence 2, No. 39 (Oct. 17, 1827); Deposition of William A. Gooding, 19 Oct. 1850, in George Heath v. George W. Hildreth, Civil Action a-1363, Fifth Judicial District of the Supreme Court of the State of New York (Herkimer NY); G.W. Hildreth, Canal-Lock Gate, Patent No. 1517, Patented Mar. 19, 1840; G. Heath, Hydraulic Canal Gate, Patent No. 2393, Patented Dec. 14, 1841; Heath v. Hildreth, Case No. 6,309, Oct. 15. 1841, Circuit Court, District of Columbia; New York State Assembly Doc. No. 201, April 21, 1846; New York State Assembly Doc. No. 18, Jan. 15, 1844, New York State Assembly Doc. No. 91, Feb. 22, 1944; New York State Assembly Doc. No. 216, May 5, 1846; Johnson, Davis Island Lock and Dam, 135 and 162; Mary Yeater, "Hennepin Canal Historic District," National Register of Historic Places Inventory-Nomination Form (written July 1977, listed September 1977), Section 7, pp. 2-3; Gjerdes, "St. Paul Locks and Dams," pp. 125-128.

92 R.A. Wheeler to Div. Engineer, 16 August 1935, RG77, Entry 111, Box 990, file 3524-part 2, WNRC; Drawings, number M-L 18 10/39A; Annual Report, 1940, p. 1160; Annual Report, 1942, p. 1028; and Annual Report, 1951, p. 1237.

93 Final Report-Dam 11, p. 52. It is unlikely that it ia an accident that elliptical Tainter gates were developed on a project where both Tainter and roller gates were being used. The elliptical Tainter includes the interior bracing frame and the surrounding skin of the roller gate along with the pivoted arch form of the older Tainters.

94 Drawings, numbers M-L 12 48/1; M-L 13 48/1; M-L 14 48/1; M-L 17 48/1; M-L 21 48/1; and M-L 22 48/1.

95 Final Report Laboratory Tests on Hydraulic Model of Lock and Dam No. 22, Mississippi River, Hannibal, Mo., RG77, Entry 111, Box 179, Envelope 7245; R.A.

Wheeler to Chief of Engineers, 13 Oct. 1934, RG77, Entry 111, Box 993, File 3524-Part 2, WNRC; Final Report-Dam 11, pp. 10 and 53; E.E. Gesler to Chief of Engineers, 13 Jan. 1937, E.E. Gesler to R. W. Kaltenbach Corp., 16 April 1937, and E.E. Gesler to Div. Engineer, 26 June 1937, RG77, Entry 111, Box 975, File 3524, WNRC.

96 Final Report-Dam 11, pp. 51 and 56; Drawings, numbers M-L 11 58/1, 58/1A, 58/1A.1, and 58/1A.2; M-l 18 58/2A.

97 O'Brien, "Lock and Dams 3-10,"HAER No. MN-20, p. 31; Drawings, numbers M-L 20 48/1; M-L 16 48/1; and M-L 18 48/1.

98 Controlling the gravity flow of water into and out of lock chambers by valves in the lock walls is not new. It seems to have originated in the 1860s or 1870s. As late as the 1846-1848 lock gates on the Illinois and Michigan canal and the 1842-1846 enlarged Lockport, New York, locks on the Erie Canal, the valves for filling and emptying the lock were located in the lock gates. However, by 1870-1874 when the Des Moines canal locks were built on the Upper Mississippi River, the valves in the lock gates were apparently intended only for emergency use. The main valves for emptying and filling the lock were in the walls of the lock and were controlled by slide valves built into the lock walls. These slide gates (valves) were operated by cables and pulleys powered by a 30-horse power steam engine housed in a 27-foot square stone engine house adjacent to the lock. This machinery was designed by Major Amos Stickney, the Corps' Keokuk resident engineer from 1872 to 1877. Both the Panama Canal locks, designed between 1902 and 1913, and the Keokuk lock, designed between 1905 and 1910, use 4 valves to control the water entering and leaving a penstock in the lock wall. The valves for filling and emptying the Keokuk lock chamber were patterned after those being used in Panama. The chamber was filled and emptied by gravity. Water entered a single straight penstock embedded in the the foot of the riverwall of the lock from intakes located on the riverward side of the river wall of the lock upstream from the upper gates. Cylindrical valves located in the river wall above the penstock directed the water from the penstock either into the eight tunnels embedded in the floor of the lock and extending from the riverwall to the land wall or back out into the river on the riverward side of the lock. Water entered and left the lock chamber through a large number of holes in both the tunnels and the lock floor above them. This arrangement was an attempt to keep turbulence inside the lock chamber at a minimum. The Ohio River locks, basically designed between 1905 and 1915, also used multiple floor ports. However, the next generation of locks, such as the Moline Lock (designed in 1905) and the Le Claire Lock (designed in 1913 and redesigned in 1920), apparently did not have floor parts. Rather, the water entered and left the locks directly from the penstocks embedded in the lock wall as in the 9-foot Channel Locks. However, at the Le Claire lock water ingress and egress as well as flow direction was controlled by what were called wagon gate valves rather than tainters. The kinds of valves used in slack-water navigation system locks is an area which needs further research in order to determine if the Corps use of Tainter gates in this project was really innovative. Mary Yeater and Peter Rathbun, "Report on Historical Investigations at I&M Canal Lock No. 14" (Springfield IL: Division of Historic Sites Illinois Department of Conservation, 1978), pp. I-I:22 and I-I:27-31; Ben Hur Wilson, "The Des Moines Rapids Canal," Palimpset V, no. 4 (April 1924), pp. 120-130; Tweet, Rock Island District, pp. 93-103 and 249; and Rathbun Associates, "Locks and Dams 11-22," pp. II-15-16; Montgomery Meigs, "Lock Valves of the Mississippi River Lock at Keokuk,

Iowa" (typewritten manuscript, ca. 1928), Montgomery Meigs and Family Paper, 1866-1931, Illinois State Historical Society Library, Old State Capitol, Springfield IL; Gjerdes, "St. Paul District Locks and Dams," p. 114.

99 Annual Report, 1981, p. 2651. By the 1880s engineers in France had used concrete construction for shore protection and American Engineers had used it to build fortifications. Marshall had learned about locks and dams when in charge of the Fox and Wisconsin Rivers prior to 1888. At that time the Corps was rebuilding locks, dams and canals along the fox. It had begun this project in 1872 (under Col. David C. Houston) and completed it in 1904 by which time it had built 18 new locks, 9 composite locks, and 13 canals. Merritt, St. Paul District, p. 257. Marshall had also experimented with concrete construction prior to 1888 when he served as a consulting engineer on a project to protect Chicago's Lincoln Park lakefront. He developed a method of pouring concrete walls on this project. He adapted this system to lock construction on the Illinois and Mississippi (Hennepin) Canal Project. However, he had to develop many more new techniques to handle a project of such unprecedented size. The methods and machines he and his assistants developed for this project became standard industry practice and helped revolutionize American building practices. Tweet, Rock Island District, pp. 163-166; Yeater, "Hennepin Canal," section 8, pp. 12-13.

Even before Marshall's Hennepin Canal structures were complete in 1908, other Corps officers known for their design innovation began to build poured concrete locks. For example the system of 10 locks and dams designed between 1896 and 1898 under Lieutenant William L. Sibert for the White River in Arkansas included poured concrete locks. See Rathbun, Little Rock District pp. 109-112. Subsequently, while serving as Pittsburgh District Engineer (1902-05), Siebert was appointed a member of the Isthmain Canal Commission. It was in that role that Sibert was instrumental in carrying concrete lock construction into the Panama Canal designs. It was also in his role as Pittsburgh District Engineer than Sibert served as an initial member of the Special Board of Engineers headed by Colonel Daniel Lockwood which began designing new Ohio River locks in 1905/6. This board also chose concrete construction. While the Ohio River locks were begin designed, Hugh L. Cooper, working closely with Montgomery Meigs designed the Keokuk lock. It was the first Upper Mississippi River lock in the Rock Island District built of concrete.

100 The final construction reports mention these being added at Locks 16, 18, 11, 21, 22 and 12 -- that is, all those in the district built on piles except Lock 17. It is not clear if the struts were not used at 17 or were simply not added in. 17 was the last lock constructed in the district. By then the struts may have been a standard feature drawn in at the initial design state and not meriting special mention. For a good description of the structs and their function see War Department, Corps of Engineers, U.S. Army, Mississippi River Lock and Dam 21 Final Report - Construction, Vol. I: Introduction and Lock (Rock Island: U.S. Army Engineer Office, August, 1939), (hereinafter referred to as Final Report-Lock 21), pp. 8-9.

101 Again this work was done at several locks and is recounted in several final reports. For a good description see Final Report-Lock 22, p. 9.

102 R.A. Wheeler to Chief of Engineers, 3 May 1934, RG77, entry 111, box 997, file 3424, WNRC.

103 Final Report Lock and Dam 15, p. 19.

104 The Illinois and Michigan Canal completed in 1848, was a fairly typical mid-nineteenth century canal. Its locks were 18 feet wide. For further details on this canal see Mary Yeater Rathbun, The Illinois and Michigan Canal (Springfield, IL: Illinois Department of Conservation, 1980), p. 23. For a discussion of the Des Moines Canal width and gates see Wilson, "Des Moines Rapids Canal," pp. 120-130; and Tweet, Rock Island District, pp. 93-103. Johnson, Davis Island Lock and Dam, pp. 53-54, covers this aspect of the Davis Island structure.

105 Johnson, Louisville District, p. 176.

106 Richard Monroe to H. Burgess, 9 June 1920, and H. Burgess to Div. Engineer, 24 July 1920, RG77, entry 81, box 798, NARA-CH; and Annual Report, 1924, p. 1090. Despite the urgings of Rock Island District civilian engineer Richard Monroe, later chief civilian engineer in the district during the 9-foot project, the Corps did not fully transform the LeClaire lock into what later became known as a standardized Ohio-Mississippi Lock design. Even though Corps engineers had solved the technological problem which had kept the Corps from designing a 110-foot wide lock in the first place, the Rock Island District did not increase the size of the lock.

107 War Department, Corps of Engineers, U.S. Army, Mississippi River Lock and Dam No. 20: Final Report - Construction, Vol. I: Introduction and Lock (Rock Island: U.S. Engineer Office, March, 1935) (hereinafter referred to as Final Report Lock 20), pp. 41-42, RG77, entry 81, box 666, NARA-CH.

108 Final Report Lock 20, pp. 24 and 48; War Department, Corps of Engineers, U.S. Army, Final Cost Report Dam 20 Mississippi River (Rock Island: U.S. Engineer Office, June, 1936), (hereinafter referred to as Final Cost Dam 20), pp. 1-2, RG77, entry 81, box 666, NARA-CH; R.A. Wheeler to Chief of Engineers, 16 Nov. 1933 and 23 July 1934, RG77, entry 111, box 993, file 3524-part I, WNRC; and Drawings, numbers M-L 20 20/1 and 40/1.

109 Interview with G. Ron Clark and James Wright, U.S. Army Corps of Engineers, Lockmaster and Former Lockmaster (Respectively) of Lock and Dam 20, Canton MO, 16 July 1984 (hereinafter referred to as Clark-Wright Interview); Inter-office memo 21 May 1940, RG77, Entry 111, box 795, file 3524, WNRC; Annual Report, 1940, p. 1160; Annual Report, 1942, pp. 1025 and 1028; and Annual Report, 1943, p. 943.

110 Annual Report, 1942, p. 1028; Annual Report, 1951, p. 1237.

111 Inter-office memo 27 April 1942, RG77, entry 111, box 975, file 3524, WNRC; Annual Report, 1942, p. 1028; Annual Report, 1951, p. 1237.

112 Corps of Engineers, U.S. Army, Completion Report on the Construction of New Lock 19, Mississippi River (Rock Island; Rock Island District, March, 1958), (hereinafter referred to as Completion Report New Lock 19), p. 3; Tweet, Rock Island District, pp. 274-278.

113 Compare Drawings, number M-L 15 41/1; M-L 20 41/1; and Teichman, "Large

Roller-Crest Dam," pp. 1-2.

[114] Interview Charles Ross with Robert Maddox, Huntington WV, 13 Oct. 1982 as cited in Johnson to O'Brien, 6 Feb. 1988 (1st letter of that date).

[115] Final Report-Dam 11, pp. 10 and 52-53.

[116] E.E. Gesler to Chief of Engineers, 27 Nov. 1936, RG77, entry 111, box 995, file 3524-part 3, WNRC.

[117] Final Report Lock 11, p. 60; Herbert G. McCormick and John W. Dixon, "Mississippi River Cofferdams," pp. 105-107. In the Rock Island District, cofferdams failed in April, 1934, during the construction of Lock 21; in April, 1936, during the construction of Dam 11; and in January, 1938, during the construction of Dam 17.

[118] McCormick and Dixon, "Mississippi River Cofferdams," p. 106; Johnson, Louisville District, p. 183.

[119] McCormick and Dixon, "Mississippi River Cofferdams," p. 106-108.

[120] For information on the location of drawings see note 26 above. The monthly reports are kept longer in the St. Paul District. In that district, copies of the monthly installation reports filed since 1970 are kept in the district office. O'Brien, "Locks and Dams 3-10," HAER No. MN-21, p.1 and confirmed in a telephone interview with W. Patrick O'Brien, National Park Service, Denver CO, 13 Jan. 1988.

[121] See above pp. 64-73; O'Brien, "Locks and Dams 3-10," HAER No. MN-20, pp.27-32 and 36; and Drawings, numbers M-L 15 47/1; M-L 20 47/1; and M-L 16 47/1.

[122] Drawings, numbers M-L 20 48/2 and 48/5; and M-L 16 48/5; M-L 14 48/1; and M-L 22 48/5; M-L 11 48/1; M-L 12 48/1; M-L 13 48/1; M-L 17 48/1; M-L 18 48/1; M-L 21 48/1.

[123] See above pp. 82-85; O'Brien, "Lock and Dams 3-10," HAER No. MN-20, pp. 37-40 and HAER NO. MN-21, p.1.; Drawings, numbers M-L 15 41/1; 40/7; W. Patrick O'Brien, "Rock Island District, Corps of Engineers, Locks and Dams 11-22, Dubuque, Iowa, to Saverton, Missouri, Photographic Inventory" (typewritten, xeroxed set of photographer's instructions, Denver: National Park Service, 1987), item II ("Detail Photography"). The original drawings of Dam 20 most easily accessible while this report was being written did not include M-L 20 41/1 or 41/3. These drawings had been checked out of the district library. They are the ones most likely to show the liftout roof sections and lifting plates. The drawings most easily accessible in no way indicate this feature. However, our 1988 photographs HAER No. MO-34-7 and HAER No. MO-34-8 clearly show lifting plates on the liftout portions of the pier house roofs. Floyd Mansberger, cultural resource specialist with the Rock Island District, was able to examine M-L 20 41/3. He confirmed that the original drawings clearly show the lifting plate and liftout portion of the roof. Telephone interview with Floyd Mansberger, U.S. Army Corps of Engineers Rock Island District, Rock Island IL, 25 Jan. 1988. Both 1c piers and the extension section to 1a piers project downstream immediately below a rectangular section of pier. These projections create slight

overhangs. In lcs the pier house sits on the rectangular section of pier abve the projection. In las the flat surface supports nothing. The detailing of the beveled edge of the projecting section on both las and lcs is remarkable similar. Compare our 1988 photographs HAER No. IL-27-28 and HAER No. MO-34-7. When looking at these two photographs the idea that the design for a precursor to the lc structures at Dam 20 was complete in July 1931 seems plausible. Then when one compares the lc structures to the piers at the Grand Valley Roller dam in Colorado (see above p. 83 and note 113), the identify f the preurssor becomes obvious. The lc pier shape was created first and then the main tall column section of the la piers added on to it to meet the specific needs of Dam 15 as it was aligned to the flow of the river. The question remains open as to why the center liftout roof section was eliminated from Dam 5. There was time to modify the design further, eliminating the liftout roof section, before the final drawings were completed for Dams 4 and 6, the other two dams with lb structures. Construction began on these two dams in Nov., 1933, and Nov., 1934, respectively.

[124]Drawings, numbers M-L 16 40/2; M-L 18 40/2; M-L 11 40/2; M-L 12 40/2; M-L 13 40/2; M-L 14 40/2; M-L 17 40/2; M-L 21 40/2; M-L 22 40/2; E.E. Gelser to Chief of Engineers, 27 Nov. 1936, RG77, Entry 111, Box 995, File 3524-Part 3, WNRC.

[125]Drawings, numbers M-L 20 70/1, 70/2, and 70/6; M-L 11 70/1; M-L 12 70/1; M-L 16 70/1; M-L 18 70/1; M-L 21 70/1; and M-L 22 70/1. The specific date explanation for the enlargement is contained in the revision box on the drawings. See, for example, M-l 21 70/1.

[126]Flat roofed roller gate pier houses in 2a and 2b roller gate piers began to be incorporated into designs for piers as early as Sept., 1934. The designs for 2a and 2b central control stations were completed in Aug. and Sept., 1936. Drawings, numbers M-L 14 70/1; M-L 13 70/2; M-L 17 70/2; M-L 14 70/2; M-L 13 70/1; and M-L 17 70/1.

[127]Final Report-Lock 11, pp.24-25 and 82-83; Final Report-Dam 11, pp. 2 and 4; War Department, Corps of Engineers, U.S. Army, Mississippi River Lock and Dam No. 11, Final Report-Construction, Vol. IV: Power, Control and Lighting System (Rock Island: U.S. Engineer Office, July, 1940), (hereinafter referred to as Final Report-Power, Control and Lighting 11), pp.2-3, RG77, Entry 81, Box 667, NARA-CH; and C.W. Ball to Contract Section OCE, 5 Jan. 1942, RG77, Entry 111, Box 694, WNRC.

[128]Drawings, numbers M-L 11 0/1-70/9; and R.A. Wheeler to Leroy C. Perkins, 17 July 1934, RG 77, entry 111, box 974, file 3524-part 1, WNRC.

[129]Drawings, numbers M-L 11 10/48A; M-O 32/11; C.W. Ball to Chief of Engineers, 26 June 1941 and 26 Jan. 1942, RG77, entry 111, box 974, file 3367, WNRC; inter office memos, 27 April 1942 and 21 May 1940, E.E. Gesler to Div. Engineers, 26 June 1937, E.E. Gesler to R. W. Kaltenbach Corp., 16 April 1937, E.E. Gesler to Chief of Engineers, 13 Jan. 1937, RG77, entry 111, box 975, file 3524-part 2, WNRC; Harry W. Hill to Chief of Engineers, 19 June 1941, RG77, entry 111, box 975, file 7245, WNRC; "Bids on upper approach deflection dike June 1941," RG77, entry 111, box 178, envelope 3390, WNRC; Annual Report, 1940, p. 1160 ; Annual Report, 1942, p. 1025; Annual Report, 1947, p. 1400; Annual Report, 1948, p. 1563; Threshold Design, Inc., Lockhouse Rehabilitation Concept Report, Mississippi River (Milwaukee, WI: Threshold

Design Inc., 1984), (Hereafter cited as Threshold, Lockhouse Rehabilitation), passim, telephone interviews with Wayne Currier, U.S. Army Corps of Engineers Lockmaster of Lock and Dam No. 11, Dubuque, Iowa. 25 Jan. 1988 and 2 Feb. 1988. (Hereafter cited as Currier interviews, 25 Jan. 1988, and 2 Feb. 1988); interview with Steve F. Ohler, U.S. Army Corps of Engineers Lockmaster Lock and Dam No. 18, near New Boston IL, 11 July 1984 (hereinafter referred to as Ohler interview).

[130] H. Doc 137; Final Report-Lock 11, pp.2-4.

[131] R.A. Wheeler to Div. Engineer, 5 Oct. 1933, RG77, entry 11, box 974, file 3408, WNRC; R.A. Wheeler to Div. Engineer, 16 Jan. 1934, RG77, entry 111, box 974, file 3524-part 1, WNRC; and Final Report-Lock 11, pp.6 and 91.

[132] Laboratory Test on Hydraulic Model of Lock and Dam No. 11, Mississippi River, Dubuque, Iowa by St. Paul Engineer District sub office, Hydraulic Laboratory, University of Iowa, Iowa City, Iowa: Hydraulic Report No. 40, April 1940, RG77, entry 111, box 178, envelope 7245. The earthen embankment extending from the levee towards the dike section of the dam clearly related to diminishing the impact of dam operation on the levee. However, its construction is not called for in the above document. No records of its construction were examined during the research phase of this project. However, it was in place by Feb., 1940 (see M-L 11 10/48A). It may be a result of siltation rather than actual construction. A likely source of further information on this issue is War Department, Corps of Engineers, U.S. Army, Mississippi River Lock and am No. 11, Final Report-Construction, Vol. III: Eagle Point Bridge Alterations (Rock Island: U.S. Engineer Office, May, 1938). The construction history of the other dikes mentioned in this paragraph is much clearer.

[133] Final Report-Dam 11, p. 16.

[134] Ibid., pp. 10 and 52-53; E.E. Gesler to Chief of Engineers, 13 Jan. 1937, E.E. Gesler to R.W. Kaltenbach Corp., 16 April 1937, and E.E. Gesler to Div. Engineer, 26 June 1937, RG77, entry 111, box 975, file 3524, WNRC.

[135] Final Report-Lock 11, p. 32; and Annual Report, 1938, p. 1049.

[136] Telephone interview with Wayne Currier, Rock Island District, Dubugue, Iowa, 27 Jan. 1988.

[137] Final Report-Lock 12, p. 20; War Department, Corps of Engineers, U.S. Army, Final Cost Report Dam No. 12, Mississippi River (Rock Island, U.S. Engineer Office, Oct., 1939), (hereinafter referred to as Final Cost Dam 12), RG77, entry 81, box 665, NARA-CH; W.H. Crossen to General Accounting Office, 23 July 1938, RG77, entry 111, box 977, file 3524, WNRC; and E.E. Gesler to Chief of Engineers, 20 Feb. 193, RG77, entry 111, box 978, file 3648, WNRC.

[138] Annual Report, 1951, p. 1237; Threshold, Lockhouse Rehabilitation, passim; Currier interviews, 25 Jan. 1988 and 2 Feb. 1988; Ohler interview.

[139] Final Report-Lock 12, pp.2-4 and 22.

[140] See above p. 85 and note 116.

Design Inc., 1984), (Hereafter cited as Threshold, Lockhouse Rehabilitation), passim, telephone interviews with Wayne Currier, U.S. Army Corps of Engineers Lockmaster of Lock and Dam No. 11, Dubuque, Iowa. 25 Jan. 1988 and 2 Feb. 1988. (Hereafter cited as Currier interviews, 25 Jan. 1988, and 2 Feb. 1988); interview with Steve F. Ohler, U.S. Army Corps of Engineers Lockmaster Lock and Dam No. 18, near New Boston IL, 11 July 1984 (hereinafter referred to as Ohler interview).

[130] H. Doc 137; Final Report-Lock 11, pp.2-4.

[131] R.A. Wheeler to Div. Engineer, 5 Oct. 1933, RG77, entry 11, box 974, file 3408, WNRC; R.A. Wheeler to Div. Engineer, 16 Jan. 1934, RG77, entry 111, box 974, file 3524-part 1, WNRC; and Final Report-Lock 11, pp.6 and 91.

[132] Laboratory Test on Hydraulic Model of Lock and Dam No. 11, Mississippi River, Dubuque, Iowa by St. Paul Engineer District sub office, Hydraulic Laboratory, University of Iowa, Iowa City, Iowa: Hydraulic Report No. 40, April 1940, RG77, entry 111, box 178, envelope 7245. The earthen embankment extending from the levee towards the dike section of the dam clearly related to diminishing the impact of dam operation on the levee. However, its construction is not called for in the above document. No records of its construction were examined during the research phase of this project. However, it was in place by Feb., 1940 (see M-L 11 10/48A). It may be a result of siltation rather than actual construction. A likely source of further information on this issue is War Department, Corps of Engineers, U.S. Army, Mississippi River Lock and am No. 11, Final Report-Construction, Vol. III: Eagle Point Bridge Alterations (Rock Island: U.S. Engineer Office, May, 1938). The construction history of the other dikes mentioned in this paragraph is much clearer.

[133] Final Report-Dam 11, p. 16.

[134] Ibid., pp. 10 and 52-53; E.E. Gesler to Chief of Engineers, 13 Jan. 1937, E.E. Gesler to R.W. Kaltenbach Corp., 16 April 1937, and E.E. Gesler to Div. Engineer, 26 June 1937, RG77, entry 111, box 975, file 3524, WNRC.

[135] Final Report-Lock 11, p. 32; and Annual Report, 1938, p. 1049.

[136] Telephone interview with Wayne Currier, Rock Island District, Dubuque, Iowa, 27 Jan. 1988.

[137] Final Report-Lock 12, p. 20; War Department, Corps of Engineers, U.S. Army, Final Cost Report Dam No. 12, Mississippi River (Rock Island, U.S. Engineer Office, Oct., 1939), (hereinafter referred to as Final Cost Dam 12), RG77, entry 81, box 665, NARA-CH; W.H. Crossen to General Accounting Office, 23 July 1938, RG77, entry 111, box 977, file 3524, WNRC; and E.E. Gesler to Chief of Engineers, 20 Feb. 193, RG77, entry 111, box 978, file 3648, WNRC.

[138] Annual Report, 1951, p. 1237; Threshold, Lockhouse Rehabilitation, passim; Currier interviews, 25 Jan. 1988 and 2 Feb. 1988; Ohler interview.

[139] Final Report-Lock 12, pp.2-4 and 22.

[140] See above p. 85 and note 116.

141 Final Cost Dam 12, p.6.

142 Final Report-Lock 12, pp.13 and 25; numerous letters and memos, RG77, entry 111, box 978, file 3524, WNRC; and Annual Report, 1939, p. 1150.

143 "Specifications for Esplanade Work Lock and Dam No. 12, Mississippi River, Bellevue, Iowa" (Rock Island: U.S. Engineer Office, July, 1939), RG77, entry 111, box 178, envelope 3648, WNRC.

144 Final Report-Lock 13, 20; War Department, Corps of Engineers, U.S. Army, Final Cost Report, Lock 13, Mississippi River (Rock Island: U.S. Engineer Office, n.d.), (hereinafter referred to as Final Cost Lock 13), pp. 16-17; ----, Final Cost Report, Dam 13, Mississippi River (Rock Island: U.S. Engineer Office, Dec., 1939), (hereinafter referred to as Final Cost Dam 13), p.6 RG77, entry 81, box 665, NARA-CH; E.E. Gesler to Chief of Engineers, 15 Dec. 1936, 31 March 1937, 24 June 1938, and 15 March 1938, RG77, entry 111, box 979, file 3524, WNRC; and E.E. Gesler Chief of Engineers, 2 June 1939, RG77, entry 111, box 980, file 3524, WNRC.

145 Annual Report, 1942, p.1028; Annual Report, 1950, p. 1449; Currier interviews, 25 Jan. 1988, and 2 Feb. 1988; Threshold, Lockhouse Rehabilitation; interview with Verlin Baker, U.S. Army Corps of Engineers lockman, Lock and Dam No. 13, 27 June 1984 (hereinafter referred to as Baker interview); Ohler interview.

146 Final Report-Lock 13, p.11; Final Cost Dam 13, p.C; Annual report, 1942, p. 1028; Annual Report, 1951, p. 1449; and Baker interview.

147 Drawings, numbers M-L 13 20/1; M-L 14 20/1; M-L 17 20/1; M-L 14 40/1; M-L 13 40/1; M-L 17 40/1; E.E. Gesler to Chief of Engineer, 30 Nov 1935, RG77, entry 111, box 979, file 3344, WNRC; Final Cost Dam 13, p.C; War Department, Corps of Engineers, U.S. Army, Final Cost Report, Dam No. 14, Mississippi River (Rock Island: U.S. Engineer Office Dec. 1939), (hereinafter referred to as Final Cost Dam 14), p.C, RG77, entry 81, box 666, NARA-CH; and ----, Final Cost Report, Dam No. 17, Mississippi River (Rock Island: U.S. Engineer Office, Oct. 1940), (hereinafter referred to as Final Cost Dam 17), p.107, RG77, entry 81, box 668, NARA-CH.

148 Annual Report, 1940, p.1155.

149 Final Report-Lock 14, pp.13 and 20; Final Cost Dam 14, p. C; W.H. Crosson to Chief of Engineers, 31 March 1939; M.E. Sorley to Central Engineering Company, 24 Nov. 1936; R.A. Wheeler to Central Engineering Company, 17 Aug. 1935 RG77, entry 111, box 982, file 3524, WNRC; and C.P. Gross to Chief of Engineers, 20 Nov. 1940 and E.E. Gelser to Chief of Engineers, 22 June 1939 RG77, entry 111, box 982, file 3648, WNCR.

150 C.L. Hall to A.L. Richards, 26 April 1930 RG77, entry 81, box 798, NARA-CH; "Lock and Dam No, 14, Mississippi River, LeClaire, Iowa: Specifications for repair of Miter gates Auxiliary Lock" (Rock Island: U.S. Engineer Office, Nov. 1937) and E.E. Gesler to Chief of Engineers, 22 June 1939, RG77, entry 111, box 982, file 3524-part 1, WNRC; Rock Island District Drawing Number 202.051,; Annual Report, 1951, p. 1237; U.S. Army Corps of Engineers, Rock Island District, Environmental Assessment, Rehabilitation of Old Lock 14, Mississippi River, LeClaire, Iowa (Rock

Island: U.S. Army Corps of Engineers, Rock Island District, 1978), passim; Currier interviews, 25 Jan. 1988, and 2 Feb. 1988; and Ohler interview.

[151] Tweet, History of Improvements Rock Island Rapids, pp.1-2 and 11; District Engineer Officer to Chief of Engineers, 27 Aug. 1913, RG77, entry 81, box 798, NARA-CH; E.Doc 7., p.20; H. Doc. 341; Rivers and Harbors Act of 2 March 1907; River and Harbors Act of 5 March 1914; R. Monroe to H. Burgess, 9 June 1920, and H. Burgess to Division Engineer, 24 July 1920, RG77, entry 81, box 798, NARA-CH; and Annual Report, 1924, p. 1090. See also above note 106.

[152] District Engineer to Chief of Engineers, 27 Aug. 1913; Rock Island District, Environmental Assessment, Rehabilitation of Old Lock 14, p. 1.

[153] Ibid.

[154] Rock Island District Drawing number 202.051.

[155] Final Report-Lock 14, pp. 6 and 12.

[156] Drawings, number M-L 14 20/1; E.L. Daley to Chief of Engineers, 11 Jan. 1934, RG77, entry 111, box 982, file 35224-part 1, WNRC; Final Report-Lock 14, p. 74.

[157] Drawings, number M-L 14 20/1.

[158] Tweet, History Improvements Rock Island Rapids, p. 15.

[159] Final Report-Lock and Dam 15), pp.17, 53-54, 60, 69-71, 142, 191, and 194; M.E. Sorley to Schadt Service Company, 17 Sept. 1935, E.E. Gesler to Chief of Engineers, 27 Dec. 1935, RG77, entry 111, box 984, file 3326, WNRC; R.A. Wheeler to Chief of Engineers 16 Oct. 1934, RG77, entry 111, box 984, file 3346, WNRC; R.A. Wheeler to Chief of Engineers, 18 Oct. 1934, RG77, entry 111, box 984, file 3518, WNRC; B.A. McGinn to Chief of Engineers, 4 Feb. 1934, G.E. Edgerton to Chief of Engineers, 7 April 1931, 27 April 1931, and G.E. Edgerton to Division Engineer, 35 March 1931, RG77. entry 111, box 985, file 3524-part 1, WNRC; R.A. Wheeler to Chief of Engineers, 23 July 1934, RG77, entry 111, box 986, file 3648, WNRC; E.N. Parker to Chief of Engineers, 2 Feb. 1933, George Spaulding to Chief of Engineers, 7 Nov. 1932, RG77, entry 111, box 986, file 3670, WNRC; C.W. Ball to Chief of Engineers, 14 Aug. 1941 and James D. Campbell to Comptroller General, 18 Feb. 1933, RG77, entry 112, box 694, WNRC.

[160] Mississippi River Lock and Dam 15, Lock, Operations Folio, Feb., 1936, file no. GP61-1 and Dam, Operations Folio, April, 1936, file no. GP51-2; George R. Spaulding to Chief of Engineers, 27 July 1931, RG77, entry 111, box 985, file 3524-part 1, WNRC; Tweet, Rock Island District, p. 384.

[161] Drawings, numbers M-L 15 47/201; Annual Report, 1942, p.1028; Annual Report, 1951, p. 1237; M-l 15 33/11, 33/12; M-L 15 78/2; Annual Report, 1980, p. 29-3; interview with James Morgan, U.S. Army Corps of Engineers, Lockmaster, Lock and Dam No. 15, July 1984; and installation inspection, 24 and 5 Sept. 1987; Ohler interview.

161 H. Doc. 137; Final Report, Lock and Dam 15, pp. 4-8; Final Report, Lock 14, p.2; and above Chap. 2, p. 34.

162 Final Report, Lock and Dam 15, p.7.

163 Final Report, Lock and Dam 15, pp. 16 and 6.

164 Ibid, pp. 13; G.E. Edgerton to Chief of Engineers, 1 Aug. 1931 RG77, entry 111, box 985, file 3524-part 2, WNRC; R.A. Wheeler to Chief of Engineers, 22 July 1934, RG77, entry 111, box 986, file 3648, WNRC; C.W. Ball to Chief of Engineers, 14 Aug, 1941, RG77, entry 112, box 694; and E.E. Gesler to Chief of Engineers, 27 Dec. 1935, RG77, entry 111, box 984, file 3326, WNRC.

165 George R. Spaulding to Chief of Engineers, 27 July 1931, RG77, entry 111, box 985, file 3524-part 1, WNRC.

166 Final Report, Lock and Dam 15, p. 6.

167 Tweet, History Improvements Rock Island Rapids, p.15.

168 Final Report-Lock 16, pp. 31-33 ; R.A. Wheeler to Central Engineering Co., 11 Nov. 1933 and 29 Dec. 1934 and R.A. Wheeler to Kelso-Burnett Electric Co., 13 July 1935, RG77, entry 111, box 986, file 3524-part 1, WNRC; Henry Berbet to Chief of Engineers, 26 April 1936, RG77, entry 111, box 987, file 3760, WNRC; Rock Island District shop drawings card index, District Library, Clock Tower Building Annex, Rock Island, Illinois.

169 "Work Moves Swiftly on Lock 16, Jobs Increase," Muscatine Journal, 23 March 1934.

170 Drawings, numbers M-L 16 10/26A; M-O 32/10; Annual Report, 1940, p. 1160; Annual Report, 1942, p. 1028; Annual Report, 1951, p. 1237; interoffice memo, 21 May 1940, RG77, entry 111, box 975, file 3524, WNRC; Currier interviews, 25 Jan. 1988 and 2 Feb. 1988; Threshold, Lockhouse Rehabilitation; and Ohler interview.

171 H. Doc. 137; Final Report-Lock 16, pp.2-3; see above pp. 33-34 and note 38.

172 Final Report-Lock 16., pp. 18 and 34; R.A. Wheeler to Chief of Engineers, 14 Nov. 1933, RG77, entry 111, box 986, file 3524-part 1,WNRC; E.L. Daley to Chief of Engineers, 28 Dec. 1933 and R.A. Wheeler to Chief of Engineers, 16 Feb. 1934, RG77, entry 111, box 986, file 3344, WNRC; R.A. Wheeler to Sprague and Henwood, Inc., 9 Jan. 1934 and J. M. Silkman to Chief of Engineers, 9 June 1934, RG77, entry 111, box 986, file 3408, WNRC; R.A. Wheeler to Division Engineer, 7 Dec. 1934, RG77, entry 111, box 986, file 35243-part 1, WNRC.

173 Annual Report, 1938, p. 1050.

174 Final Report-Lock 17, pp. 17, 25 and 28; Final Cost Dam 17, p. 107; E.E. Gesler to Chief of Engineers, 23 April 1937 and E.E. Gesler to Maxon Construction, 19 Feb. 1937, RG77, entry 111, box 988, file 3524, WNRC; R.L. Dean to Contract Section OCE, 1 Dec, 1938 and American Surety Company to War Department, 6 Aug. 1940

RG77, entry 111, box 988, file 3524-part 2, WNRC.

[175] Annual Report, 1950, p. 1449; Annual Report, 1951, p. 1237; Currier interviews, 25 Jan. 1988 and 2 Feb. 1988; and Ohler interview.

[176] Final Report-Lock 17, pp. 9, 17, and 25.

[177] Ibid, pp. 25 and 33.

[178] E.E. Gesler, Finding of Fact, 17 June 1938, RG77, entry 111, box 988, file 3367, WNRC; and entire contents of RG77, entry 111, box 682.

[179] Annual Report, 1940. p.1156; Final Report-Lock 17, p.33.

[180] "Specifications for Esplanade Work-Lock and Dam No. 17", March, 1939, RG77, entry 111, box 179, WNRC.

[181] Final Report-Lock 18,pp.13,16, and 60; War Department, Corps of Engineers, U.S. Army, Final Cost Report Dam No. 18, Mississippi River (Rock Island: U.S. Engineer Office, Nov. 1938), (hereinafter referred to as Final Cost Dam 18), pp. 2, 87, 94-105, RG77, entry 81, box 668, NARA-CH; R.A. Weeler to Edward M. Rocho, 7 Aug. 1935, RG77, entry 111, box 990, file 3399, WNRC; R.A. Weeler to S.A. Healy, 12 Sept. 1935 and E.L. Daley to Chief of Engineers, 19Feb. 1934, RG77, entry 111, box 990, file 3524-part 1, WNRC; E.E. Gesler to Kelso-Burnett Electric Company, 16 July 1936, RG77, entry 111, box 990, file 3524-part 2, WNRC; E.E. Gelser to Layton and Plumb, 21 Aug. 1937 and R.A. Wheeler to Chief of Engineers, 21 March 1934, RG77, entry 111, box 991, WNRC.

[182] Annual Report, 1940, p. 1160; Annual Report, 1942. p. 1028; Annual Report, 1951, p. 1237; inter office memo, 21 May 1940 and E.E. Gelser to Division Engineer, 26 June 1937 and to Chief of Engineers 13 Jan. 1937, RG77, entry 111, box 975, file 3524, WNRC; M-L 18 10/39A; M-O 32/11; Threshold, Lockhouse Rehabilitation, passim; Currier interviews, 25 Jan. 1988 and 2 Feb. 1988; and Ohler interview.

[183] H. Doc. 137; Final Report-Lock 18, pp.2-4; Final Cost Dam 18, p.1.

[184] R.A. Wheeler to Division Engineer, 16 August 1935, RG77, entry 111, box 990, file 3524-part 2, WNRC.

[185] Final Report-Lock 18, p. 22; and Annual Report, 1938, p. 1050.

[186] Tweet, Rock Island District, pp.93, 95, and 97; Completion Report New Lock 19, pp. 17, 20, 24-25, 59-60, 65, 68, 70-71, an 76-7.

[187] Tweet, Rock Island District, pp. 121-122, 245-250, and 277-278; Tweet, Taming Des Moines Rapids), pp. 3-10; G. Walter Barr, "Interesting Details About the Keokuk Dam," Iowa Factories, II, pp.6-10; Drawings, number M-L 19 110/4; "Keokuk Lock and Dam," file at Iowa State Historical Department, Des Moines, Iowa; Mississippi River Lock and Dam No. 19; Repairs to Keokuk Lock Miter Gates (Rock Island: U.S. Engineer Office, March, 1934), p.1, RG77, entry 81, box 666, NARA-CH; R.A. Wheeler to Chief of Engineers, 23 April 1934, E.E. Gesler to Chief of Engineers, 24 Jan. 1938,

and C.P. Gross to Chief of Engineers, 29 Jan 1940, RG77, entry 111, box 992, file 3524, WNRC; C. W. Ball to Chief of Engineers, 18 Nov. 1941, RG77, entry 111, box 992, file 3394, WNRC; Completion Report New Lock 19, passim; First Stage, New 1200 foot Lock 19, Mississippi River, Keokuk, Iowa, operations folio, 1952, file no. GP65-26; Stage II, Construction, New 1200 foot Lock 19, Mississippi River, Keokuk, Iowa, operations folio, 1954; Mississippi River, Lock and Dam 19, Public Rest-room, 1961-1965, file no. GP65; Mississippi River, Lock and Dam No. 19,Old Lock and Dry Dock, Sheet Pile and closure, As Built Drawings, 1977; interview Ray English, lock tender, Lock 19, Keokuk IA, 24 July 1984; and interview Larry Weiman, hydraulic engineer Union Electric Company, Keokuk Power Plant, Keokuk IA, 24 July 1984.

[188] Annual Report, 1867, p. 265; Ben Hur Wilson, "The Des Moines Rapids Canal," Palimpsest. V, no. 4 (April 1924), pp. 120-130; Tweet, Rock Island District, pp. 93-103.

[189] 1910-1914 construction photographs, 28 vol. collection, Union Electric company, Keokuk Plant, Keokuk, Iowa; Tweet, Rock Island District, pp.247-248; M-L 19-1 110/3.

[190] Tweet, Rock Island District, pp. 121-122 and 247-248.

[191] Tweet, Rock Island District, pp-247-249; McClean, "Keokuk Lock and Dam," p.3.; and Rathbun Associates, "Lock and Dams 11-22"),vol. I, pp. II-14-15.

[192] Completion Report New Lock 19, p.3; Tweet, Rock Island District, pp. 274-278.

[193] Completion Report New Lock 19, p. 43; Tweet, Rock Island District, p. 278 and 249.

[194] Keokuk Industrial Association, "1914 Survey", p. 87.

[195] Final Report-Lock 20,p. 19-22; Final Cost Dam 20), pp. 1; Pillsbury to U.S. District Engineer Rock Island, 26 Nov. 1932; E.N. Parker to Chief of Engineers, 16 Nov. 1933; R.A. Wheeler to Division Engineer, 30 Sept. 1933, all three in RG77, entry 111, box 993, file 3524-part 1, WNRC; R.A. Wheeler to Division Engineer, 22 June 1935; D. A. Morris to Comptroller General 24 June 1935; R. A. Wheeler to Chief of Engineers 25 May 1935; R.A. Wheeler to Fries-Walters, 8 April 1935; R.A. Wheeler to Link Belt Co, 1 April 1935; and R.A. Wheeler to Link-Belt Co., 27 Dec. 1934, all six in RG77, entry 111, box 993, file 3524-part 2, WNRC; R.A. Wheeler to The Atlas Car & Mfg. Co., 7 May 1935 and R.A. Wheeler to Division Engineer, 30 March 1935, both in RG77, entry 111, box 992, file 3356; Burt E. Hoover to E.E. Abbott, 30 July 1935; R.A. Wheeler to Lakeside Bridge Co., 24 July 1935 both in RG77, entry 111, box 994, file 3524-part 3, WNRC; and E.. Geler to Division Engineer, 12 Jan. 1938, RG 77, entry 111, box 994, file 3524-current file, WNRC.

[196] Annual Report, 1940, p.1160; Annual Report, 1942,p. 1028; Annual Report, 1951, p. 1237; Clark-Wright interview; Peter A. Rathbun site inspection 16 Nov. 1987; Ken Barr interview 19 Feb. 1988.

[197] H. Doc. 137; Final Report Lock 20, p. 2.

198 R.A. Wheeler to Chief of Engineers, 31 Oct. 1934, RG77, entry 111, box 993, file 3524-part 2, WNRC; installation inspections 16 July 1984 and 15-16 Nov. 1987; Clark-Wright interview; and Barr interview.

199 It should be noted that the construction of complex 20 and 4 was not as concurrent as was the construction of many of the pairs or groups of complexes built concurrently within the Rock Island District alone. While Lock 20 and 4 were begun within a month of each other (in Oct. and Nov., 1932, respectively) and Lock 5 was not started until 5 months later (in April, 1933), Dam 5 was begun concurrently with Dam 20 (in Oct., 1933) while Dam 4 was not begun for another month (in Nov., 1933). There were some design changes made in pier houses of Dams 4 and 5 which were not made in those of Dam 20. Complex 20's distinctive central control station is discussed above. The fact that it was developed as part of the dam design process is reflected in the index on Drawings, number M-L 20 40/1.

200 Barr interview.

201 Clark-Wright interview.

202 Final Report Lock 20, p.4.

203 Clark-Wright interview.

204 W.A. Snow to Chief of Engineers, 14 Dec. 1933, RG77, entry 111, box 994, file 3524, WNRC; War Department, Corps of engineers, U. S. Army, Mississippi River Lock and Dam No. 21 Final Report-Construction, Vol. I: Introduction and Lock (Rock Island: U.S. Engineer Office, August 1939), (hereinafter referred to as Final Report-Lock 21), pp.13 and 19-26 and -----, Final Cost Report Dam No. 21, Mississippi River (Rock Island: U.S. Engineer Office, May, 1939), (hereinafter referred to as Final Cost Dam 21), p. 18 both in RG77, entry 81, box 669, NARA-CH; E.E. Gesler to McCarthy Improvement Co., 14 Aug. 1936 and C.H. Barth to E. A. Koenemann Co., 12 March, 1937 both in RG77, entry 111, box 995, file 3524-part 3, WNRC; and Harry W. Hill to Chief of Engineers, 31 Oct. 1940, RG77, entry 112, box 694, WNRC.

205 Annual Report, 1940, p. 1160; Annual Report, 1942, p. 1028; Annual Report, 1951, p. 1237; Threshold, Lockhouse Rehabilitation, passim; Currier interviews, 25 Jan. 1988 and 2 Feb. 1988; and Ohler interview.

206 Final Report-Lock 21, p. 2.

207 Ibid., p. 26; and E. L. Daley to Chief of Engineers, 7 March 1935, RG77, entry 111, box 995, file 3524.

208 Final Report-Lock 21, p.27; series of letter and memos from 1935 constituting RG77, entry 111, box 997, file 7243, WNRC; and E.E. Gesler to McCarthy Improvement Company, 14 Aug. 1936, RG77, entry 111, box 995, file 3524-part 3, WNRC.

209 E.E. Gesler to Chief of Engineers, 17 Nov. 1936, RG77, entry 111, box 995, file 3524-part 3, WNRC.

210 Annual Report, 1939, p. 1150.

211 Final Report-Lock 22, pp.13, 18, and 70; War Department, Corps of Engineers, U.S. Army, Final Cost Report, Dam No. 22, Mississippi River (Rock Island: U.S. Engineer Office, Oct., 1939), (hereinafter referred to as Final Cost Dam 22), pp. 87-97 in RG77, entry 81, box 669, NARA-CH; and ----, Mississippi River lock and Dam No. 22, Esplanade Improvement, Final Report-Construction (Quincy, IL: U.S. Engineer Office, Nov., 1939), (hereinafter referred to as Final Report Esplanade 22), p. 4 RG77, entry 81, box 666, NARA-CH; E.L. Daley to Chief of Engineers, 12 Jan. 1934, RG77, entry 111, box 997, file 3524, WNRC; E.E. Gesler to Massman Construction Co., 12 Sept., 1936; Joseph Schaefe to Chief of Engineers, 26 April 1938; E.E. Gesler to E. A. Koenemann Electric Co., 223 March 1937; and E.E. Gesler to Chief · Engineers, 24 Dec. 1935 all in RG77, entry 111, ox 998, file 3524-part 2, WNRC; and E.E. Gesler to Chief of Engineers, 1 Nov. 1938, and E.L. Daley to Chief of Engineers, 28 March 1934, both in RG77, entry 111, box 998, file 3648, WNRC.

213 See above pp. 67, and 70.

214 Annual Report, 1939, p. 1150; Final Report-Lock 22, p.25.

BIBLIOGRAPHY

BOOKS

Armstrong, Ellis, et al. History of Public Works in the United States 1776-1976. Chicago: American Public Works Association, 1976.

Burner, David. Herbert Hoover: A Public Life. NY: Alfred A. Knopf, 1979.

Cullem, George W. Biographical Register of the Officers and Graduates of the U.S. Military Academy from 1802 to 1867. Revised ed., with a supplement, containing the Register of Graduates to Jan. 1, 1979. New York: James Mille, 1879.

Dickerman, Alan R.; Radosevich, George E.; and Noble, Kennet. Foundation of Federal Reclamation Policies: An Historical Review of Changing Goals and Objectives. Fort Collins, CO: Department of Economics, Colorado State University, 1970.

Dimock, Marshall E. Developing America's Waterways: Administration of the Inland Waterways Corporation. Chicago: The University of Chicago Press, 1935.

Dobney, Frederick J. River Engineers of the Middle Mississippi: A History of the St. Louis District, U.S. Army Corps of Engineers. St. Louis: U.S. Army Engineer District, 1978.

Dorsey, Florence. Master of the Mississippi, Henry Shreve and the Conquest of the Mississippi. Boston: Houghton, Mifflin, Co., 1941.

Fine, Lenore and Remington, Jessie A. The Corps of Engineers: Construction in the United States, United States Army, in World War II. Washington, DC: Office of the Chief of Military History, 1972.

Fite, Gilbert C. George N. Peek and the Fight for Farm Parity. Norman, OK: University of Oklahoma Press, 1954.

Fries, Robert F. Empire in Pine: The Story of the Lumbering Industry in Wisconsin, 1830-1900. Madison: 1951.

Hays, Samuel P. Conservation and the Gospel of Efficiency: The Progressive Conservation Movement 1890-1920. Cambridge, MA: Harvard University Press, 1959, reprinted with a new preface by the author, New York: Antheneum, 1974.

History of Clinton County Iowa. Clinton: Clinton County Historical Society, 1976.

Hofstadter, Richard. The Age of Reform From Bryan to F.D.R. New York: Vintage Books, 1955.

Hunter, Louis. Steamboats on the Western Rivers, An Economic and Technological History. Cambridge, MA: Harvard University Press, 1949.

Institute for Government Research. The U.S. Reclamation Service: Its History, Activities and Organization. Fort Collins, CO: Department of Economics, Colorado State University, 1970.

James, George Whaton. Reclaiming the Arid West: The Story of the United States Reclamation Service. New York: Dodd, Mead, and Company, 1917.

Johnson, Leland R. The Davis Island Lock and Dam 1870-1922. Pittsburgh: U.S. Army Corps of Engineer District, 1985.

-----. The Falls City Engineers: A History of the Louisville District Corps of Engineers United States Army. Louisville: U.S. Army Engineers District, 1974.

-----. The Falls City Engineers: A History of the Louisville District Corps of Engineers United States Army 1970-1983. Louisville: U.S. Army Engineer District, 1984.

-----. Men, Mountains and Rivers: An Illustrated History of the Huntington District, U.S. Army Corps of Engineers. Huntington: U.S. Army Engineer District, 1977.

Larson, Agnes M. History of the White Pine Industry in Minnesota. Minneapolis: 1949.

Leuchtenburg, William E. Franklin D. Roosevelt and the New Deal, 1932-1940. New York: Harper & Row, 1963.

Merrit, Raymond H. Creativity and Conflict: A History of the St. Paul District U.S. Army Corps of Engineers. St. Paul: U.S. Army Engineer District, 1980.

Nichols, Roger L. and Halley, Patrick L. Stephen Long and American Frontier Exploration. Newark, DE: University of Delawara Press, 1980.

Nixon, Elgar B. Franklin D. Roosevelt and Conservation, 1911-1945. Hyde Park, NY: General Services Administration, National Archives and Resources Service, Franklin D. Roosevelt Library, 1957.

Noble, Kennet. Foundation of Federal Reclamation Policies: An Historical Review of Changing Goals and Objectives. Fort Collins, CO: Department of Economics, Colorado State University, 1970.

Nye, Russell B. Midwestern Progressive Politics. New York: Harper and Row, 1959.

Rathbun, Mary Yeater. The Illinois and Michigan Canal. Springfield, IL: Illinois Department of Conservation, 1980.

Roberts, Nelson C. and S.W. Moorhead. Story of Lee County Iowa. Chicago: The S.J. Clarke Publishing Company, 1914.

Robinson, Michael C. History of Navigation in the Ohio River Basin: National Waterways Study: U.S. Army Corps of Engineers Water Resource Support Center, Institute for Water Resources--Navigation History NWS-83-5. Washington DC: Government Printing Office, 1983.

Salontons, Theodore, and Hicks, John D. Argricultural Discontent in the Middle West, 1900-1939. Madison: University of Wisconsin Press, 1951.

Scarpino, Phillip V. Great River: An Environmental History of the Upper Mississippi, 1890-1950. Columbia: University of Missouri Press, 1985.

Schoklitsch, Arim. Hydraulic Structures: A Text and Handbook. Translated by Samuel Shulits, Vol. II. New York: American Society of Mechanical Engineers, 1937.

Scott, John S. A Dictionary of Civil Engineering. 2nd ed. Baltimore, MD: Penguin Books, 1965.

Taylor, Emerson Gifford. Gouverneur Kemble Warren The Life and Letters of An American Soldier 1830-1882. Boston: 1932.

Tweet, Roald. A History of Navigation Improvements on the Rock Island Rapids (The Background of Lock and Dam 15). Rock Island: U.S. Army Engineers, Rock Island District, 1980.

-----. A History of the Rock Island District U.S. Army Corps of Engineers 1866-1983. Rock Island: U.S. Army Engineer District, Rock Island, 1984.

-----. Taming of the Des Moines Rapids: The Background of Lock 19. Rock Island: U.S. Army Engineer District, Rock Island, 1978.

Twinning, Charles E. Downriver Orrin H. Ingam and the Empire Lumber Company. Madison: 1975.

-----. Phil Weyerhaeuser Lumberman. Seattle: University of Washington Press, 1985.

The U.S. Reclamation Service: Its History, Activities and Organization. New York: D. Appleton and Co., 1919.

United States Army, Office of the Chief of Engineers. Laws of the United States Relating to the Improvement of Rivers and Harbors, from August 11, 1790, to January 1, 1939. 3 Vols. Washington, DC: Government Printing Office, 1913 and 1940.

Wolfe, P.B. Wolfe's History of Clinton County, Iowa. Indianapolis: B.F. Bowen & Co., 1911.

Wood, Richard G. Stephen Harriman Long, 1784-1864, Army Engineer, Explorer, Investor. Glendale, CA: A.H. Clarke Co., 1966.

INTERVIEWS

Baker, Verlin. U.S. Army Corps of Engineers, Lockman at Lock and Dam No. 13. Telephone interview by author. 27 June 1984.

Barr, Ken. Archeologist, U.S. Army Corps of Engineers, Rock Island District, Rock Island IL. Telephone interview by author. 19 February 1988.

Boland, Beth Grovner. Office of the Keeper of the National Register, Washington DC. Telephone interview by author. 11 May 1988.

Clark, Ron G. and Wright, James. U.S. Army Corps of Engineers, Lockmaster and Former Lockmaster (respectively) at Lock and Dam 20, Canton MO. Interview by author. 16 July 1984.

Currier, Wayne. U.S. Army Corps of Engineers, Lockmaster of Lock and Dam No. 11, Dubuque Iowa. Telephone interview by author. 25 January, 27 January, and 2 February 1988.

English, Ray. U.S. Army Corps of Engineers, Locktender at Lock 19, Keokuk IA. Interview by author. 24 July 1984.

Mansberger, Floyd. U.S. Army Corps of Engineers, Rock Island District, Rock Island Illinois. Telephone interview by author. 25 January 1988.

Morgan, James. U.S. Army Corps of Engineers, Lockmaster at Lock and Dam No. 15. Telephone interview by author. July 1984.

Ohler, Steve F. U.S. Army Corps of Engineers Lockmaster Lock and Dam No. 18, near New Boston, Illinois. Telephone interview by author. 11 July 1984.

O'Brien, W. Patrick. National Park Service, Denver Colorado. Telephone interview by author. 13 January 1988.

Ross, Charles. Retired U.S. Army Corps of Engineer engineer, Huntington, WV. Interview by Robert Maddox. 13 Oct. 1982.

Weiman, Larry. Hydraulic Engineer, Union Electric Co., Keokuk Power Plant, Keokuk, IA. Interview by author. 24 July 1984.

MANUSCRIPT COLLECTIONS

Chicago, Illinois. Chicago National Archives and Record Center. Record Group 77. Entry 81.

Clinton, Iowa. Clinton Public Library. Citizens Historical Association Biographical Sketches.

Des Moines, Iowa. Iowa State Historical Department. Keokuk Lock and Dam File.

Iowa City, Iowa. Iowa State Historical Society Library. Miscellaneous Keokuk Collection.

Springfield, Illinois. Illinois State Historical Society Library. Montgomery Meigs and Family Papers, 1866-1931.

Suitland, Maryland. Washington National Records Center. Record Group 77. Entry 111, Entry 112.

Washington, DC. National Archives. Record Group 77.

MAPS

U.S. Army Corps of Engineers, Rock Island District. "Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project." The original contract drawings are organized into structural groups and assigned an operations folio number relative to that structure. Rock Island District Library vault, Clock Tower Building Annex, Rock Island, Illinois.

NEWSPAPERS/JOURNALS/MAGAZINES

Barr, G. Walter, "Interesting Details About the Keokuk Dam." Iowa Factories 2, pp. 6-10.

Arkansas Gazette. 17 October 1935.

"Building the Rolling-Crest Dam Across Grand River." Engineering News 76, No. 2 (13 July 1916).

Davenport (WA) Times.

Gross, Charles P. and McCormick, H.G. "The Upper Mississippi River Project." The Military Engineer 33, No. 190 (July-August, 1941).

"Halleck Seaman, Man of Vision." Clinton Herald, Centennial Edition. 18 June 1955.

Heavey, W. F. "Concreting at Ohio River Lock No. 45." Military Engineer 16 (March-April, 1924), pp. 144-146.

Link, Arthur S. "What Happened to Progressive Movement in the 1920s?" American Historical Review 64 (1959) pp. 833-851 as reprinted in David M. Kennedy, ed., Progressivism: The Critical Issues. Boston: Little, Brown and Company, 1971.

"May Build River Lock Opposite City of Dubuque." Dubuque Journal, 28 September 1933.

McCormick, Herbert G. and John W. Dixon. "Mississippi River Cofferdams." The Military Engineer 28, No. 158 (March-April, 1936) pp. 105-108.

Mowry, George E. "The California Progressive and His Rationale: A Study in Middle Class Politics." Mississippi Valley Historical Review 36 (Sept., 1949), pp. 239-250.

"New Power Plant Replaces Old Waterwheels." Engineering-News Record 99, No. 23 (8 December 1927), pp. 907-911.

"Patent Lock Gate." The Farmer's Journal, Welland Canal Intelligence 2, No. 39 (17 October 1827).

Peterson, William J. "Rafting on the Mississippi: Prologue to Prosperity." Iowa Journal of History 58, No. 4 (1960), pp. 289-320.

Reinecke, P.S. "The Rhine and the Upper Mississippi." The Military Engineer 30, No. 171 (May-June, 1938).

Robinson, Michael C. "The Federeal Barge Fleet: An Analysis of the Inland Waterways Corporation, 1924-1939." National Waterways Roundtable Proceedings. Washington, D.C.: U.S. Government Printing Office, 1980.

"Roller-Gate Dams for Kanawha River." Engineering News-Record VIII (21 September 1933), pp. 337-338.

Teichman, F. "Large Roller-Crest Dam, Grand Valley Project, Colorado." Engineering News 76, No. 1 (6 July 1916).

Wilson, Ben Hur. "The Des Moines Rapids Canal." Palimpset April 1924.

"William Milnor Roberts, Civil Engineer." Engineering News, 11 January 1879.

"Work Moves Swiftly on Lock 16, Jobs Increase." Muscatine Journal, 23 March 1934.

PHOTOGRAPHS

U.S. Army Corps of Engineers, Rock Island District. Photograph Collection. Rock Island Arsenal, Rock Island Illinois.

Union Electric Company, Keokuk Power Plant. 1910-1914 Photograph Collection. Keokuk Power Plant, Keokuk, Iowa.

PUBLISHED REPORTS

Deposition of William A. Gooding, 19 Oct. 1850, in George Heath v. George W. Hildreth, Civil Action a-1363, Fifth Judicial District of the Supreme Court of the State of New York (Herkimer NY).

G.W. Hildreth, Canal-Lock Gate, Patent No. 1517, Patented Mar. 19, 1840; G. Heath, Hydraulic Canal Gate, Patent No. 2393, Patented Dec. 14 1841.

Heath v. Hildreth, Case No. 6309, Oct. 15 1841, Circuit Court, District of Columbia.

Mississippi River Lock and Dam No. 19: Repairs to Keokuk Lock Miter Gates. Rock Island: U.S. Engineer Office, March 1934.

New York State Assembly Doc. No. 18. Jan. 15, 1844.

New York State Assembly Doc. No. 91. Feb. 22, 1944.

New York State Assembly Doc. No. 201. April 21, 1846.

New York State Assembly Doc. No. 216. May 5, 1846.

Twenty-Second Convention National Rivers and Harbors Congress. Proceedings of the Twenty-Second Convention National Rivers and Harbors Congress, Washington, D.C., December 8 and 9, 1926. Washington, DC: Press of Randall Inc., 1927.

U.S. Army Corps of Engineers. Annual Reports of the Chief of Engineers United States Army, to the Secretary of War for the years 1867-1940. Washington, DC: Government Printing Office, 1868-1941.

-----. Completion Report on the Construction of New Lock 19, Mississippi River. Rock Island: Rock Island District, March 1958.

U.S. Army Corps of Engineers, Rock Island District. Environmental Assessment, Rehabilitation of Old Lock 14, Mississippi River, LeClaire, Iowa. Rock Island: U.S. Army Corps of Engineers, Rock Island District, 1978.

UNPUBLISHED REPORTS

Gjerde, Jon. "Historical Resources Evaluation: St. Paul District Locks and Dams on the Mississippi River and Two Structures at St. Anthony's Falls." St. Paul: St. Paul District U.S. Army Corps of Engineers, 1983.

"Lock and Dam No. 14, Mississippi River, LeClaire, Iowa: Specifications for repair of Miter gates Auxiliary Lock." Rock Island: U.S. Engineer Office, November 1937.

McLean, Larry. "Keokuk Lock and Dam." National Register of Historic Places Inventory Nomination Form (1976).

O'Brien, William Patrick. "Historic American Engineering Record Documentation, Lock and Dam Systems 3-10, Upper Mississippi River 9-Foot Channel Project, U.S. Army Corps of Engineers, St. Paul District." Denver: National Park Service, 1987.

-----. "Rock Island District, Corps of Engineers, Locks and Dams 11-22, Dubuque, Iowa, to Saverton, Missouri, Photographic Inventory." Denver: National Park Service, 1987. Typewritten.

Threshold Design, Inc. Lockhouse Rehabilitation Concept Report, Mississippi River. Milwaukee: Threshold Design Inc., 1984.

Rathbun Associates. "Historical-Architectural and Engineering Study Locks and Dams 11-22, Nine-Foot Navigation Project, Mississippi River." Rock Island: U.S. Army Engineer District, 1985.

Rathbun, Mary Yeater. "The United States Army Corps of Engineers in the Little Rock

District." 1987 draft manuscript on file with the office of History, office of the Chief of Engineers, Ft. Belvoir, VA.

Rathbun, Mary Yeater and Peter A. "Report on Historical Investigations at I&M Canal Lock No. 14." Springfield, IL: Division of Historic Sites Illinois Department of Conservation, 1978.

Yeater, Mary. "Hennepin Canal Historic District." National Register of Historic Places Inventory-Nomination Form (1977).

UNITED STATES CONGRESSIONAL DOCUMENTS

U.S. Congress. House. A Bill Providing for the Improvement and Completion of Prescribed Sections of the Mississippi, Missouri and Ohio Rivers. H.R. 3921. 68th Cong., 1st sess., 1924.

-----. Committee on Rivers and Harbors Report on proposed Rivers and Harbors Act. H. Rpt. 581, 68th Cong., 1st sess., 1924.

-----. Committee on Rivers and Harbors Report on proposed Rivers and Harbors Act. H. Rpt. 952, 68th Cong., 1st sess., 1924.

-----. Committee on Rivers and Harbors Report on proposed Rivers and Harbors Act. H. Rpt. 1053, 68th Cong., 1st sess., 1924.

-----. Committee on Rivers and Harbors. Mississippi River to Minneapolis--Decree of Injunction Restraining the Government from Construction of a Lock and Dam at Alma, Wis. H. Doc. 7, 72nd Cong., 1st sess., 1932.

-----. H. Doc. 583, 69th Cong., 2nd sess., 1926.

-----. Letter from the Secretary of War, Transmitting a Report Furnishing Information in Relation to the Improvement of the Des Moines Rapids. E. Doc. 83. 35th Cong., 1st sess., 1858.

-----. Message from the President of the United States, Transmitting Copies of surveys made in Pursuance of Acts of Congress, of 30th April, 1824, and 2nd March, 1829. E. Doc. 7. 21st Cong., 1st sess., 1829.

------. Mississippi River, Between Mouth of Missouri River and Minneapolis, Minnesota (Interim Report). H. Doc. 290. 71st Cong., 2nd sess., 1930.

-----. Public Resolution No. 10. H. J. Resolution 271, 72nd Cong., 1st sess., 1932.

-----. Report of Committee of Rivers and Harbors on proposed Rivers and Harbors Act. 68th Cong., 2nd sess., 1925.

----. Survey of Mississippi River. H. Doc. 341. 59th Cong., 2nd sess., 1907.

-----. Survey of Mississippi River Between Missouri River and Minneapolis. H. Doc. 137.

72nd Cong., 1st sess., 1932.

-----. Committee on Rivers and Harbors. Hearings on H.R. 3921 providing for the Improvement and Completion of Perscribed Sections of the Mississippi, Missouri, and Ohio Rivers held before the Committe on Rivers and Harbors, House of Representatives, 68th Congress, 1st Session. 68th Cong., 1st sess., 1924.

-----. Hearings before the Committee on Rivers and Harbors, House of Representatives, 69th Congress, 1st session on the following subjects: Report on Umqua Harbor and River, Oreg.; Report on Islais Creek, San Francisco Harbor, Calif.; Raising the levels of the headwaters of the Mississippi River; Control of floods on the Illinois River, Illinois; Allowing credit and disbursing officers for Reimbursement of certain subsistence expenses; Acceptance and approval of bids for furnishing materials and labor; Collection of commercial statistics. 69th Cong., 1st sess., 1926.

-----. Statement of Hon. Herbert Hoover, Secretary of Commerce, before the Committee on Rivers and Harbors, House of Representatives, 69th Congress, 1st Session, on the subject of the Development of Inland Waterway Systems in the United States. 69th Cong., 1st sess., 1926.

-----. Hearings before the Committee on Rivers and Harbors, House of Representatives, 71st Congress, 2nd Session, on the Subject of the Improvements of the Mississippi River between the Mouth of the Missouri River and Minneapolis. 71st Cong., 2nd sess., 1930.

-----. Hearings before the Committee on Rivers and Harbors, House of Representatives, 72nd Congress, 1st Session, on the subject of "The Improvement of the Mississippi River between the mouth of the Missouri River and Minneapolis." 72nd Cong., 1st sess., 1932.

-----. Hearings before the Committee on Rivers and Harbors, House of Representatives, 73rd Congress, 1st Session, on the Subject of Continuing the Improvement of Upper Mississippi River, and Proposals of the Anerican Railways in Connection with the Improvement of Inland Waterways, Distribution of Expenses for Recostruction of Bridges and other structures, Proposes Tonnage Tax or Toll Charge. 73rd Cong., 1st sess., 1933.

U.S. Congress. Senate. Report from the Secretary of War, in Compliance with a Resolution of the Senate of the 25th Instant, in Relation to the Rock River and Des Moines Rapids of the Mississippi River. S. Doc. 139. 25th Cong., 2nd sess., 1837.

-----. Report of the Secretary of War, Communicating in Compliance with a Resolution of the Senate of December 16, 1856, Information Relative to the Des Moines and Rock River Rapids, and the Harbor at Dubuque, Iowa. E. Doc. 45. 34th Cong., 3rd sess., 1857.

-----. Report of the Secretary of War in Answer to a Resolution of the Senate Relative to the Improvement of the Des Moines and Rock River Rapids. E. Doc. 12. 33rd Cong., 2nd sess., 1854.

-----. Report on the proposed River and Harbor Bill (H.R. 11472). S. Rpt. 1143, 68th Cong., 2nd sess., 1925.