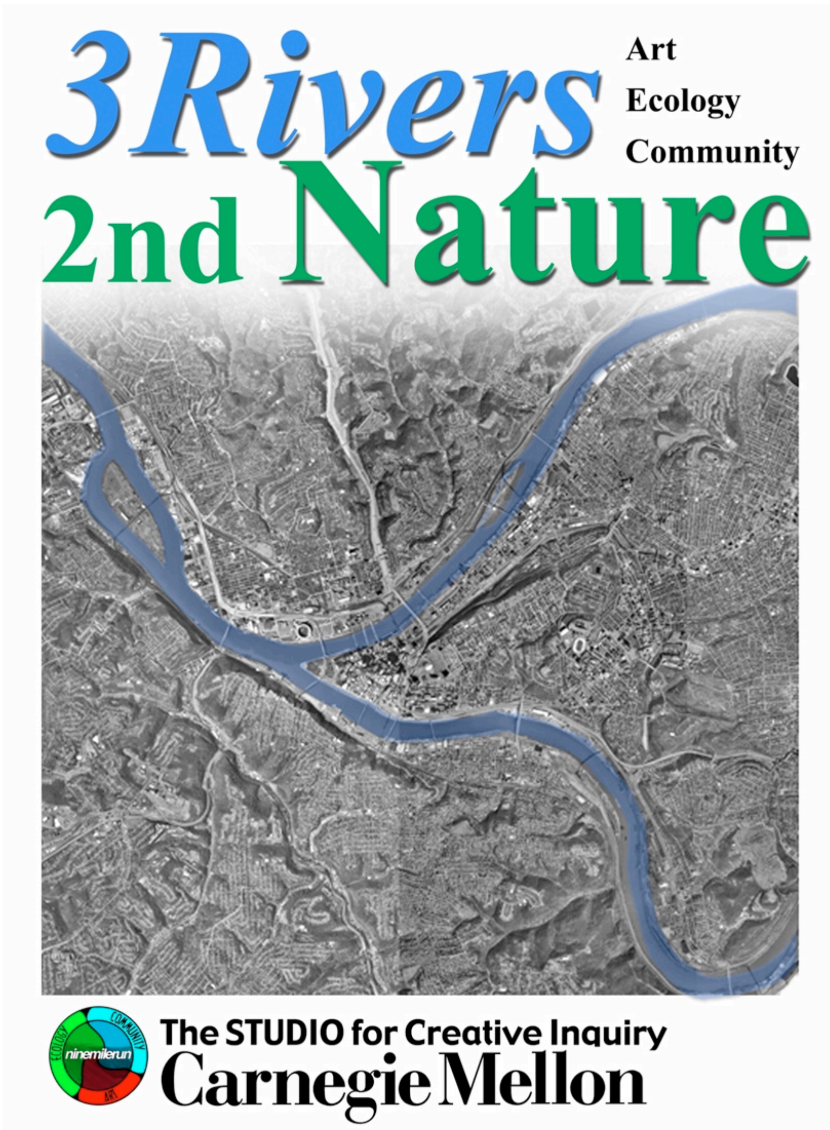
From Rivers to Lakes
Engineering Pittsburgh's Three Rivers



A report by

Shera A. Moxley
Project Historian, 3 Rivers-2nd Nature, STUDIO for Creative Inquiry, Carnegie Mellon University
Department of History, Carnegie Mellon University

Map Preparation

Beth McCartney, GIS, Geographic Information Systems

Partners in this project include

3 Rivers Wet Weather Incorporated (3RWW)
Allegheny County Health Department (ACHD)
Allegheny County Sanitary Authority (ALCOSAN)

3 Rivers-2nd Nature Advisors

John Arway	Chief, Environmental Services, Pennsylvania Fish and Boat Commission
Wilder Bancroft	Environmental Quality Manager, Allegheny County Health Department
Don Berman	Environmental Consultant
Bob Bingham	Professor of Art, Co-Director, STUDIO for Creative Inquiry, Carnegie Mellon University
James Davidson	Laboratory Manager, Allegheny County Health Department
David Dzombak	Professor of Civil and Environmental Engineering, Carnegie Mellon University
Mike Koryak	Limnologist, United States Army Corps of Engineers
Mary Kostalos	Professor of Biology, Chatham College
Michael Lambert	Director, Three Rivers Rowing
Edward Muller	Professor of History, University of Pittsburgh
Jan Oliver	Wet Weather Program Director, ALCOSAN
Beth O'Toole	Director, Pittsburgh Voyager
Tom Proch	Biologist, Pennsylvania Department of Environmental Protection
John Schombert	Director, 3 Rivers Wet Weather
Dan Sentz	Environmental Planner, Pittsburgh Department of City Planning
Joel Tarr	Richard S. Caliguiri Professor of Urban and Environmental History and Policy, Carnegie Mellon University
Steve Tonsor	Professor of Biological Science, University of Pittsburgh
Davitt Woodwell	Director, River Life Task Force

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Room 111, College of Fine Arts, Carnegie Mellon University
Pittsburgh, Pennsylvania 15213
Voice: 412-268-3454
Fax: 412-268-2829
http://www.cmu.edu/studio

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If you believe that **ecologically healthy rivers are 2nd Nature!** and would like to participate in a river dialogue about water quality, recreational use, and biodiversity in the 3 Rivers Region,

Contact:

Tim Collins, Research Fellow
Director, 3 Rivers-2nd Nature Project
STUDIO for Creative Inquiry
Carnegie Mellon University
Voice: 412-268-3454
Fax: 412-268-2829
tcollins@andrew.cmu.edu

From Rivers to Lakes: Engineering Pittsburgh's Three Rivers

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Executive Summary

From first contact nearly three centuries ago, European explorers of the trans-Appalachian West recognized the strategic and commercial value of the Allegheny, Monongahela, and Ohio rivers. They vied for control over the city of Pittsburgh sited at the confluence of these vital water highways. Immediately they prioritized the economic potential of the rivers and sought to tame them for economic ends. They worked to improve navigation of the three rivers—to simplify, manipulate, and thus control the rivers' natural hydrologic systems—to facilitate commercial gain. This report discusses the evolving technologies various interests employed to transform Pittsburgh's three rivers from hazardous, unpredictable natural streams into controlled interstate water expressways.

The history of engineering Pittsburgh's three rivers may be divided into four technological stages. The first spans colonial exploration and state efforts in the early republic until 1824. During this time, French, British, and American explorers mapped the Allegheny, Monongahela, and Ohio rivers as well as their tributary streams and the watersheds they drained. Once they obtained basic topographic and hydrologic data, they attempted to improve the navigability of these streams to win for Pittsburgh the role of commercial gateway linking the trans-Allegheny western hinterlands with Atlantic port cities. Colonial and state governments designated Pittsburgh's rivers navigable public highways and prohibited their obstruction by artificial structures. Both private and public interests supported an assortment of efforts aimed at improving the rivers' channels, including removing snags, scouring sand and gravel bars, and exploding boulders and root clusters. These efforts required extensive annual maintenance, however, and made no permanent improvements to the navigability of the rivers.

The second period of river engineering marked the beginning of federal participation in waterway improvement, carried out under the auspices of the Army Corps of Engineers. In 1824 Congress passed the first law giving the Army engineers authority to improve navigability on the nation's inland rivers. For the next half century the Corps of Engineers persevered through acrimonious sectional debate over federal involvement in civil works projects, intermittent congressional funding, and the disruptions of war to effect open-channel improvements on the Ohio River. Like their predecessors, Army engineers pursued comprehensive channel clearance work to remove obstructions to navigation. They experimented with a variety of wing dams to deepen

channels and lengthen the navigation season for lighter-draft vessels. But Army engineers were not the only ones active in improving navigation on Pittsburgh's rivers. During this period the state of Pennsylvania pursued similar efforts on the Allegheny River. Private parties attempted more comprehensive structural engineering on the Monongahela River. The Monongahela Navigation Company worked to control that river through a system of dams with toll locks, providing a slackwater system navigable year-round.

After the Civil War it became evident to federal planners that even the thirty-inch channel achieved on the Ohio River was inadequate for the dramatically increasing commercial tonnage on Pittsburgh's rivers. From 1874 to 1929 the Corps of Engineers emplaced a system of dams with locks on the Ohio River from Pittsburgh to its junction with the Mississippi River at Cairo, Illinois. Canalization of the Ohio River guaranteed a nine-foot navigation channel year-round, independent of the vagaries of seasonal and meteorological flow fluctuations. With the successful construction of the slackwater system, the corps accomplished complete and permanent control of the Ohio River. In addition, it canalized the Allegheny River and purchased the Monongahela slackwater system from its private owners, restoring toll-free navigation to Pittsburgh's most commercial river. By the onset of the Great Depression, the Allegheny, the Monongahela, and the Ohio had been transformed from naturally flowing rivers into restrained stairstepped chains of lakes.

In the most recent period of the history of engineering Pittsburgh's three rivers, the Corps of Engineers modernized its slackwater systems to speed commercial navigation. The corps replaced first-generation dams on the Ohio River with concrete high-lift dams to reduce the number of lockage delays. During this period Army engineers also replaced and remodeled aging structures of the Monongahela slackwater system, one of the oldest in the country. The Allegheny River slackwater system is the youngest serving Pittsburgh and carries the least commercial tonnage of the three. It has not yet required extensive modernization, but many of its original structures are nearing the end of their projected service lives. An opportunity may exist here to reconsider the commercial utility of a controlled navigation system.

Over the course of nearly three centuries, then, various private and public interests, dominated by the Army Corps of Engineers, have progressively altered the Allegheny, Monongahela, and Ohio rivers. These engineering efforts aimed at mitigating the unpredictable, hazardous, and costly characteristics of the rivers, transforming them into controlled chains of lakes to facilitate inexpensive commercial traffic. Today Pittsburgh's three rivers function in the landscape of the built environment more than they resemble their original natural hydrologic systems.

From Rivers to Lakes: Engineering Pittsburgh's Three Rivers

Introduction

Over nearly three centuries since European contact, the city of Pittsburgh has grown from a rugged frontier military outpost into a thriving mercantile center and then into a teeming industrial metropolis. The city's surrounding natural resources fueled its development as one of the first and most important urban centers on the western fringe of the young United States. Historian Richard Wade remarks about Pittsburgh that "no place in the West seemed more certain to be the site of a great city. Nature itself had made the suggestion unmistakably." The Allegheny River opened a corridor into productive Pennsylvania and New York forests, farmland, and oil fields. The Monongahela River valley yielded rich iron and coal deposits that gave the city its central product and identity: steel. Pittsburgh was founded at the confluence of these two rivers where they formed the Ohio, the main transportation artery of the trans-Appalachian West. Wade further assesses Pittsburgh's advantages: "Here were all the classic requirements for a great city: water power, coal and iron, ready access to farm lands, and a market area of almost limitless extent."[1] These unbounded markets and deposits of raw materials stretched out from Pittsburgh in every direction along three river corridors and the basins they drained. To exploit them most advantageously, various interest groups over the years sought to improve the reliability of their vital river highways.

From first contact, European explorers of the trans-Appalachian West and the Ohio Valley prioritized the rivers' economic potential—a cultural relationship to natural resources that has changed little over time, even in post-industrial Pittsburgh. Through nearly three centuries, residents of the confluence attempted to simplify, manipulate, and control their environments. The engineering efforts they applied to the Allegheny, Monongahela, and Ohio rivers were underpinned by an ideology that fused private profit to public good. In an effort to mitigate the vagaries of hydrology, weather, and other natural systems, various interest groups in and around Pittsburgh emplaced increasingly elaborate engineering technologies on the three rivers. They attempted to provide more reliable water supplies, to extend the navigation season, to reduce the hazards of waterborne travel, and to shorten the length of the journey to raw materials and markets.

[1] Richard C. Wade, *The Urban Frontier: Pioneer Life in Early Pittsburgh, Cincinnati, Lexington, Louisville, and St. Louis* (Chicago: University of Chicago Press, Phoenix Books, 1964), 10. This work was originally published as *The Urban Frontier: The Rise of Western Cities, 1790-1830* (Cambridge: Harvard University Press, 1959).

All of these engineering measures ultimately aimed to simplify river navigability—to manipulate and subdue nature to serve economic ends.

The history of engineering Pittsburgh's three rivers may be divided into four technological stages. In colonial times and in the early years of the United States, private interests and local governments supported rudimentary techniques to remove hazards and obstructions to navigation such as driftwood, rocks, and shoals. Beginning in 1824 the federal government asserted its constitutional mandate to oversee national civil works, including roads, railroads, rivers, and canals. Congress placed the Army's engineering corps in charge of inland river improvement projects. As had their predecessors, Army engineers tried to open the river channels to easier navigation. Using technology that was more advanced and drawing upon greater financial reserves, the Corps of Engineers also removed obstructions to navigation and built low timber or stone dams to deepen channels. By 1874, however, these temporary improvements to navigation no longer served the needs of the three rivers' heavy commercial traffic. In the period after 1874, the Corps of Engineers effected radical, permanent improvements to navigation by "canalizing" the Allegheny, the Monongahela, and the Ohio rivers. Canalization meant structurally altering the rivers so that their waters acted like those in a canal: a year-round supply of deep water with minimal current. The corps erected a series of dams with locks on each of the three rivers. Once slackwater systems fully controlled the rivers, Army engineers in the twentieth century pursued maintenance and renovation to turn Pittsburgh's three rivers into modern interstate water expressways.

I. Early Efforts: Exploring and Improving the Frontier Highways

A. The Contest for Empire: France and Great Britain

The French were the first Europeans to survey, map, and engineer the rivers in the Ohio Valley. During their first journeys down the Ohio early in the eighteenth century, French explorers and military men encountered hazards to navigation in the river and its tributaries. They recognized the Ohio River system as a network of critical water highways by which to penetrate the North American interior. Furthermore, the French understood that commercial and territorial expansion could be hampered severely unless these impediments to navigation could be removed. When Baron Longueuil undertook a campaign against the Chickasaw Indians in 1739, Joseph Gaspard Chaussegros de Lery from the French Corps of Engineers accompanied the expedition and drew the first reasonably accurate map of the upper Ohio River system. His map represented the courses of French and Conewango creeks and traced the Allegheny and Ohio rivers, which the French understood to be one river, named *La Belle Rivière*, or "the Beautiful River." By the middle of the century, when the British challenged the French for possession of a North American empire, both nations increased their activity in the region. In 1753 chief of Canadian engineers Captain Francois Le Merçier constructed a ring of French forts along Lake Erie and cleared *Riviere Le Boeuf* (French Creek) of fallen trees, or snags. The engineer hoped this effort would facilitate transport of French troops downstream to oust the British from their position at the confluence of the Monongahela and Allegheny rivers and allow the French to erect Fort Duquesne in its place.[2]

In the fall of 1753 Lieutenant Governor Robert Dinwiddie of Virginia dispatched the young surveyor George Washington to protest the French trespass onto British territory. During the course of this mission, Washington explored the Monongahela, Beaver, Allegheny, and upper Ohio river watersheds. He reconnoitered French forts and calculated troop strength, selected potential locations for British fortifications, studied the navigability of the Ohio's headwater rivers, and prepared maps of the entire area.[3] The French and British struggle for the area escalated over the next several years into the French and Indian War in North America and the Seven Years' War on the European continent. The British emerged victorious, and the Treaty of Paris in 1763 codified their supremacy in North America. British engineers were free to study navigation issues in the Ohio Valley.

In June 1766 engineers Harry Gordon, Thomas Hutchins, George Croghan, and George Morgan set off from Fort Pitt in seventeen bateaux, light flat-bottomed boats, to map the length of the Ohio River to its confluence with the Mississippi. Among other specifically military concerns, their instructions directed them to record detailed hydraulic data, including the width, depth, and velocity of the Ohio; to chart the river's channels; and to collect extensive topographic data about the riverbanks and surrounding lands. The resulting Gordon-Hutchins map was the first comprehensive hydrographic survey of the Ohio River, and stood as the most reliable map of the region for the next half-century.[4]

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[2] Leland R. Johnson, *The Headwaters District: A History of the Pittsburgh District, U. S. Army Corps of Engineers* (Pittsburgh: U. S. Army Corps of Engineers, 1979), 2-3; National Waterways Study, U. S. Army Engineer Water Resources Support Center, and Institute for Water Resources Study, "History of Navigation in the Ohio River Basin," by Michael C. Robinson, Navigation History NWS-83-5 ([Fort Belvoir, VA]: U. S. Army Corps of Engineers, January 1983), 53 [hereinafter cited as Robinson, "History of Navigation in the Ohio River Basin"].

[3] Johnson, *The Headwaters District*, 5; Robinson, "History of Navigation in the Ohio River Basin," 53.

[4] Johnson, *The Headwaters District*, 8-10; Robinson, "History of Navigation in the Ohio River Basin," 53.

B. Navigable Public Highways

Once the British secured control over the Ohio Valley, they turned their attention to opening the area to settlement and commerce. Improving navigation on the Ohio and its tributaries was central to this aim. To this end, colonial legislators initiated several steps to facilitate navigation. First, the government had to establish its authority to regulate rivers. For instance, in 1771 the Pennsylvania Council declared the Kiskiminetas River to be legally navigable. By designating the Kiskiminetas a navigable public highway and forbidding the emplacement of any structures that might obstruct navigation, the colonial government asserted its authority to regulate waterways in the public interest. This governmental authority continued through the transition from colony to state. In 1782 the new state assembly in Pennsylvania added the Youghiogheny and Monongahela rivers to the list of navigable public highways.[5] In addition to protecting rivers from artificial obstructions to navigation, the legal designation of certain rivers as public highways preserved them as public commons, ensuring equal access and opportunity for use to all persons. Moreover, this protected legal status privileged the economic use of rivers by defining them as arteries of trade and transport.

Official designations as navigable public highways ostensibly protected such rivers from the emplacement of human-constructed barriers to navigation, such as fish dams, milldams, and low bridges. But the natural barriers to navigation were much more prevalent and in many ways more formidable. In the late eighteenth and early nineteenth centuries, well before any programs of comprehensive structural engineering of the rivers, hazards to navigation in the Pittsburgh area included ice gorges on the Allegheny River, low water in the Monongahela River, and, more generally, extreme seasonal flow fluctuations, sand bars, shifting channels, gravel ripples, rocky shoals, boulders, and a variety of floating and submerged snags.[6] When George Washington made another trip down the Ohio in 1770 to survey the boundaries of the Virginia regiment's bounty lands, he described the length of the Ohio from Pittsburgh to Logstown (Economy), Pennsylvania, as full of "ugly rifts and shoals, which we found difficult to pass."[7] In 1786 John Badollet conducted a survey of the Youghiogheny and Monongahela rivers at

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[5] Johnson, *The Headwaters District*, 41-43.

[6] Ibid., 41; see also Sherman L. Frost and William J. Mitsch, "Resource Development and Conservation History along the Ohio River," in *The Ohio River: Its History and Environment*, Special Issue of *The Ohio Journal of Science* 89 (December 1989): 145.

[7] Quoted in Archer Butler Hulbert, *The Ohio River: A Course of Empire* (New York: G. P. Putnam's Sons, 1906), 93.

the request of Pennsylvania governor Thomas Mifflin. He reported that the Monongahela was afflicted by caving banks that fell into the river and formed sand bars, and that the Youghiogheny was filled with boulders.[8] In 1803 the Lewis and Clark expedition departed from Pittsburgh, but struggled seventy-six days through low water on the Ohio to reach its junction with the Mississippi at Cairo, Illinois.[9] The hazards of low water, snags, and sandbars that plagued Allegheny, Monongahela, and Ohio river navigators in the late eighteenth and early nineteenth centuries were numerous and expensive. During this period flatboat losses to collisions with snags and boulders ranged between twenty and twenty-five percent of the total built. Marine insurance rates for commerce between Louisville and Pittsburgh were set at six percent of cargo value for barges and ten percent for the less maneuverable flatboats, meaning that insurers expected to lose one out of every ten flatboat cargoes.[10]

From the turn of the nineteenth century to 1824, Pittsburgh entrepreneur Zadok Cramer published twelve editions of his immensely popular *Navigator*. This pamphlet was a guide to the Ohio and Mississippi complete with descriptions of the rivers and their cities, plus landmarks, travel advice, and navigation charts. Emigrants to the west relied on Cramer's *Navigator* and numerous plagiarized facsimiles of it to prepare them for their journeys down the Ohio and Mississippi and to guide them safely to their new homes. In the third edition, published at Pittsburgh in 1802, Cramer added descriptions and navigation charts for the Allegheny and Monongahela rivers. He noted the presence of cataracts in the Monongahela, and cautioned travelers about ice in the Allegheny. Cramer waxed poetic about the beauty of the Ohio River, especially the "numerous islands that are interspersed in this river . . . [which] add much to the grandeur of its appearance." But he also warned that "they very much embarrass the navigation, particularly in low water, as they occasion a great many shoals and sand bars." Furthermore, Cramer used his *Navigator* to advocate comprehensive improvements to navigation, particularly the removal of natural obstacles:

> Many of the impediments that are at present met with while the water is low, might in a dry time be got rid of, and that at not a very considerable expence; at least the expence would be by no means adequate to the advantages accruing from the undertaking, if properly managed.

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[8] Johnson, *The Headwaters District*, 42-43. Moreover, Badollet reported both rivers obstructed by fish dams.

[9] Frost and Mitsch, "Resource Development and Conservation History along the Ohio River," 145.

[10] Leland D. Baldwin, *The Keelboat Age on Western Waters* (Pittsburgh: University of Pittsburgh Press, 1941), 83, 183-184, 230n.12. For more extensive discussion of navigation hazards on the western rivers, see generally 56-84.

> Rocks that now, during the dry season, obstruct or render dangerous the navigation of the large flat bottomed, or what are called Kentucky boats, might be blown, even a considerable depth under water; channels might be made through the riffles, and the snags and fallen timber along the banks entirely removed.
>
> These improvements together with many others that might be enumerated will undoubtedly, sooner or later, be carried into effect, as they appear to be a national concern of the first importance.[11]

By the time Cramer appealed for improvements to the inland rivers, the state of Pennsylvania had already launched navigation improvement programs of its own.

C. Early Efforts toward Channel Improvement

At the end of the eighteenth century, when the trans-Appalachian West opened to settlement and commerce, eastern port cities vied for trade from the Great Lakes and the Ohio and Mississippi valleys. Pennsylvania's gateway cities of Pittsburgh and Philadelphia competed with New York City, Baltimore, and Richmond to dominate access to the growing hinterland of the Old Northwest. To this end, in 1790 Governor Thomas Mifflin launched an ambitious infrastructure program, encompassing roads, canals, railroads, and improved waterways. Over the next two years the Pennsylvania assembly funded river improvement at the headwaters of the Ohio as part of a comprehensive plan to link the eastern and western parts of the state via a water route with connecting portage roads. The 1791 and 1792 acts provided for the improvement of the Allegheny River from Warren to Portage Creek; French Creek for its entire length; the Youghiogheny River from its junction with the Monongahela to the mouth of Indian Creek near Ohiopyle Falls; and the Monongahela River from Pittsburgh to the Virginia state line.[12]

Pennsylvania officials acted swiftly to implement this legislation. In December 1792 the state let the contract for Monongahela River improvements to Samuel Jackson. In his bid he proposed to remove dangerous rocks and build low stone dams to scour sand bars and deepen channels. He intended to clear a channel fifty feet wide for the entire length of the Monongahela from its origin at the junction of the Tygart and West Fork rivers in Virginia to its mouth at Pittsburgh. Furthermore, Jackson guaranteed the low-

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[11] Zadok Cramer, *The Ohio and Mississippi Navigator*, Third Edition (Pittsburgh: John Scull, 1802; reprint, Morrison, IL: Karl Yost, 1987), 3-6 (page numbers refer to the 1802 edition).

[12] Johnson, *The Headwaters District*, 41-43. West Virginia did not secede from Virginia until 1863 in the midst of the Civil War.

water channel to handle boats with a six-inch draft. He completed these improvements in compliance with the terms of the contract by 1798.[13]

Pennsylvania let the contract for Youghiogheny River improvements in January 1793. Isaac Meason and John Gibson placed the successful bid for this work, which was similar to that performed by Jackson on the Monongahela at the same time. Meason and Gibson removed hazardous rocks, destroyed fish dams, and cleared a navigation channel with explosives. They placed the rock fragments from the demolition in riprap wing dams to scour bars and channels. Meason and Gibson successfully completed the improvements on the Youghiogheny from the mouth of Indian Creek above Connellsville to the river's junction with the Monongahela at McKeesport and collected their final payment in 1797.[14]

The Commonwealth of Pennsylvania inaugurated similar improvement measures on the Allegheny River and on French and Conewango creeks as the eighteenth century drew to a close. After the initial improvements were completed, the state continued to fund maintenance work on the various rivers until 1825, when it shifted priorities to pursue extensive canal construction.[15] At this time, the federal government began to display greater interest in internal improvements.

Channel improvements to the Ohio River came somewhat later than did improvements to its tributary streams. In 1817 the National Road from Cumberland, Maryland, in the Potomac Valley reached its terminus at Wheeling, Virginia, diverting traffic from Pittsburgh and threatening its status as gateway to the west. Moreover, severe droughts in 1818 and 1819 stranded several million dollars of downstream-bound cargo at Pittsburgh and caused an economic recession in the city. After these calamities, Pittsburgh civic leaders organized a project to clear the Ohio of navigation hazards and regain the city's supremacy in the western trade. With funding from private sources in Pittsburgh, August Wilkins and a team of workers spent several weeks in October 1819 removing rocks and blasting gravel bars to clear a channel from Pittsburgh to Wheeling.[16]

Meanwhile, the state of Ohio also became involved in river improvement. In 1817 the legislature invited all states bordering on the Ohio River to convene a commission to discuss plans for improving navigation on the entire length of the river. The commission was spurred to action by the 1818-1819 drought and recession, and met in Pittsburgh in August 1819. It appointed Magnus Murray to survey the upper portion of the river for improvements from Pittsburgh to the Falls of the Ohio at Louisville,

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[13] Ibid., 45-46.
[14] Ibid., 47-48.
[15] Ibid., 41, 48.
[16] Ibid., 52.

Kentucky. Murray located 102 major obstructions in this stretch, and in November the commission forwarded his report to the legislatures of upper basin states Kentucky, Ohio, Virginia, and Pennsylvania. The commission was unable to estimate costs for this unprecedented project, but recommended that each state contribute $10,000. Only Pennsylvania actually appropriated these funds, however, so channel clearance work was limited to the Pittsburgh-to-Wheeling stretch recently improved by the Pittsburgh civic group under Wilkins. Foreman Asa Shephard carried out this work during low-water seasons from 1821 to 1825, when funds were exhausted. Shephard's work crew removed boulders and snags from twenty-one ripples, dredged channels through sand and gravel bars, and closed the back channels of islands with low riprap dams that directed low-flow water into the main channel of the river.[17]

D. The Monongahela Navigation Company

At roughly the same time it acted to improve navigation on the Ohio River from Pittsburgh to Wheeling, the Pennsylvania legislature also facilitated navigation on the Monongahela. This was done to persuade travelers to depart the National Road at Brownsville, Pennsylvania, and begin their waterborne journey there rather than continuing overland to rival municipality Wheeling. In 1814 the legislature sponsored a survey of the Monongahela River. As many travelers and commercial operators lamented, the Monongahela was afflicted by severe flow fluctuations that restricted navigation to periods of seasonal high water. The surveyors concluded that only a system of dams with locks could make the river navigable year-round.[18]

Pursuant to the surveyors' recommendations, the state chartered the Monongahela Navigation Company on March 14, 1817, and earmarked state funds to purchase a portion of the company's stock. The company proposed a series of sixteen dams averaging four feet in height plus adjacent locks to canalize the Monongahela from Pittsburgh to the Virginia state line. The fixed dams would impound permanent pools to provide slackwater navigation independent of seasonal and meteorological flow fluctuations. The Monongahela Navigation Company proposed an ambitious and comprehensive plan, the first serious consideration of radical and permanent structural alterations to any of Pittsburgh's rivers. The company's charter expired, however, before

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[17] Ibid., 51-54; see also Frost and Mitsch, "Resource Development and Conservation History along the Ohio River," 145-146; and Louis C. Hunter, *Steamboats on the Western Rivers: An Economic and Technological History* (Cambridge: Harvard University Press, 1949; reprint, New York: Dover Publications, 1993), 189-190 (page numbers refer to the reprint edition).

[18] Johnson, *The Headwaters District*, 91.

it was able to initiate construction of any of the works. In 1822 the state transferred its Monongahela Navigation Company stock appropriation of $10,000 to a public commission charged with improving navigation on the river from the Virginia state line to Pittsburgh. By 1825 this commission had improved the Monongahela channel by clearing snags, boulders, and bars. But the far-sighted canalization project would have to wait.[19]

E. Summary

The earliest endeavors to improve navigation on the rivers in Pittsburgh's vicinity embodied two goals. Both public and private interests pursued waterway improvement to facilitate economic activity and win for Pittsburgh the role of commercial gateway linking the western hinterland with Atlantic ports. To this end, rudimentary engineering efforts at channel clearance aimed to lengthen the navigation season and reduce the economic impact of low water.[20] First, engineers obtained and mapped basic hydrologic and topographic data about the Ohio River and its tributaries in this frontier area. Next, the government declared these rivers and creeks navigable public highways and prohibited their obstruction by artificial structures. Both private interests and the state of Pennsylvania supported various projects to remove snags, scour sand and gravel bars, explode boulders, dredge riffles, and effect other means of channel clearance. These efforts required extensive annual maintenance, however, and made no permanent improvements to the navigability of the rivers. Complete control of the river systems remained elusive. In 1825 Pennsylvania redirected its internal improvement resources from rivers to the development of an east-west canal to compete with New York's Erie Canal. At this time, the federal government assumed control over navigation improvements on the inland rivers and applied its more extensive financial and technological resources. Under the guidance of the Army's engineering corps, the federal government pursued more comprehensive and permanent navigation improvements even beyond the scale of those contemplated by the Monongahela Navigation Company.

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[19] Ibid., 91-92; Richard T. Wiley, *Monongahela: The River and Its Region* (Butler, PA: Ziegler Co., 1937), 153-157.

[20] Johnson, *The Headwaters District*, 54.

II. Open-Channel Work, 1824 to 1874

A. Legal Foundations

In 1824 Congress enacted two measures which gave the federal government, acting through the Army's engineering corps, authority over development of the nation's inland waterways. On April 30 Congress passed the General Surveys Act, which gave the Army Corps of Engineers continuing authority to conduct surveys and undertake various planning studies for transportation projects that might enhance national defense and aid commercial development.[21] One month later Congress passed a contentious internal improvements bill. Legislators engaged in extensive debate about the constitutional authority for federal involvement in civil works and about how the work should be accomplished. Much of the debate rhetoric masked sectional rivalries among Northern, Southern, and Western political and economic interests, however. Each section fought for internal improvements and the commercial boom that followed road, canal, and waterway development. The resulting civil works act, passed on May 24, authorized the federal government to enhance navigation on the inland rivers and directed that this work be done under the auspices of the Army Corps of Engineers. The original bill contemplated the removal of snags and the construction of small wing dams to scour sand bars in an effort to provide a low-water channel of minimum three-foot navigation depth from Brownsville on the Monongahela to New Orleans at the mouth of the Mississippi. The law as passed, however, deleted improvements to the Monongahela and added work on the section of the Mississippi from Cairo to St. Louis, all for an appropriation of $75,000.[22]

B. Snag Removal

Snag removal was the heart of the inland waterway improvement act. The term "snag" referred generally to any timber obstruction in a waterway. Most were trees that fell into the river when banks eroded from beneath their root base. As the tree became waterlogged and lost its buoyancy, it stalled in the river, as the current could no longer carry it downstream. The heavier butt end of the tree sank to the riverbed and began to accumulate sand and gravel in its root system, embedding it firmly in the river bottom. Some snags faced upstream, waiting to impale approaching watercraft, but in most cases

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[21] Robinson, "History of Navigation in the Ohio River Basin," 12; Frost and Mitsch, "Resource Development and Conservation History along the Ohio River," 146; Johnson, *The Headwaters District*, 64.
[22] Ibid., 63-66.

the current swung the top of the snag around and inclined it downstream. Those that bobbed in the current were classified by rivermen as "sawyers." Those that rotted off below the surface of the water were known as "planters." A small collection of snags tangled together became an "islet," and as islets grew and collected more debris, they became extremely hazardous "rafts."[23]

Pursuant to his new instructions, General Alexander Macomb, chief engineer of the Army, solicited bids for the inland rivers snag-removal contract. In conjunction with the contract, he offered a $1000 prize for the best snag-pulling device. John Bruce of Kentucky won the contest with his "machine boat," a craft composed of two substantial flatboats positioned along side each other, about eight feet apart, and joined by heavy cross timbers. These timbers supported a strong wooden lever from which hung on one end an iron claw and on the other a heavy rope attached to a windlass. The crew positioned the boat over the snag and affixed the claw. The leverage afforded by the windlass allowed the crew to break off the snag at the river bottom, extract it from the riverbed, or raise it high enough to saw it off and render it harmless. Bruce's machine boat could not handle the largest snags, however, and his contract performance was less than satisfactory to the War Department.[24]

In late 1826 Bruce was replaced by renowned riverman Henry M. Shreve, who developed a series of steam-powered snag-pulling devices. His first, the *Heliopolis*, began work on the Mississippi River in 1829. Shortly thereafter the *Heliopolis* was joined by the *Archimedes*, and the twin snag boats set to work clearing the Mississippi and Ohio rivers of snags and wrecks. Nicknamed "Uncle Sam's Toothpullers," Shreve's snag boats were more powerful than Bruce's. Each boat could handle snags up to sixty feet long and weighing as much as seventy-five tons. It took each boat about forty-five minutes to extract a snag, and each could average sixteen large snags per day.[25] By 1835 Shreve had cleared most of the Mississippi and lower Ohio rivers of their hazardous

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[23] Hunter, *Steamboats on the Western Rivers*, 235-237; Robert F. Cairo, "Snag Boats on the Western Rivers, Part I," *Nautical Research Journal* 26 (June 1980): 83.

[24] Hunter, *Steamboats on the Western Rivers*, 192-193; Johnson, *The Headwaters District*, 67-71; Cairo, "Snag Boats on the Western Rivers, Part I," 87.

[25] Ibid., 93; Tim Spell, "Uncle Sam's Toothpullers," *Nautical Research Journal* 26 (March 1980): 39; see also Hunter, *Steamboats on the Western Rivers*, 193-200; and Johnson, *The Headwaters District*, 72-74. For schematics, drawings, and photographs of the various snag boats, see Cairo, "Snag Boats on the Western Rivers, Part I," 83-93; idem, "Snag Boats on the Western Rivers, Part II," *Nautical Research Journal* 26 (December 1980): 167-176; and Spell, "Uncle Sam's Toothpullers," 38-42. For a more complete treatment of Henry Shreve's career on the western rivers, see Edith S. McCall, *Conquering the Rivers: Henry Miller Shreve and the Navigation of America's Inland Waterways* (Baton Rouge: Louisiana State University Press, 1984).

snags and shipwrecks. Shreve's success was marked by the drop in insurance premiums on river cargo, which were reduced to half the amount charged nine years earlier.[26]

C. State Efforts on the Allegheny and Monongahela Rivers

The terms of the 1824 civil works act limited federal internal improvements to interstate rivers like the Ohio. The original bill called for funding of Monongahela River work, but because the proposed stretch from Brownsville to Pittsburgh was entirely within the state of Pennsylvania, Congress struck the Monongahela provision from the final wording of the law.[27] After 1825 Pennsylvania directed more capital toward the Mainline Canal linking Philadelphia with Pittsburgh, but it did not abandon its rivers altogether. While Shreve removed snags from the Mississippi and Ohio rivers under federal mandate, Pennsylvania continued to support improvements to the Allegheny, Monongahela, and other rivers. Work proceeded on these rivers under a mixture of federal and state efforts.

From 1824 to 1837 several surveying and engineering parties examined the Allegheny River for a variety of projects. One survey contemplated a canal linking the Ohio River to Lake Erie. Another studied the possibility of a canal parallel to the Allegheny that would link the proposed Pennsylvania Mainline Canal with the projected French Creek Canal to extend Pennsylvania's east-west water highways. Further surveys recommended a system of dams with locks to canalize the Allegheny. Army engineer Major George Hughes conducted the most comprehensive of these surveys in 1837. He recommended slackwater navigation from Olean, New York, to Pittsburgh—a plan similar to that proposed by the Monongahela Navigation Company for that river. In 1845 the Pennsylvania legislature urged the federal government to fund the Allegheny slackwater program, but Congress was not forthcoming with appropriations.[28] Waterborne commerce on the unimproved Allegheny stalled, and thereafter both technological and economic development of this river lagged a generation behind improvements on the Monongahela or the Ohio.

The greater commercial importance of the Monongahela River meant that its navigation improvements outpaced the Allegheny's. The Monongahela Navigation Company had proposed a slackwater navigation system for the river as early as 1817, but

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[26] Hunter, *Steamboats on the Western Rivers*, 200; Spell, "Uncle Sam's Toothpullers," 39, 42.

[27] Johnson, *The Headwaters District*, 65.

[28] Sarepta Kussart, *The Allegheny River* (Pittsburgh: Burgum Printing Co., 1938), 321-325; Johnson, *The Headwaters District*, 87-91; Gannett, Fleming, Coddry, and Carpenter, Inc., "A History of Navigation Improvements on the Allegheny River," prepared for the U. S. Army Corps of Engineers, Pittsburgh District (Pittsburgh: By the author, August 1981), 1-5.

the company's insolvency precluded any construction. By 1825 only snag and rock removal and basic channel clearance work facilitated travel on the Monongahela. Three years later Pennsylvania engineer Edward Gay recommended a series of dams with locks—much like those proposed by the Monongahela Navigation Company—to afford year-round navigation from Pittsburgh to the Virginia state line. In 1833 the Corps of Engineers conducted its own survey of the Monongahela, and recommended a slackwater system able to accommodate 100-ton steamships year-round as far as Brownsville, an important river port for emigrant and commercial traffic from the National Road. Pennsylvania lobbied to secure federal funding for the Monongahela slackwater system, but was unsuccessful. Unlike its policy toward the Allegheny, however, Pennsylvania decided to underwrite Monongahela improvements without federal assistance. In 1836 it chartered a second Monongahela Navigation Company, which organized the following year. The new company proposed seven dams to extend slackwater navigation to the state line.[29]

D. The Ohio River Improvement Project

During the mid-1830s Henry Shreve continued to direct the tremendous project of snag removal on the main streams of the Ohio and Mississippi. But Shreve's big snag boats could not ascend the Falls of the Ohio at Louisville, and in 1835 Congress bifurcated administration of the Ohio River. Shreve retained responsibility for the Lower Ohio as part of his Mississippi River assignment, and Congress transferred jurisdiction over the Upper Ohio to Lieutenant George Dutton, giving him $50,000 for channel clearance. In the fall Dutton set off from Pittsburgh to update maps of the Ohio from Pittsburgh to Louisville and to plan a new improvement effort for this stretch. He recommended a slackwater system to make the Upper Ohio navigable year-round, but met familiar opposition from rivermen who feared that a series of dams would slow downstream traffic during high-water periods. Regardless, the meager $50,000 appropriation to serve the approximately 600 river miles between Pittsburgh and Louisville forced Dutton to limit his improvement plans to snag and rock removal and the emplacement of wing dams to scour bars or close secondary channels. Before he could make much progress, the Corps of Engineers reassigned him to construction duty on the

[29] Idem, "A History of Navigation Improvements on the Monongahela River," prepared for the U. S. Army Corps of Engineers, Pittsburgh District (Pittsburgh: By the author, March 1980), 1-3; Wiley, *Monongahela: The River and Its Region*, 157-159; Johnson, *The Headwaters District*, 92-93.

extension of the National Road west of Wheeling, and the Ohio River project was transferred to Captain John Sanders.[30]

Sanders opened the Office of Ohio River Improvements in Pittsburgh in 1836 and began his tasks. Working with smaller snag boats, he and his crew cleared the Ohio of snags and shipwrecks from Pittsburgh to Louisville. His crew also dug up or blasted rocks, boulders, stumps, and root clusters from the channel, and when high water prohibited channel work, they used hand tools to clear tree hazards from banks and islands. Moreover, Sanders analyzed transportation patterns on the Upper Ohio to determine the engineering efforts best suited to enhance commercial navigation. He recognized that flatboats and keelboats transported the bulk of tonnage on the river, primarily produce, lumber, and coal. He also realized that most of this cargo traveled only downstream, and only at times of high water. The Ohio carried a substantial amount of steamboat traffic as well, primarily merchandise, manufactures, and passengers. And steamboats were the only vessels that regularly traveled both downstream and upstream. Sanders concluded that a channel two hundred feet wide with a minimum depth of thirty inches would guarantee low-water passage by up to 100-ton steamboats. Working with a limited budget, Sanders proposed low stone wing dams to effect the thirty-inch channel.[31]

Sanders' proposal for wing dams was part of a larger experimental project by the Corps of Engineers that aimed to improve navigation on all of the western rivers. Unlike snags, which yielded to a relatively simple, uniform, and inexpensive technology, each sand or gravel bar constituted a unique obstacle requiring a tailored engineering solution. Potentially elaborate and expensive solutions had to account for the individual hydraulic conditions forming each bar. Moreover, complete elimination of bars actually could hamper navigation rather than improve it. Bars acted as natural dams to restrain the river in pools. While elimination of a bar would remove a direct obstacle to vessel passage, the overall depth of water would be stabilized at a lower level, lessening the channel depth stream-wide. To address this hydraulic puzzle, Army engineers considered construction of stone or timber dikes to concentrate low-stage streamflow into the desired channel. These wing dams protruded from the riverbank part way into the stream and funneled water into a narrower space. The resulting swifter current scoured the river bottom, cutting a deeper channel for navigation. Army engineers experimented with wing dams at several points on the Ohio and Mississippi from the mid-1820s to the early 1830s. They generally were successful in increasing channel depth by several inches, which allowed light-draft steamboat navigation independent of considerations of seasonal

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[30] Ibid., 74-75; see also Leland R. Johnson, "Engineering the Ohio," in *Always a River: The Ohio River and the American Experience*, ed. Robert L. Reid (Bloomington: Indiana University Press, 1991), 190.

[31] Johnson, *The Headwaters District*, 75-76; see also idem, "Engineering the Ohio," 190.

and weather-related water levels. This first decade of work with wing dams resulted in a significant increase in the length of the navigation season, and gave Sanders hope for successful employment of this technology on the Upper Ohio.[32]

E. A Generation of Neglect

Wing dams proved susceptible to the ravages of floodwater, currents, weather, and vandalism. They required constant maintenance by Army engineers, and constant maintenance required steady funding by Congress and political support by the presidential administration. As noted above, in 1824 Congress initiated federal responsibility for the improvement of inland waterways by passing two acts empowering the Corps of Engineers to direct these kinds of civil works projects. Three years later Congress passed a rivers and harbors act which was the first in a series of annual appropriations directing the Army engineers to remove any type of obstruction to navigation at any stage of the rivers.[33] Federal appropriations for navigation developments on the Ohio, though small, continued more or less regularly until Martin Van Buren assumed the presidency in 1837. Van Buren believed that the Constitution failed to authorize federal action toward waterway improvement, and halted all national waterway projects when the country entered an economic recession in 1837. Funding for inland river improvements did not resume until 1842 under John Tyler's administration. These several years of neglect were disastrous for Sanders' thirty-inch project on the Upper Ohio. The channel filled with driftwood and snags and floodwaters washed out unfinished wing dams. Riparian interests such as sawmill and gristmill operators resented the channel diversions effected by wing dams and occasionally resorted to vandalism to restore their own water chutes. Army engineers resumed open-channel efforts in 1842, but the Mexican War from 1846 to 1848 plus irregular and inadequate funding from Congress plagued western river improvement as a whole during the 1840s and 1850s.[34] In the two decades before the Civil War, then, discontinuities in political and fiscal support stalled inland waterway improvements. Work ceased altogether during the war itself, resulting in a generation of significant neglect.

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[32] Hunter, *Steamboats on the Western Rivers*, 200-202.

[33] Frost and Mitsch, "Resource Development and Conservation History along the Ohio River," 146; Johnson, *The Headwaters District*, 71.

[34] Charles Henry Ambler, *A History of Transportation in the Ohio Valley* (New York: Arthur H. Clark Co., 1931; reprint, Westport, CT: Greenwood Press Publishers, 1970), 396 (page numbers refer to the reprint edition); Johnson, *The Headwaters District*, 79-85; Robinson, "History of Navigation in the Ohio River Basin," 16-17.

F. The Second Monongahela Navigation Company

State and private projects fared much better in the antebellum period. The most successful inland river improvement project during this time was the canalization of the Monongahela River, accomplished by the second Monongahela Navigation Company. Pennsylvania chartered the new company in 1836, and it commenced construction in 1838. The company proposed seven dams to afford slackwater navigation from Pittsburgh to the Virginia state line. Lock and Dam 1 was located about a mile above the Smithfield Street Bridge in Pittsburgh, and Lock and Dam 2 was sited about ten miles further upriver, at Braddock's Upper Ripple above the mouth of Turtle Creek. Each dam had a single lock chamber measuring fifty feet wide by 190 feet long. The company completed both structures in 1841. Locks and Dams 3 and 4 were of the same dimensions and were finished in late 1844. They afforded high-water pools six feet deep and low-water pools four feet deep for the entire sixty miles from Pittsburgh to Brownsville. The company added a second, larger lock chamber at Lock and Dam 1 in 1848 and at Lock and Dam 2 in 1854 to accommodate increasing Monongahela River traffic, particularly the large coal barges. Two more dams with locks were erected in 1856, and the seventh and final lock and dam operated by the Monongahela Navigation Company was built at Jacob's Creek near the West Virginia state line in 1883. This structure completed the system of privatized, toll navigation on the most commercial portion of the Monongahela. The federal government funded the remainder of the Monongahela slackwater project, and the Corps of Engineers completed Locks and Dams 8 and 9 in 1889, affording slackwater navigation from Pittsburgh to Morgantown, West Virginia.[35]

G. The Youghiogheny Navigation Company

The pool behind the Monongahela River's Dam 2 backed up the Youghiogheny River seven miles, affording slackwater navigation for this short distance. This tributary carried barge traffic to and from Connellsville and the success of the Monongahela's slackwater technology, plus its toll revenue, inspired entrepreneurs to attempt a similar project on the Youghiogheny. As early as 1814 a Connellsville and West Newton Navigation Company organized to emplace locks on the stream, and in 1816 a Youghiogheny Navigation Company was incorporated to improve the river's channel.

[35] Gannett, et al., "A History of Navigation Improvements on the Monongahela River," 2-10; Johnson, *The Headwaters District*, 95-99, 128-129; see also Hunter, *Steamboats on the Western Rivers*, 206-207.

Instead, its investors exercised the portion of its charter that permitted organization of a bank in Connellsville. Neither navigation company actually constructed any works. In 1843, however, the Pennsylvania legislature chartered another Youghiogheny Navigation Company for the purpose of constructing a slackwater system from McKeesport to West Newton, a distance of just under twenty miles. Financial difficulties delayed the start of construction until 1848, but Lock and Dam 1 at Boston and Lock and Dam 2 at Buena Vista opened to traffic in late 1850. Together, they provided four-foot pools of slackwater to West Newton. Youghiogheny slackwater was short-lived, however. Damage by ice and floods plagued the company's works, and a particularly severe ice gorge completely destroyed the dams in February 1867. The Pittsburgh and Connellsville Railroad, completed through the valley in 1861, eclipsed barge transport on this portion of Pittsburgh's river system. The Youghiogheny Navigation Company's structures were never rebuilt.[36]

The Rivers and Harbors Act of 1910 authorized the Army engineers to restore slackwater on the Youghiogheny River by emplacement of three dams with locks, but the corps never implemented these plans. Periodic surveys from 1875 to the 1930s fathomed even more grandiose engineering of the Youghiogheny. These proposals incorporated the Youghiogheny in a waterway system to link the Ohio River to the Atlantic Ocean. Most of these recommendations sought to connect Pittsburgh to Cumberland, Maryland, via a canalized Youghiogheny, thence through the Chesapeake and Ohio Canal to the Potomac River, Chesapeake Bay, and the Atlantic Ocean. Like the more limited Youghiogheny slackwater to West Newton, none of these plans was brought to fruition.[37]

H. Rehabilitation of the Ohio's Thirty-Inch Channel

A generation of intermittent improvement work plus the ravages of river battles during the Civil War left the western rivers in a state of disrepair with regard to navigability. In 1866 vessels had to negotiate 285 obstructions in the Ohio River: ninety snags, sixty-six drift piles, forty-six wrecked steamboats, and eighty-three sunken barges. As river conditions worsened and regular commerce resumed after the disruption of civil war, federal courts addressed the United States government's legal authority to regulate inland waterways. In 1865 the Supreme Court issued a decision in *Gilman v. Philadelphia* which upheld the constitutionality of federal authority over inland

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[36] Tim Palmer, *Youghiogheny: Appalachian River* (Pittsburgh: University of Pittsburgh Press, 1984), 300; Johnson, *The Headwaters District*, 99-100.

[37] Palmer, *Youghiogheny*, 300; Flood Commission of Pittsburgh, *Report of Flood Commission of Pittsburgh, Penna.* (Pittsburgh: Flood Commission of Pittsburgh, 1912), 27, 234.

waterways. The Court affirmed the federal government's police power to keep inland river highways free from obstructions to navigation. Civil War Reconstruction inaugurated an era of increasing federal power at the expense of states' rights, and the *Gilman* decision signaled the Republican administration's commitment to federal civil works projects.[38]

The Ohio River received the immediate attention of Congress and the Corps of Engineers once the Civil War ended. In 1866 Colonel John N. Macomb reopened the Office of Western River Improvements at Cincinnati. That same year William Milnor Roberts resumed Sanders' aborted improvements to the Upper Ohio with a generous budget of $272,000. He began with a massive snag-clearing project. Next Roberts rebuilt Sanders' ruined wing dams and added new ones at the bars and shoals where barges encountered the most difficulty. Roberts sought to restore Sanders' thirty-inch channel on the Ohio and to improve it by six inches if possible. Every additional six inches of channel depth allowed each boat and barge to increase its cargo by seventy tons, affording a substantial economic gain to producers, carriers, and consumers. By 1870 Roberts and his crew had improved the Upper Ohio's channel tremendously.[39]

The Corps of Engineers began reorganization of the Ohio River Improvement Project in 1871. Colonel William E. Merrill pursued several goals to modernize the engineers' ability to maintain open-channel navigation on the Ohio. First, Merrill lobbied Congress for more generous funding than its usual postwar annual appropriation of $50,000 expected to serve a river 981 miles long with an estimated commerce exceeding $500 million. Merrill built more and better dam structures and ended the practice of contract snagging and dredging by establishing these services in an Army engineers' maintenance fleet. In addition, he pressed Congress to enhance nighttime navigation by installing white marker towers with lanterns on the Ohio's banks and placing buoys in the channel. In 1874 Congress established inland river lighthouse districts which placed 150 marker lights and buoys on the Ohio the following year.[40]

I. Summary

Despite political and fiscal vagaries plus the disruption of war, in the fifty-year period from 1824 to 1874 the Army Corps of Engineers made significant improvements

[38] Johnson, *The Headwaters District*, 114, 110.
[39] Ibid., 109-115; Ambler, *A History of Transportation in the Ohio Valley*, 402-403.
[40] Johnson, *The Headwaters District*, 115-117; Robinson, "History of Navigation in the Ohio River Basin," 23-25.

to navigation on the Ohio River and its tributaries. Beginning in 1824, various pieces of legislation gave the Army engineers authority over inland waterway improvements. This authority was confirmed by judicial review in 1865 after nearly a half-century of vigorous national debate. The Corps of Engineers pursued arduous channel clearance work, removing snags, boulders, shoals, wrecks, and all manner of obstructions to navigation. Engineers experimented with varieties of wing dams to deepen the river in pursuit of the thirty-inch channel on the Ohio, which they hoped would lengthen the navigation season for lighter-draft boats. Congress provided for both day and nighttime aids to navigation in the form of marker lanterns and channel buoys. Despite the more advanced technologies employed, however, the results remained temporary and improved navigability on the Ohio River only marginally over its state in the period before federal intervention. But by 1875 the Corps of Engineers recognized that even the successful completion of the thirty-inch channel was obsolete. Towboat and barge combinations capable of hauling immense tonnages were eclipsing keelboats and light-draft steamboats as the vessels of choice for commercial transport, and these craft required significantly deeper water. In fact, they required deep slackwater pools for navigation, much like the smaller systems emplaced on the Monongahela and Youghiogheny rivers by this time. During the 1870s Colonel Merrill prepared Congress and the Corps of Engineers for a new era of radical waterway improvement and control: the complete canalization of the Ohio River from Pittsburgh to Cairo with minimum slackwater pools of six-foot depth.[41]

III. Canalization, 1874 to 1929

A. Six-Foot Slackwater

In 1870 William Milnor Roberts, who had resumed open-channel work on the Upper Ohio after the Civil War, proposed canalizing the Ohio River with a series of dams to afford navigation pools of six-foot depth. Roberts had designed the immensely successful lock and dam system on the Monongahela River, and he drafted similar plans for the Ohio. In Roberts' estimation, the 450-foot difference in elevation between Pittsburgh and Cairo could be negotiated by a series of sixty-six locks. Roberts submitted his proposal to Colonel Merrill, who reviewed it and other plans as well. One engineer proposed storage reservoirs on the Ohio's tributaries that could release water during low-flow seasons to maintain a navigable pool on the main stem. Another suggested diverting water from Lake Erie through the Mahoning and Beaver rivers or through Lake Chautauqua and the Allegheny. A third plan contemplated a canal running

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[41] Johnson, *The Headwaters District*, 134-136; idem, "Engineering the Ohio," 192.

alongside the length of the Ohio. Roberts' plan won Merrill's approval because the corps was well versed in the engineering required by canalization; because its low dams would inundate little bottomland, and considerably less than would the storage reservoirs; and because the pools backing up behind the dams would create or enhance riverport harbors.[42]

Roberts' lock and dam designs proved adequate for Monongahela River commerce in mid-century, but Merrill recognized that traffic patterns were changing on the Ohio. The growing volume of towboat-barge combinations required more elaborate engineering solutions. The Monongahela Navigation Company had built fixed dams that required lockage to pass in either direction. Merrill wanted movable dams on the Ohio system which could be raised to retain pools of water in seasons of low flow, then be collapsed in times of high water to lay flat on the riverbed. This design would allow downstream passage without the inconvenience and delay of lockage. After exhaustive research in the United States and Europe, Merrill decided that the Chanoine wicket dams in use on the Seine and other rivers in France would serve his purposes on the Ohio. These devices had been invented in 1852 by Jacques Chanoine, chief of the French Corps of Engineers. The Chanoine dam consisted of a series of wickets, or large timber panels, placed adjacent to one another across the width of the river and hinged to a submerged concrete foundation on the riverbed. Each wicket was about three-and-one-half feet wide and thirteen feet long. During drought periods, when vessels required an artificial navigation pool, the wickets could be raised to an upright position, supported by heavy iron poles extending downstream. The series of raised wickets formed a dam and created a slackwater pool, and traffic used the lock chamber to negotiate the dam. In times of high water the iron props would be dislodged from behind the wickets, and they would fall flat to the river bottom, allowing natural navigation. In addition, Merrill planned lock chambers measuring 110 feet by 600 feet, capable of passing ten barges and a towboat without double lockage. He calculated that the amount of water retained by such large lock chambers would buckle the traditional swinging mitering lock gates, so he designed an innovative rolling lock gate to close them. Merrill's mechanism consisted of a wooden structure mounted on iron wheels that traversed the mouth of the lock on 11.5-foot gage rail track. When open, the lock gate retracted into a recess in the landward lock wall.[43]

Much of the engineering in Merrill's plan for canalization of the Ohio was untested. Movable wicket dams had never been constructed in a river the size of the

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[42] Ibid., 192; idem, *The Headwaters District*, 134-135.

[43] Idem, "Engineering the Ohio," 193-194; Robinson, "History of Navigation in the Ohio River Basin," 25-26; Johnson, *The Headwaters District*, 136-138, 147.

Ohio. The 110-foot-wide lock chambers were the largest in the world, and were wider than those built on the Panama Canal in 1914. The rolling lock gates were also an engineering novelty. Moreover, coal shippers and towboatmen remained hostile to canalization of the Ohio, fearing the delays and inconveniences of fifty or more locks on the downstream voyage. To allay these various concerns, Merrill proposed a single experimental lock and dam structure sited five miles below Pittsburgh at Horsetail Ripple next to Davis Island. The Davis Island Dam would create a deep pool for Pittsburgh where coal tows could be assembled for the downstream journey. If the slackwater pool and lock apparatus proved cumbersome for the towboat and barge operators, Merrill agreed to demolish the structure and restore the natural channel. Congress agreed to fund Merrill's gamble in 1875.[44]

Construction began on Davis Island Dam in 1878, and after several delays, it opened to river traffic on October 7, 1885, with much fanfare and a thirty-nine-boat parade. With 305 wickets spanning 1223 feet, it was the longest dam in the world. It created Pittsburgh harbor with a capacity for 12,000 boats and barges, and boasted the first navigational lock on the Ohio River's main stem. Davis Island Dam also afforded a more stable water supply for riverside industries, and acted to dilute some of their noxious effluents perceived as hazards to public health. Its final cost totaled $940,832.31.[45] The dam proved its worth shortly. A severe flood in July 1888 sank at least one hundred boats on the Monongahela River, but none of the boats moored in the Pittsburgh Pool behind Davis Island Dam was lost. The dam continued to demonstrate its value for flood control, pollution abatement, and reliable water supply for municipal and industrial uses.[46] Congress, however, remained tentative about the complete canalization of the Ohio. In 1888 it authorized further study of the six-foot slackwater project for the Upper Ohio, which the Corps of Engineers endorsed enthusiastically. The legislature did not approve operational funding, however, until 1890. Further authority for the six-foot slackwater project was erratic. Lock and Dam 6, named after Merrill and located just below the mouth of the Beaver River, was authorized in 1890. Locks and Dams 2 through 5 followed in 1896, and Locks and Dams 7 through 18 were approved in 1899, to afford slackwater to Marietta, Ohio. At this point the Army engineers changed strategy

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[44] Ibid., 138; Robinson, "History of Navigation in the Ohio River Basin," 26.

[45] Johnson, *The Headwaters District*, 132-141; Frost and Mitsch, "Resource Development and Conservation History along the Ohio River," 146; Johnson, "Engineering the Ohio," 194; Robinson, "History of Navigation in the Ohio River Basin," 26-27. For a monograph about Davis Island Dam, see Leland R. Johnson, *The Davis Island Lock and Dam, 1870-1922* (Pittsburgh: U. S. Army Corps of Engineers, 1985).

[46] Idem, *The Headwaters District*, 146.

to prioritize construction of dams immediately below major river ports and at the mouths of tributary streams rather than continue downstream sequentially.[47]

B. Monongahela Emancipation

The early success of slackwater navigation on the Monongahela River was afforded by the efforts of the private Monongahela Navigation Company, which collected lock tolls to recoup its capital investment and make the venture profitable. This extra operating expense put Monongahela River coal shippers at a disadvantage against Kanawha River shippers in West Virginia, where government locks were free. The Rivers and Harbors Act of 1884 prohibited tolls, fees, or operating charges of any kind levied or collected on public navigational works owned by the United States. After the passage of this act, operators on the Monongahela River lobbied Congress to purchase the Monongahela Navigation Company's system and restore free navigation on the river. The company resisted selling, and after several attempts at compromise, in 1896 Congress directed the secretary of war to initiate condemnation proceedings. More legal battles ensued, but in 1897 the Supreme Court ruled that the United States had the authority to acquire the property in the public interest. The United States recompensed the company $3,761,615.46 for its property and toll franchise in the largest condemnation award to that date. Operators on the Monongahela River celebrated its emancipation on July 16, 1897.[48] With the river under federal jurisdiction, the Corps of Engineers extended seven-foot slackwater on the Monongahela to its headwaters at Fairmont, West Virginia. The completion of six additional dams in 1903 gave the Monongahela River 131 miles of slackwater pools navigable year-round. Army engineers also carried out significant reconstruction and re-engineering on the aging Monongahela Navigation Company structures, including remodeling or replacing some locks and dams, raising dam height and consequently the navigable pool depth, and other rehabilitative measures.[49]

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[47] Robinson, "History of Navigation in the Ohio River Basin," 27-28.

[48] Gannett, et al., "A History of Navigation Improvements on the Monongahela River," 11-12; Johnson, *The Headwaters District*, 141-143.

[49] Gannett, et al., "A History of Navigation Improvements on the Monongahela River," 12-29; Johnson, *The Headwaters District*, 152-155.

C. Slackwater on the Allegheny

A technological generation behind the navigation improvements on the Monongahela and the Ohio, the Allegheny River boasted only the temporary fruits of annual channel maintenance. Consequently, it carried much less commercial tonnage than either the Monongahela or the Ohio, and only the oil boom upriver in the 1860s fostered demand for significant improvements to its navigability. In 1878 Congress granted the first federal funding for Allegheny River improvement with an appropriation of $10,000. The following year Colonel Merrill assigned Thomas P. Roberts, son of Ohio River slackwater designer William Milnor Roberts, to survey the Allegheny from Olean to Pittsburgh. His report mapped numerous shoals on the river and located thirty-two low bridges that impaired steamboat navigation. As an initial measure, Roberts carried out the familiar open-channel improvements of snag, rock, and wreck removal, including extraction of the abandoned piers of the Pennsylvania Mainline Canal Aqueduct at the mouth of the Kiskiminetas River. He and his crews then built dams to close the back channels of Six-Mile and Nicholson's islands. At the urging of rivermen, Roberts constructed a sandbag wing dam to deepen the channel at Garrison's Ripple near Herr's Island, opening access to Allegheny Arsenal. Similar annual maintenance continued, and by the end of the nineteenth century Army engineers had established a channel 150 feet wide with a minimum low-water depth of one foot from Pittsburgh to the New York state line, for a sum just under $200,000.[50]

But the wing dam at Garrison's Ripple was only a temporary measure. Colonel Merrill already was designing a dam with lock for Herr's Island, which Congress approved in 1885. A variety of delays undermined the construction schedule, but the structure finally opened to navigation on July 28, 1903, completing the Pittsburgh harbor. Army engineers received authorization from Congress to extend slackwater eighty miles up the Allegheny to Monterey, Pennsylvania. They started construction on Locks and Dams 2 and 3, at Six-Mile Island (Aspinwall) and Springdale, respectively, by 1902. But canalization of the Allegheny to facilitate steamboat navigation was worthless as long as the thirty-two low bridge obstacles remained. For the next quarter-century the Corps of Engineers mediated a protracted and acrimonious dispute between the Pittsburgh rivermen's lobby on one side and railroads, private corporations, and municipal bridge

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[50] Ibid., 124-127; U. S. Army Corps of Engineers, Pittsburgh District, comp., "Navigation on the Monongahela and Allegheny Rivers" (Pittsburgh: U. S. Army Corps of Engineers, March 1939), 5; Frederick Way, Jr., *The Allegheny*, Rivers of America Series, eds. Stephen Vincent Benét and Carl Carmer (New York: J. J. Little & Ives Co., 1942), 209-210; Kussart, *The Allegheny River*, 325-328; Gannett, et al., "A History of Navigation Improvements on the Allegheny River," 5-16.

owners on the other. The Six-Mile Island and Springdale locks and dams were finished in 1908, affording slackwater to Natrona. Then the corps halted further construction to await the outcome of the bridge controversy. In 1912 Congress considered the extension of slackwater to Rimerton, Pennsylvania, by five additional lock and dam structures, but made approval contingent upon raising the bridges. Debate and delay continued, however, until the secretary of war issued an ultimatum to recalcitrant Allegheny County commissioners in 1923. By 1929 all obstructing bridges had been raised, moved, or altered to provide a forty-eight-foot clearance over pool levels. Using relief funding during the Great Depression, by 1938 the Corps of Engineers had extended nine-foot slackwater to East Brady, seventy-two miles above Pittsburgh. The plans for slackwater to Oil City or even all the way to Olean, New York, however, were never implemented.[51]

D. Nine Feet to Cairo

Congress grudgingly authorized and funded six-foot slackwater on the Ohio River from Pittsburgh to below Cincinnati by 1902. It also had funded nine-foot slackwater on the lower Mississippi River, and had approved the isthmian canal in Panama. Ohio Valley rivermen urged Congress to incorporate their river into the nine-foot scheme, fearing the economic disadvantage of six-foot slackwater when the Mississippi and Panama projects were completed. Major William L. Sibert and other Army engineers argued that the additional three feet of channel depth on the Ohio would effect a savings of 32.5¢ per ton. They predicted that nine-foot slackwater on the Ohio, in conjunction with the improved Mississippi and Panama waterways, would boost Ohio River commerce to ten million tons per year, shipped at an annual savings of more than three million dollars.[52] In 1902 Congress ordered the Army engineers to study the feasibility of augmenting the Ohio's six-foot slackwater, and three years later it approved nine-foot slackwater behind the first six dams below Pittsburgh. The corps estimated that it might take as many as fifty-four dams with locks to canalize the Ohio to a nine-foot depth for its entire 981 miles to Cairo, however, and Congress hesitated to make such a momentous commitment at this stage. But full endorsement of nine-foot slackwater came shortly when Congress passed the Rivers and Harbors Act of 1910. Moreover, the legislature promised steady funding of the project's $66 million to complete the canalization of the

[51] Johnson, *The Headwaters District*, 127, 143-145, 148-151, 171-173; Way, *The Allegheny*, 210-213; Kussart, *The Allegheny River*, 328-333; Ambler, *A History of Transportation in the Ohio Valley*, 411; Gannett, et al., "A History of Navigation Improvements on the Allegheny River," 16-29.
[52] Johnson, *The Headwaters District*, 158.

Ohio by 1922.[53] In fact, the Corps of Engineers provided nine feet of slackwater on the Ohio River by October 1929 at a cost of $125 million. This long-awaited accomplishment was heralded by a floating parade the entire length of the river and a presidential address by Herbert Hoover at the parade's stop in Cincinnati.[54]

E. Summary

The achievement of nine-foot slackwater on the Ohio River from Pittsburgh to Cairo crowned the end of an era for inland river navigation improvements. In 1874 Congress had authorized the Corps of Engineers to explore radical solutions to inland river navigation. The Army engineers moved beyond temporary open-channel efforts such as snag removal and shoal remediation to effect more permanent, year-round navigation to accommodate the increasing tonnages being transported on the Ohio and its tributaries. Canalization transformed the nature of the Ohio significantly. In periods of high water, the Chanoine wickets were lowered, and the river flowed much as it always had. In times of drought, however, the Chanoine wickets were raised, backing up deep navigation pools behind the dams they created. Slackwater systems altered and controlled the Monongahela and the Allegheny even more dramatically. Unlike the collapsible dams on the Ohio, those on the Monongahela and Allegheny were fixed structures. They required lockage to traverse the vertical fall of the river in either direction and during any level of water. In effect they transformed these two rivers into a stairstepped series of navigation pools. A chain of lakes was to be the fate of the Ohio as well. Despite the triumph of nine-foot slackwater in 1929, the Ohio required additional navigation improvements. Army engineers contemplated even more radical measures to place the Ohio under complete control.

IV. Modernization in the Twentieth Century

A. Ohio River Modernization

By the early twentieth century most of the structural engineering on Pittsburgh's three rivers was complete. Through canalization, Army engineers had succeeded in

[53] Ibid., 158-159; Robinson, "History of Navigation in the Ohio River Basin," 28; see also Ambler, *A History of Transportation in the Ohio Valley*, 404-422.
[54] Johnson, *The Headwaters District*, 169-170; Robinson, "History of Navigation in the Ohio River Basin," 28-30.

simplifying river navigation by eliminating or mitigating the vagaries of hydrology and weather. Army engineers then shifted their attention to modernizing existing structures and incorporating new technology. As well, after 1936 their mission expanded to encompass basin-wide flood control.

The Davis Island Dam, with its first navigational lock on the Ohio River, was the pilot structure of the six-foot slackwater project in 1885. It soon became obsolete for the nine-foot slackwater project and the deeper-draft barge traffic for which the project expansion was designed. Timber wickets longer than twenty feet were cumbersome to raise from their riverbed recesses, so Army engineers required new technology to support the navigation pools of the nine-foot project. In 1915 they proposed replacing the movable Chanoine wicket dam at Davis Island with a fixed concrete structure located one-and-one-half miles further downstream. Because the wicket dam collapsed flat to the riverbed in times of high water, it still could pass traffic downstream while other vessels were locking upstream or when the lock chamber was closed for repair. The proposed twenty-one-foot-high fixed concrete dam would not be navigable except through its lock chamber. To neutralize the objections of rivermen who feared delays, Army engineers planned two locks for the replacement dam. The main lock chamber would be standard Ohio River dimensions, 110 feet by 600 feet. The secondary lock chamber would conform to Monongahela River standards at fifty-six feet by 360 feet. The double locks would be able to pass two tows at once, would not prohibit navigation if one chamber were closed for repair, and could conserve water during drought times by using only the smaller lock. Congress approved the replacement dam in 1917 and construction began in 1919. The new Emsworth Dam—actually two separate dams straddling Neville Island—opened to navigation on September 1, 1921. The pool raised by Emsworth Dams gave Pittsburgh harbor fifty miles of shoreline, and rendered Davis Island Dam and Ohio River Dam 2 at Glenfield, Pennsylvania, superfluous. The corps removed them in 1922.[55]

Like Davis Island Dam before it, the Emsworth Dams complex was another engineering first on the Ohio. As the first high-lift fixed concrete dam on the Ohio River, Emsworth inaugurated the modernization of the canalized Ohio. After the completion of nine-foot slackwater to Cairo in 1929, tonnage on the Ohio doubled roughly every eleven years. By mid-century the low-lift navigable dams of the initial canalization project had become obsolete. Their 110-foot by 600-foot lock chambers had become an obstacle to

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[55] Johnson, *The Headwaters District*, 165-167; Pittsburgh District, comp., "Navigation on the Monongahela and Allegheny Rivers," 5; Leland R. Johnson, *The Ohio River Division, U. S. Army Corps of Engineers: The History of a Central Command* (Cincinnati: U. S. Army Corps of Engineers, Ohio River Division, 1992), 125.

navigation for ever-larger towboat-barge combinations, which had to be broken apart, locked through in two stages, then reassembled. Many of the original lock and dam structures had begun to show signs of age and required constant and costly maintenance. The original Ohio River canalization system was designed in the 1870s to handle thirteen million tons of commerce per year. By the 1950s it strained under a commercial tonnage five times greater.[56]

The first wicket dams of the original canalization project were also the first to be replaced by the modern high-lift dams. After Emsworth in 1921, the corps replaced Dams 3 and 4 with Dashields Locks and Dam in 1929, and Dams 5 and 6 with Montgomery Locks and Dam in 1936. The Corps of Engineers' Ohio River Division initiated its official program of Ohio River Modernization in 1955. Modern dams with their standardized engineering technology proceeded down the Ohio. The final two original structures, Dams 52 and 53 near Cairo, are scheduled for replacement by 2005. The lifts of the modern Ohio dams range from twelve to thirty-seven feet and provide an increased pool elevation behind them. Thus each modern dam built on the Ohio supplanted one or more of the old dams, reducing the original fifty-three wicket dams to only nineteen high-lift dams. This dramatic reduction in lockages cut travel time on the river in half and transformed the Ohio from a local waterway to a truly interstate water expressway. The new lock chamber dimensions also facilitated speed and economy of transit. The Corps of Engineers designed each new dam with dual lock chambers. The larger chamber measured 110 feet by 1200 feet and was able to accommodate the largest Ohio River tows in a single lockage, while the former standard 110-foot by 600-foot lock became the new auxiliary chamber. The corps contemplates even further modernization. The replacement structure for Locks and Dams 52 and 53 will contain twin 1200-foot locks, and Army engineers plan to furnish second 1200-foot lock chambers to select high traffic dams such as McAlpine at Louisville.[57]

B. Monongahela River Modernization

Army engineers enacted a similar modernization project on the Monongahela River during this time. As one of the oldest slackwater projects in the United States, the Monongahela system ages a half-century ahead of the Ohio and Allegheny systems. Original Monongahela Navigation Company structures, erected during the mid-

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[56] Robinson, "History of Navigation in the Ohio River Basin," 37.

[57] Johnson, "Engineering the Ohio," 200-203; idem, *The Ohio River Division*, 364-365; Robinson, "History of Navigation in the Ohio River Basin," 37-40; see also Johnson, *The Headwaters District*, 249-253.

nineteenth century, neared or exceeded their projected fifty years of service as canalization was started on the Allegheny and completed on the Ohio. Unlike on the Ohio, slackwater on the Monongahela had been afforded by fixed dams since its canalization by the Monongahela Navigation Company in the mid-nineteenth century. Nevertheless, these low structures accommodated neither the ideal nine-foot slackwater pools nor the increasing freight. And single lock chambers with tiny fifty-six-foot by 360-foot dimensions caused frustrating and expensive delays. With few funds available until after World War II, the Corps of Engineers patched the nineteenth century system as effectively as it could by renovating some structures and relocating others. For example, in 1926 the corps eliminated Lock and Dam 9 when it relocated Locks and Dams 7 and 8, and in 1932 it reconstructed Lock and Dam 4 near Charleroi. When the engineers raised the crest of Emsworth Dams on the Ohio in 1938, the increased Pittsburgh Pool eliminated the need for the first locks and dams on both the Monongahela and the Allegheny, and the engineers removed them.[58]

With funding freed after Wold War II, the Corps of Engineers inaugurated its Monongahela River modernization project in 1948. Over the next twenty years, Army engineers installed three modern high-lift dams on the Upper Monongahela. Morgantown Lock and Dam, completed in 1950, afforded nine-foot slackwater to Morgantown and eliminated the old Locks and Dams 10 and 11. Hildebrand Lock and Dam supplanted old Locks and Dams 12 and 13 in 1960. And the corps finally extended nine-foot slackwater to the head of the river at Fairmont, West Virginia, in 1967, when Opekiska Lock and Dam displaced old Locks and Dams 14 and 15. The lock at each of the three modern dams measured eighty-four feet by 600 feet. They allowed the standard six-barge Monongahela tows to pass in one lockage, replacing antiquated structures that had required time-consuming and expensive triple lockage.[59]

The middle and lower sections of the Monongahela River, from Morgantown to Pittsburgh, received less systematic modernization. For example, in 1951 and 1953 the corps opened two enlarged lock chambers at Locks and Dam 2, the most congested traffic area of the river. One of the new lock chambers retained the old lock's measurements of

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[58] Ibid., 237-239; Leland R. Johnson and Jacques S. Minnotte, *The Headwaters District Roundtables: An Eyewitness History of the Pittsburgh District, United States Army Corps of Engineers, 1936-1988* (Pittsburgh: U. S. Army Corps of Engineers, 1989), 92-92, 183; Gannett, et al., "A History of Navigation Improvements on the Monongahela River," 16-35.

[59] Johnson, *The Headwaters District*, 239-240; Johnson and Minnotte, *The Headwaters District Roundtables*, 92, 183; Gannett, et al., "A History of Navigation Improvements on the Monongahela River," 36-39; U. S. Army Corps of Engineers, Navigation Data Center, "Lock Characteristics—Upper Ohio River and Kanawha, Monongahela, and Allegheny Rivers," <http://www.wrsc.usace.army.mil/ndc/lkuohio.htm>, November 3, 2000.

fifty-six feet by 360 feet, and the second was expanded to 110 feet by 720 feet, capable of locking a towboat and fourteen barges in a single pass. The corps left the original Dam 2, a 1905 structure, in service. In 1967 Army engineers replaced old Locks and Dams 5 and 6 with the modern high-lift Maxwell Locks and Dam, and raised the crest of Dam 4 to provide nine-foot slackwater up to the Maxwell locks. The smaller lock chambers of Dam 4 retained some of their service life, so the corps did not replace them at that time, though it reserved space in the new dam for later construction of larger lock chambers eighty-four feet wide.[60]

Intermittent congressional funding forced the Corps of Engineers to continue haphazard implementation of the Monongahela River modernization program. Since 1948 the Corps of Engineers has reduced the original fifteen Monongahela dams to nine and has extended nine-foot slackwater the entire length of the river from Pittsburgh to Fairmont. Five fully modern high-lift dams with locks are located at Maxwell, Grays Landing, Morgantown, Hildebrand, and Opekiska. Portions of the original navigation structures, sometimes paired with replaced or reconstructed locks or dams, remain at Locks and Dams 2, 3, 4, and 8, however. These structures are approaching or have exceeded their projected fifty-year service lives, and soon even the replacement structures will require a second generation of replacements to maintain slackwater navigation on the Monongahela River.[61]

C. The Status of Allegheny River Slackwater

The canalized stretch of the Allegheny River, seventy-two miles from Pittsburgh to just above East Brady, Pennsylvania, is the youngest slackwater system serving Pittsburgh. As discussed above, the Corps of Engineers emplaced its original navigation structures between 1898 and 1938. Most of these remain in service at the end of the twentieth century. In 1930 Congress considered several options to improve the pools from Pittsburgh to Lock and Dam 3. Ultimately, Army engineers replaced original Locks and Dams 2 and 3, constructed from 1898 to 1908, with new facilities. New Lock and Dam 2 opened in October 1934 less than a mile above the site of its predecessor, near Highland Park Bridge in Pittsburgh. New Lock and Dam 3 opened in 1934 as well, near

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[60] Johnson, *The Headwaters District*, 240-241; Johnson and Minnotte, *The Headwaters District Roundtables*, 92, 183; Gannett, et al., "A History of Navigation Improvements on the Monongahela River," 39-40; U. S. Army Corps of Engineers, Navigation Data Center, "Lock Characteristics—Upper Ohio River and Kanawha, Monongahela, and Allegheny Rivers," <http://www.wrsc.usace.army.mil/ndc/lkuohio.htm>, November 3, 2000.

[61] Johnson, *The Headwaters District*, 241-242; Johnson and Minnotte, *The Headwaters District Roundtables*, 92, 97, 183.

Cheswick, Pennsylvania, two miles downriver from its old location at Springdale. In 1936, using Depression relief funds, the Corps of Engineers dredged the pool behind Dam 8 to a depth of eight feet and raised the dam height an additional three feet the following year. The corps also began construction of Lock and Dam 9, immediately above East Brady. Army engineers completed the final dam in the Allegheny slackwater system in 1938, the same year they removed Lock and Dam 1 made superfluous by the raised pool behind Emsworth Dams on the Ohio. The Allegheny River carries far less commercial traffic than either the Ohio or the Monongahela. Consequently, the Corps of Engineers has not initiated any new construction for navigation improvements on the Allegheny since completion of the original slackwater system in 1938.[62] The Allegheny does not boast any high-lift navigation dams, and in this sense it cannot be considered a modernized slackwater system as the Monongahela and Ohio systems are characterized. Today the upper portion of the system supports primarily recreational craft. If lower river commercial traffic does not justify modernization on the scale of the Ohio and Monongahela systems, an opportunity may exist here to reconsider the commercial utility of the controlled navigational system.

D. Summary

Two of the three slackwater navigation systems serving Pittsburgh have undergone modernization during the twentieth century to meet expanding transportation needs. The Corps of Engineers expanded lock chamber dimensions to 110 feet by 1200 feet on the Ohio and 110 feet by 600 feet or 720 feet on the Monongahela to accommodate the deeper-draft river vessels and larger towboat-barge combinations servicing river commerce. The corps also decreased the number of dams with locks riverboat operators must negotiate. The Ohio River's original fifty-three navigable Chanoine wicket dams will be reduced to nineteen non-navigable concrete high-lift dams by 2005. The corps has converted some of the Monongahela's original fifteen dams to modern high-lift dams, and river craft now lock through only nine navigation structures on that river. The modernization of the Ohio River slackwater system is nearly complete, making it a truly interstate highway. Modernization of the Monongahela system has been more intermittent, but it, too, accommodates staggering interstate tonnages. Only the Allegheny River slackwater system, the youngest of the three, survives on most of its original navigation structures without the benefit of modernization.

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[62] Gannett, et al., "A History of Navigation Improvements on the Allegheny River," 29-40; Johnson and Minnotte, *The Headwaters District Roundtables*, 181.

Conclusion

Pittsburgh's three rivers have endured significant structural changes to enhance their navigability in the nearly three centuries since the French first explored *La Belle Rivière*. Early explorers—French, British, and American—recognized the critical importance of the water highways of the Allegheny, Monongahela, and Ohio rivers and their tributaries, as well as the strategic implications of establishing a settlement at their juncture. To effect territorial and commercial expansion, private and public interests sought to simplify navigation of these rivers and mitigate their hazards. Early efforts concentrated on channel improvements. Snag, rock, and wreck removal, plus bar and shoal remediation decreased the economic and physical risks of river travel, making it somewhat speedier and hence cheaper. Wing dams concentrated river flow into narrow chutes, deepening channels over bars and ripples and lengthening the navigation season by alleviating some of the impact of low water. Despite these slight structural additions to the rivers, they still flowed naturally. In fact, channel clearance measures were necessarily only temporary; the rivers constantly formed new bars, eroded or washed out primitive dams, added new snag hazards, and generally resisted these rudimentary efforts at human control.

The trend toward massive, deep-draft towboat-barge combinations near the end of the nineteenth century proved even the thirty-inch open channel to be inadequate to accommodate the burdens of river commerce. Modifying the successful privatized slackwater system of the Monongahela Navigation Company, the Army Corps of Engineers pursued the complete canalization of the Ohio and other rivers. The first phase of the radical Ohio River project employed wicket dams and afforded six- then nine-foot slackwater from Pittsburgh to Cairo by 1929. The technology of the collapsible wicket dam allowed natural river flow in times of high water and impounded navigation pools in times of low water. This dual nature of the canalized Ohio marked a period of transition from the unrestrained open-channel river of antebellum times to the modern fully regulated river of today. When commercial waterborne tonnage continued to grow in the twentieth century, Army engineers updated the slackwater systems on Pittsburgh's most commercial rivers, the Ohio and the Monongahela. They replaced earlier generation low-lift navigable dams with a lesser number of high-lift non-navigable dams to modernize these rivers into interstate expressways. Over the course of nearly three centuries, the Allegheny, Monongahela, and Ohio have been progressively transformed from free flowing rivers into stairstepped chains of lakes.

From first European contact, Pittsburgh's three rivers have been prized for their commercial potential. Economic activity has been the privileged use of these river commons. Employing increasingly more elaborate technology, various interests led by the Army Corps of Engineers have simplified, manipulated, and ultimately controlled the Allegheny, Monongahela, and Ohio river systems. Pittsburgh's three rivers, once unrestrained natural hydrologic systems, today function within the controlled landscape of the modern built environment.

Map Appendix

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