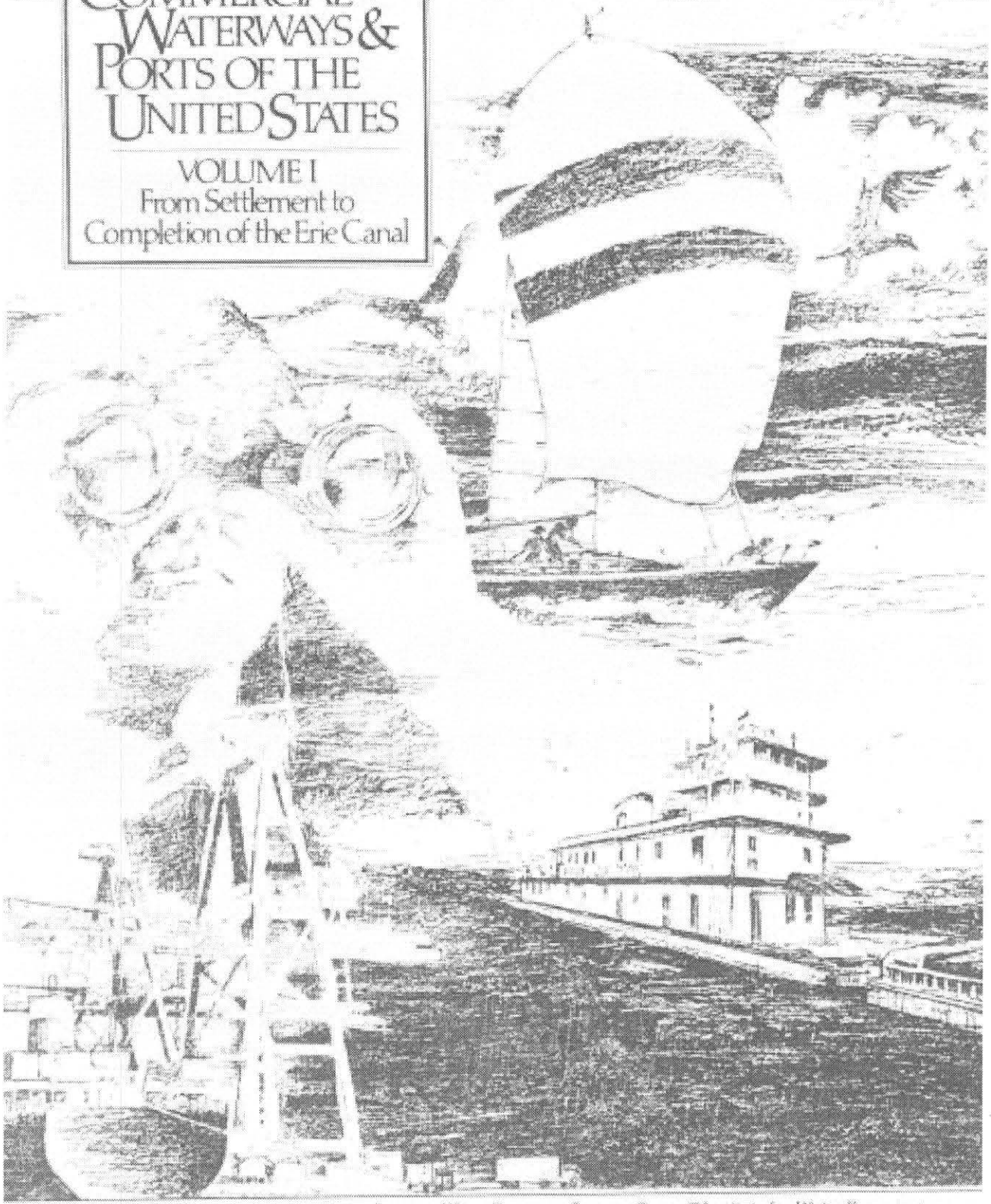
History of the Commercial Waterways & Ports of the United States

VOLUME I
From Settlement to Completion of the Erie Canal



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This staff paper is one of a series that reviews the history of waterways and ports in the U.S. in the context of transportation needs of the nation today and into the next century. The current volume, number one in the series, examines the period from settlement of the country to the completion of the Erie Canal in 1825.

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Although not a comprehensive history of waterways and ports, attention centers on important experiences in the development of water transportation. Among these are the Mount Vernon Compact, 1785; Albert Gallatin's 1808 report on roads and canals; development of private and state canal projects; construction of the Erie Canal (the greatest water resource of the 19th century) and the impacts of the role of government on our national economy and society and regional development.

In a broader sense the report deals with the field of water resources management, the role of the federal government as a government of substance and action, relationships among the states, melding of private institutions and entrepreneurship with public resources and responsibilities, the values of intermodalism, the importance of multipurpose projects, and the impact of technical change on our navigation system.

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NATIONAL WATERWAYS STUDY

Staff Papers

In the course of the National Waterways Study, the staff of the Institute for Water Resources will prepare staff papers on a wide range of subjects related to the waterways, their development and use. These papers are being made available in preliminary form for purpose of review and discussion. They are not in their preliminary form official parts of the National Waterways Study reports.

Questions or review comments on this staff report should be addressed to Mrs. Arlene L. Dietz, National Waterways Study Manager, at (202) 325-7141 or to Mr. Robert W. Harrison, Senior Economist, at (202) 325-7420, Institute for Water Resources, Water Resources Support Center, U.S. Army Corps of Engineers, Ft. Belvoir, Virginia 22060.

PREFACE

The National Waterways Study offers the opportunity for a review of the history of the waterways in the context of the transportation needs of the nation today and into the next century. Such a review serves practical purposes in that it helps identify those actions toward resources development which have been effective and those which did not produce desired results or led to unfavorable outcomes.

A comprehensive history in the classic sense of the waterways and ports of the United States is beyond the scope of the National Waterways Study. What is desired is a search for those elements of waterways experience which will help in the planning of a more effective modern system of water transport for the Nation. Thus, the center of attention will be directed to the planning processes which led to those types of public debate and cooperation productive of useful public improvements. The American experience in development of effective public works, including water transportation, has been more varied than many students realize until they take a close look at both the successes and failures in public affairs. Both the successes and the failures hold vaulable meanings for the National Waterways Study.

Most of the problems we deal with today in trying to plan an efficient waterways system have been considered in one or more earlier phases of national effort to develop a strong economy and to build the infrastructure needed to maintain it. In the approach outlined we seek a comparison among the many goals sought through resource development and the means used to realize them and a selection of those combinations of goals and means which demonstrated promise of usefulness in solving today's problems.

HISTORY OF THE COMMERCIAL WATERWAYS AND PORTS OF THE UNITED STATES

I. From Settlement to Completion of the Erie Canal

In the rotunda of the U.S. Capitol building, a series of large paintings depict events of signal importance in the history of the Nation. Among these is the Discovery of the Mississippi by DeSoto, A.D. 1541, a very handsome painting. There are few who would challenge the importance of this discovery and the great role of this waterway in the shaping of America, not only in the century of discovery, but in the whole of national history. Certainly the native Indian tribes of America made active use of the rivers, lakes and seacoasts, as evidenced by their movements and by the earthworks they left and the artifacts found to mark their earliest camps and settlements, frequently near the confluence of major rivers. The divisions of Indian tribal territory were usually bounded by reference to streams and lakes and the colonists from Europe frequently did the same. Indeed our roadways and major railroads to this day follow the trails established by the Indian. The importance to the early European explorers and settlers of sheltered harbors, estuaries and tidal rivers capable of floating their ocean sailing vessels can scarcely be overestimated. Each generation, in a sense, writes its own history in the way it uses the resources and accumulated wealth left to it. Nowhere is this more clearly demonstrated than in the use, development and management of the great rivers, lakes and coastal areas of the New World.

For over 200 years the waterways of North America served the English, Dutch, French and Spanish colonies well. Few nations have been so generously endowed with harbors, bays, estuaries and rivers usable for navigation by sailing ships. The Delaware and Hudson Rivers served the Dutch interests in America. The Hudson was particularly important as it aided in contact with the French in Canada by way of Lake Champlain. The Mohawk, a tributary of the Hudson, led toward the Great Lakes and the Ohio River, reaching its most important connection, the Mississippi River as it flows to the Gulf of Mexico.

Tidewater men of Virginia used the rivers and creeks tributary to Chesapeake Bay as highways to widely scattered plantations. Oceangoing vessels of that day could sail for considerable distances up the James, York, Rappahannock and Potomac Rivers to the wharves of plantation owners. The Virginia House of Burgesses enacted considerable legislation directing the improvement of navigation on these and other streams, but little was accomplished as the rivers provided generally satisfactory navigation to the fall line.

Improvements were limited to marking channels, placing lights at strategic points, and establishing wharves and piers at plantations and settlements. In time the need for labor to transfer cargo from ships to wagons led to settlements at the fall lines of the coastal rivers. Such settlements grew to become the cities of Petersburg on the Appomattox, Richmond on the James, Fredricksburg on the Rappahannock, and Georgetown and Alexandria on the Potomac.

The rocky New England coast was not as inviting, but here too, settlements were possible and soon Boston and Plymouth were important centers for colonial commerce. The Connecticut River served as a gateway to much of New England. This river was probably first explored about 1610 by the Dutchman, Adriaen Block, who sailed up the river as far as the rapids, at present Enfield, Connecticut. For almost 200 years thereafter, the Connecticut proved the principal transportation route in New England. During the colonial period, flatboats and canoes carrying fur from trading posts and the products of the interior were moved, on the river, between the falls and transferred over the successive falls, until Hartford, Connecticut was finally reached. There, lumber, produce and fur were placed on sailing craft bound for Boston, New York and the Indies. A shipbuilding industry of some size grew up at Middletown and Wethersfield, Connecticut. Thus, by the end of the colonial period, a substantial system of waterway transportation based on the use of rivers in their natural state had developed on the Connecticut River from Wells River Junction in Vermont to the sea.[1]

To the French was left the development of a grand strategy as the European empires sought possession and control of North America. By good luck the colonial French found themselves in a strategic position as they held the two main rivers which penetrated deepest into the heart of the continent--the St. Lawrence on the north and the Mississippi and tributaries from the south. Having entered the Gulf of St. Lawrence in 1534, they explored the Great Lakes and the Upper Mississippi. The mouth of the Mississippi was brought under French control by Bienville in 1717, when New Orleans was founded. The French explorers established a series of forts and outposts to form a remarkable but weak chain which they hoped would hold this western empire for France, but they were soon challenged.

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[1] Chorpening, C. H. "Waterway Growth in the United States, American Society of Civil Engineers," Centennial Transactions, Paper No. 2643, Vol, Ct, 1953, p. 976.

Noted earlier was the route by the Mohawk River to the Great Lakes and the valley of the Ohio. New York governors used this route to begin explorations. Virginia governors also sent out scouts to Virginia land claims in the west. The Ohio Company of Virginia was founded in 1748 as a trading corporation with plans to penetrate the Ohio as far as the falls at the present site of Louisville, Kentucky. The Ohio Company was aggressive, having many prominent backers in America and in England. Trading posts were established and the Potomac and Monongahela Rivers were used for movement of goods and supplies. This activity excited the French and also some of the colonial merchants in New York and Pennsylvania who saw the western trade falling to Virginia. They began to develop alternative routes to the west. The French resented this invasion of a dominion which they claimed as their own and sent armed forces into the upper Ohio basin in 1753. In spite of a warning carried by George Washington to the French camp on the Allegheny, they proceeded in the destruction of depots of the Ohio Company. There soon followed the French and Indian War which eventually resulted in loss of the French empire in America.

The American colonies were familiar with the many navigation improvements made on European rivers and with the canal projects which were becoming common in Europe. The canal lock was understood from ancient times. It came into common use in Greece and Italy during the last half of the 15th century. The years 1600-1680 were a time of active canal building in France. In England, canal building came later, reaching a peak in the late 18th century. But in the colonies there were few public funds for navigation improvements beyond channel markers and lights at strategic points. Yet there were men of imagination in every colony who saw the possibilities for improving and connecting the rivers and making the ports safer. In Massachusetts, Thomas Machin was such a man. He saw, for example, that the hazards of navigation around Cape Cod could be reduced by cutting a canal across that cape to provide a safer sheltered route. Many years later this was accomplished.

In the colony of New York, Cadwallader Colden, the Surveyor General, began in 1724 a survey of the rivers of New York. Colden later became the Lieutenant Governor of the colony of New York. He kept his interest in improvement of the waterways and in 1750 took the leadership in the construction of a short canal in Orange County, New York. This may have been the first canal built in the territory which became the United States. Fifty years earlier the French had dug a canal at Lachine on the St. Lawrence River in what is now Canada.

The southern colonies also had citizens who were interested in internal improvements. As soon as the French and Indian War was over, there was renewed interest in the navigation of the Potomac and James Rivers. George Washington (encouraged by his friend Elkanah Watson) and Thomas Johnson of Maryland were active promoters of navigation works. Washington, then in the Virginia House of Burgesses, worked for the passage of an act for opening the Potomac to navigation from the tidewater to Fort Cumberland, Maryland.

Independence from England did not lead to complete harmony among the former colonies, particularly on river navigation problems. Maryland and Virginia had been fussing for over 200 years over management of the Potomac. The Potomac was in Maryland, but entered the Chesapeake Bay in Virginia where the mouth of the Potomac and the lower Chesapeake had been improved by the establishment of lights and channel markers and other aids to navigation essential to safe use of the Potomac River. In 1785 representatives of Maryland and Virginia met at Mount Vernon where they discussed ways of cooperating on navigation matters. They developed a document to guide their states which became known as the "Mount Vernon Compact." Students of the early years of the Union consider this document of great importance as it contains many concepts and principles later used in the constitutional provision which guides the states in their cooperative relationship where joint resource problems arise. Following the meeting at Mount Vernon, other states expressed the need to form agreements on the development of navigable rivers. Pennsylvania had a special interest in the Chesapeake because of the Susquehanna River. Delaware was also interested. This led to the Annapolis Convention of 1786. From this there followed the Constitutional Convention of 1787. "Thus waterways and the necessity for regulating commerce were major elements leading to the development of the Constitution, and the 'Mount Vernon Compact' foreshadowed the commerce clause of the Constitution which, remains today the basic law under which waterway improvements are undertaken by the Federal Government."[2]

The compacts mentioned above proved to have a unifying force throughout the colonies. The interstate compact of 1785 under which Virginia agreed to allow Maryland shipping to pass the capes of Chesapeake Bay without payment of duties preceded by almost half a century the interpretation of the commerce clause of the Constitution by the Supreme Court in the historic case of Gibbon vs Ogden. That case established firmly the

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2 Chorpening, Op. Cit., p. 986

rights of citizens of one state to pass freely over the rivers and waterways of another, asserted the Federal control over the interstate commerce that exists today, and showed that the right of the Federal Government to control included the right to improve. The historian, A. J. Beveridge, stated that John Marshall's decision in that case "... has done more to knit the American people into an indivisible nation than any force in history except only war."[3]

From the very beginning the Federal Government was interested in the navigable waterways. The Constitution gave Congress the power "...to regulate commerce with foreign nations and among the several states and with the Indian tribes." The first congressional appropriation for waterways management was that of April 6, 1802, providing $30,000 for erecting and maintaining public piers in the Delaware River. Congressional acts of 1823 and 1824 got the Army Corps of Engineers involved for the first time in navigation improvements. The appropriation of March 3, 1823, was made in the sum of $150 for examination and surveys of the harbor of Presque Isle on Lake Erie in Pennsylvania. This was the first legislative assignment to the Corps of Engineers of a survey for navigation improvement. The Acts of 1824 were far reaching and are looked on as the true beginning of the Corps of Engineers role in developing the waterways of the nation. Under the Act of April 30, 1824, President Madison was authorized to have surveyed "...the routes of such roads and canals as he may deem of national importance in a commercial or military point of view." The Act of May 24, 1824, initiated Federal improvements for navigation on the Ohio and Mississippi Rivers, appropriating $75,000 for the effort.

It is interesting to note that the early legislation contained many provisions that are still important steps in Corps of Engineers planning: preparation of a plan of improvement, development of cost estimates for the plan selected, and appraisal of the future effects of the work. The legislation of April 30, 1824, specified that improvements sought should be of national importance.

While Federal interests in development of navigation is as old as the nation, it should not be assumed that the states were inactive. In fact, during the first 75 years of national history, the states took the initiative in the improvements of the commercial waterways. The first acts of the Congress on navigation gave approval to state projects for improving the

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[3] Ibid, p. 986.

commercial waterways by removing snags, wrecks, and other obstacles to transportation. The states also had a long list of canals which they were planning to build to improve and connect the natural system of river navigation.

They soon sought direct Federal support for canal building, but the initial reaction was that this was a task for state and local interests. Later the Federal Government did, however, respond with development of a program of land grants begun in 1827 to aid inland navigation. In several instances the Federal Government also bought stock or made loans to canal development companies.

The period of active canal development, 1780-1850, is a distinct chapter in the history of American waterways and river engineering science. The early canals were typically carried out by private companies organized for this purpose. Later the individual states assumed the responsibility for construction and management of the larger canal projects. Many distinguished citizens served as officers and stockholders of canal companies. William Penn, Governor Spottswood of Virginia, Benjamin Franklin, and George Washington, for example, all took an active interest in the development of navigation canals.

Canal building in America in the late 18th and 19th centuries attracted much attention in Europe, particularly among European engineers whose opinions were being increasingly sought. The Senate of the United States was also interested, sensing the political importance of internal improvements such as roads, canals, ferries and other aids to transportation. In 1807 a Senate resolution directed the Secretary of the Treasury, Albert Gallatin, to investigate and report upon road and canal matters, as they might effect the new nation. Gallatin's report of April 4, 1808, was designed to be a popular document and it soon became so and remained in the public eye for a generation. It contained a skillful summary of the road and canal work underway and proposed, and went on to show how independent projects could be joined and extended into a national transportation system. His plan for developing roadways connecting interior rivers with corresponding Atlantic tidewater streams was the first proposal leading toward a national system of transportation in which there was an attempt to integrate modes, a concept which is still a goal of the Federal Government.

Gallatin singled out the projects of clear national importance while acknowledging the local value of many road and canal plans which the states or private groups had drawn up. Along the Atlantic coast he recommended completing planned canals and developing new canals which would help to connect New

England with the South Atlantic states. This would facilitate trade among the states by providing a route sheltered from Atlantic storms.

For the Atlantic seaboard, Gallatin supported the development of canals inland on the Susquehanna, Potomac, James and Roanoke Rivers and on the Santee, making travel by boat beyond the fall line possible. Gallatin also recommended a canal from Muscle Shoals, connecting the Tennessee with the Tombigbee River for securing water transportation to Mobile, Alabama, on the Gulf of Mexico.

These proposals were all generally popular and they were largely carried out. Gallatin also directed attention to how best to connect the seaboard states with the interior of the country, particularly with the Ohio River Basin. He thought that two canals with parallel roadways should be built, one connecting the Hudson River with Lake Champlain and the other connecting the Mohawk River with Lake Ontario. Concepts of this type had been on the New York state agenda for a considerable time, but officials eventually found a better plan--the Hudson River - Lake Erie Canal.

Passage from the coastal states to the west under Gallatin's plan was to be further facilitated by four roads connecting the Allegheny River in the west with the Susquehanna or Juniata River in the east; the Monongahela with the Potomac, the Kanawha with the James, and the Tennessee with either the Santee or the Savannah River.

Secretary Gallatin's report, "Roads and Canals," proposed few projects that were entirely new, but it looked at the work accomplished and that proposed with a new perspective--a national point of view. The defense aspect of transportation was emphasized, particularly the need to consolidate the Federal hold on the western lands through securing the western and northern boundaries. This expression of the broader social significance of travel and commerce did much to persuade national leaders of the Federal role in transportation and in water navigation in particular. Gallatin introduced the importance of planning waterway development into his discussions of the role of the states and the Federal Government in road and canal building. Gallatin was also aware of the dual relationship of navigation policy to transportation policy as a whole and to water resources policy in its broadest context. In his report, he introduced a letter (dated December 8, 1807) from Robert Fulton, inventor of the steamboat, in which the possibilities for multiple purpose aspects of waterway development were discussed. The use of water from canals for agriculture, for municipal supplies and manufacturing was forseen. One hundred years after Gallatin's report the Inland

Waterways Commission in its report of February 1908 said, "Gallatin's work, in conjunction with that of George Washington (in the Mount Vernon Compact) may be said to have inaugurated the waterways policy of the United States."

The most tangible evidence of this policy came some years later when the Congress initiated a series of land grants from the public domain to promote state canal building projects. The first canal grant was made in March 1827 giving over 500,000 acres to the states of Indiana and Illinois. From 1827 through 1866 grants were made exceeding 4.4 million acres to the five states of the old Northwest Territory for canal building as follows:

LAND GRANTS TO STATES FOR BUILDING CANALS, 1827-1866

States	Canals	Acres Granted
Indiana	Wabash and Erie Canal	1,457,366
Ohio	Wabash and Erie Canal	266,535
	Miami and Dayton Canal	333,826
	General Canal Purposes	500,000
Illinois	Illinois River to Lake Michigan	290,915
Wisconsin	Milwaukee and Rock River	125,431
	Breakwater and Harbor Ship Canal	200,000
Michigan	St. Marys Ship Canal	750,000
	Portage Lake-Lake Superior Ship Canal	400,000
	Lac LaBelle Ship Canal	100,000
Total		4,424,073

In addition to land grants, the Federal Government also subscribed to or purchased stock in private companies engaged in canal building. The Congress also authorized loans to several canal companies. The canal companies involved in sale of stock or in borrowing funds from the Federal Government from 1825-1866 were: the Chesapeake and Delaware Canal, $450,000; Louisville and Portland Canal, $235,000; Dismal Swamp Canal, $200,000 and the Chesapeake and Ohio Canal, $400,000.

While land grants and financial support were offered to assist in canal building, the Federal Government was reluctant to become directly involved in major canal development. Private companies and later the states dominated canal work until after

the Civil War. While canal developments were sweeping the country, the U.S. Government was employed, usually through the Corps of Engineers, in improvements to the major coastal ports and harbors and to the great Mississippi River and tributaries where the steamboat was rapidly making river navigation a major factor in passenger and freight movement.

Early Private and State Canal Projects - 1780-1850

There is no sharp beginning and end to the period of canal construction for navigation in the U.S. Many small canals were started before 1780 and several major canals were finished a year or two after 1850. In 1808 there were 115 miles of canals in use. By 1850, there were over 4,200 miles of navigation canals. The peak in canal planning and construction came after the completion of New York State's Erie Canal in 1825, connecting the Hudson River with Lake Erie and giving New York City merchants the best route to the markets of the west, and western farmers the best markets in the nation and abroad for their grain and other produce. The engineering and economic success of the Erie Canal was one of the great triumphs of the 19th century. It fired the imagination of a whole generation. Water transportation was now seen as the one sure way to develop two-way trade with the west. The intensive use and the high earnings of the Erie Canal even before it was completed, sparked a national canal building mania.

Europeans in the very early years of American canal building saw the potential that this mode of transport offered for North America, not only for the movement of manufactured goods and farm and forest commodities, but for the movement of settlers to the western lands. America's wealth then was largely in land and the way to secure and multiply this wealth was to settle the land. Their interest also stemmed from the fact that American canal builders frequently sought their advice. America learned greatly from the experience of early 19th century canal building in England. Today American engineers, economists and planners are again interested in the rapid redevelopment of European waterways now taking place in England and Germany, particularly, and to a lesser degree in France. The development of the Common Market seems to have stimulated a second look at the usefulness of waterways in modern technological economies. Likewise there are many lessons to be learned from the American experience in canal construction and management. Most of the problems water resource planners face today, the canal planning builders faced in one form or another in the early 19th century. Often their solutions represented genuine breakthroughs in science and social management.

In this age of rapid transportation and high energy consumption, it is difficult to imagine the importance which even small improvements in transportation made in the life and economy of early America. The canal represented a great leap forward in efficiency over road haulage. Consider that a team of four horses on a typical road in 1800 could haul one ton 12 miles a day. If the road was improved to the "turnpike" standard, one and a half tons might be transported with the same team in the same time. Few roads were of "turnpike" standards, however. On the canal with a towpath, one horse could easily draw a 30-ton barge at a steady rate of two miles per hour. With the canal, most of the lift needed to move "uphill" was provided hydraulically. The savings in transportation costs were, of course, tremendous when canals could be utilized. For passenger traffic canals were safe and compared with other modes available they were at least equally fast. In many respects they provided a comfortable way to travel. Travelers on American canals left many interesting reports. Many found the canals a beautiful and even exciting way to travel. If declining petroleum supplies suggest an energy constrained future, the waterways could become a more diversified carrier than they are now.

The desire for canals was felt greatest by those who had attempted to navigate interior streams in a natural condition. The broad estuaries of the coastal rivers and bays, such as the large Chesapeake Bay, posed few problems, but above tidewaters, the rivers became very difficult to navigate. During floods it might be possible to pass over the rapids, but the currents were strong and treacherous and many loads were lost. During low water, the channel was often found full of snags and sharp rocks. Nevertheless, the downriver passage of rafts and floats on the larger streams were often successful. It was common to sell the larger rafts and flatboats at the end of the journey for building material as there was no reasonable way to make a return trip upstream by flatboat or raft. Such boats ordinarily carried 40 to 50 tons, but a few attempts to market the produce of whole communities quite often ended in disaster as large rafts were difficult to maneuver and could easily run aground. Keelboats, capable of carrying 15 to 50 tons, were soon designed for river traffic. The shaped ends made steering easier resulting in a safer boat during storms, and generally preventing groundings. Downstream commerce continued to exceed upstream movement, but the keelboat could be pulled upstream, a laborious hand operation. When the river was swift, ropes were often fixed to the bank and the boat pulled upstream hand over hand. Occasionally towpaths were built along the more difficult reaches. On these, men were found pulling boats almost as often as horses or mules. All who experienced travel by river through flood or drought longed for the quiet, certainty and safety of a

slackwater canal. The canal offered a controlled and generally predictable environment with its gentle slopes, towpaths and picturesque locks to do the lifting.

The development of the steamboat offered the prospect that the interior rivers might become navigable in both directions and that large loads might be carried. The period of canal building was well underway before the effectiveness of the steamboat was demonstrated. The concept of a steam railroad was also in its infancy. Throughout the canal building era, the possibility that the canal would be made obsolete by the railroad was feared. Various steps were taken to forestall railroad completion, often without success. The development of the steampowered boat on the rivers and lakes aided the major canals. Steamboat passengers and shippers of freight were able to continue their movement by water, otherwise impossible but for the artificial canals connecting the navigable rivers.

The technological revolution in transportation brought on by steam power on water and land did not, at first, have the influence on canal development plans and projects that the economic revolution of the late 18th and early 19th centuries had. The European wars greatly stimulated American trade. In 1791 the American export trade was estimated at 19 million dollars; in 1794 at 33 million; and in 1907 at 108 million. As the vessels of the warring nations were needed elsewhere, American shipping began to carry a much larger proportion of the American trade. In 1789, about 50 percent of the vessels engaged in American trade were of foreign registry. In 1796, only 6 percent were foreign ships. The market prices of many farm products rose rapidly, many doubling in a few years. Exports of cotton, for example, rose from 138,000 pounds in 1792 to 60 million pounds in 1807. There was a great demand for grain in Europe, but it was difficult to get grain over the mountains to New York and Baltimore and that which could be moved to New Orleans found that market in foreign hands. Thus, economic conditions set the stage for water transport plans of all types, but particularly canal plans as these were judged to be the most reliable. They were tested and ready to be put in operation. The New York merchant and the settler on the frontier both saw their fortunes and fate tied up in the quest for better waterways. The ruling classes on the seaboard held millions of acres in western land grants. George Washington, for example, had 20,000 acres in grants on the Kanawha and Ohio Rivers. Canals would make these lands more valuable, easier to sell or to use. The soldier and the small farmer also wanted canals built so they could go west to start farming on new land. With water transportation they could more easily take their families and their household goods and farming tools. The canal development era started during a period of great optimism. The growing economy had enabled the new states to

build up for the first time modest surpluses in their treasuries. The state officials and administrators wanted to exercise their authority to develop public projects. Canal projects filled the bill. Tolls could be charged for use of canals and thus return to the states and to the private supporters their investment. This could be used to set in motion further internal improvements. The future looked bright.

Connected to the economic considerations was the great question of the political integrity of the nation. This is what worried Washington and Jefferson and many other public-sprited men. There was no time to waste in providing the transportation facilities which would end the isolation of the west.

In summarizing, by 1808 the following canals were completed: Appomattox, Virginia; Baldwinville, New York; Cape Fear, North Carolina; Carondelet, Louisiana; Conewago, Pennsylvania; Dismal Swamp, Virginia; James River, Virginia; Middlesex, Massachusetts; Mohawk and Ontario, New York; Montaque Falls, Massachusetts; Potomac, D.C. and Maryland; Pawtucket Falls, Massachusetts; Santee and Cooper, South Carolina; Schuylkill and Susquehanna, Pennsylvania; South Hadley Falls, Massachusetts; and Susquehanna, Pennsylvania.

Waugh has pointed out that there are many technical problems in developing workable, manmade, artificial waterways. The canal building era proved to be a varitable school for practical engineering. Many devices were used to carry canals over difficult terrain and across major streams. Waugh says "...ingenious and monumental engineering works were devised. Remarkable feats were accomplished with locks, inclined planes, portage railways, aqueducts, and tunnels."[4]

The Middlesex Canal extending from near Boston Harbor (Charlestown's millpond) to Chelmsfork on the Merrimack River was the longest canal, (27 miles, with 22 locks) built before the New York Erie Canal. The Dismal Swamp Canal was the next longest (22 miles) originally built with four locks. The locks were large for the time, 100 feet long by 18 feet wide. During the construction of the Erie Canal frequent reference was made to the experience on these two canal projects.

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[4] Waugh, Jr., Richard G., "Canal Development in Early America," Board of Engineers for Rivers and Harbors, U.S. Army Corps of Engineers, Fort Belvoir, Virginia, p. 23, not dated.

Fig. 1. - The Canals of Early America (1786-1851).

LEGEND

1 Cumberland & Oxford	12 Chemung	25 Santee & Cooper
2 Middlesex	13 Genesee Valley	26 Carondelet
3 Blackstone	14 Morris	27 Ohio & Penn.
4 New Haven & Northhampton	15 Delaware & Raritan	28 Sandy & Beaver
5 Delaware & Hudson	16 Delaware Division	29 Muskingum
6 Champlain	17 Lehigh Navigation	30 Ohio & Erie
7 Erie	18 Schuylkill Navigation	31 Hocking
8 Black River	19 Susquehanna & Tidewater	32 Miami & Erie
9 Oswego	20 Penn. State Canal	33 Whitewater
10 Cayuga-Seneca	21 Chesapeake & Delaware	34 Wabash & Erie
11 Chenango	22 Chesapeake & Ohio	35 Louisville & Portland
	23 James River & Kanawha	36 Illinois & Michigan
	24 Dismal Swamp	

Source: Waugh, Jr., Richard G., "Canal Development in Early America," Board of Engineers for Rivers and Harbors, Fort Belvoir, Virginia 22060.

The Erie Canal

The old Erie Canal has been called "...the first major water project in the United States...."[5] Measured in terms of water moved, it was the greatest water resource project of the 19th century. Many also considered it the best planned. Its planners and builders certainly utilized all the experience and inventive talent available and once construction was completed, the managers were able through skillful operation and administration, to overcome those defects of design which became apparent. The Erie was often called the Grand Western Canal or just the Grand Canal, particularly by New Yorkers.

The Erie Canal was started by the New York State government in 1817 and officially completed in 1825. It took two more years to get the project in full operation. It joined the Hudson River with Lake Erie by a single canal, a bold stroke which Gallatin had not foreseen. The canal had a length of 363 miles, was 40 feet wide at the water surface, tapering to 28 feet at the bottom of the canal. It had a depth of 4 feet of water. There were 81 lift locks each 90 feet long and 15 feet wide. It could handle barges up to 78 feet long and 14 feet wide, with 3 feet 6 inches depth, but the first barges were 70 feet long and 7 feet wide with a 30-ton capacity. Such a barge could carry 1,000 bushels of grain. This was the typical size of barges on most English canals. From Tidewater on the Hudson River above Albany, the canal entered Lake Erie at Buffalo, New York at an elevation of 572 feet. Construction cost was $12,720,032.25, including the feeder canals, considerably above the cost as estimated during the planning period. The canal was opened as each unit was completed. The first part opened was the 15-mile section between Utica and Rome, New York, on October 23, 1819. To mark the event there was a great celebration. A boatload of officials left Rome for Utica as spectators lined the canal, accompanied by ringing bells and the roar of cannons. A letter of the times described the event as "sublime."[6] There were many such celebrations as completed parts were opened. In 1825 there was a truly grand celebration the length of the canal, marking the completion of the Erie Canal Project. The whole of New York seemed to have taken part, so great was the excitement when a flotilla of western coal barges finally arrived in New York City, although the city had not supported the canal project.

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5 Langbein, W. B., Hydrology and Environmental Aspects of Erie Canal (1817-99), Geological Survey Water-Supply Paper 2038, U.S. Government Printing Office, Washington, D.C., 1976, p. 1.

6 Drago, Harry Sinclair, Canal Days in America, New York, 1972.

The canal was subjected to heavy use from the day it opened. In the first year after completion, the revenues of the Erie Canal began to exceed the expenses of maintenance. By 1838, the net receipts had paid the interest on the construction debt and reduced the amount of the debt by three and one-half million dollars. Enlargement of the canal was put underway in 1836.

There are many aspects of the planning of the Erie Canal which deserve study, not only for their historical values, but because they hold lessons for current water resource development. Problems of hydrology, environment, operations and maintenance, and such economic questions as user charges came up early in the Erie Canal deliberations.

One of the earliest decisions was to build a canal independent of the local streams, as opposed to one where the natural channels of rivers were cleaned and improved. Experience on the Mohawk River where the Western Lock Navigation Company, chartered in 1792, had built a canal near Rome, demonstrated the difficulty of making "canals" out of river courses with all of the uncertainties commmon to a natural stream. Many parts of the canals of the colonial period were merely streams that were cleaned of obstructions and deepened. This appeared to be the cheapest way to do the job, but maintenance was difficult as the frequent high water damaged or destroyed the improvements.

A second decision made early in New York State deliberations on canal management was to favor public as opposed to private construction, operation and maintenance of the canal. This was a dramatic reversal of earlier practice and it did not come easy. The Federal Government was, however, asked to support the Erie Project but President Jefferson declined. He thought the idea was good but ahead of its time by a century. The decision in favor of State operation stemmed in a large part from public reluctance to see such a large and important project put in private hands. While the ownership and control of the canals rested on the public, the barges were privately owned by companies or individuals and operated under state rules. Another important policy question focused on the best route for the canal. A passage to Lake Ontario was rejected as it was feared the potential traffic here might be attracted to Montreal. The economic, as well as the physical size of the canal was also debated at length. In the usual balancing act between cost and benefits, a middle position was taken as the safest in light of the many unknowns. The slope of the canal was also studied in some detail as there was the possibility that a graded canal (built as an inclined plane from Lake Erie to the Hudson River) would make possible a source of Lake Erie water for a large part of New York State. But at the time there

was not sufficient knowledge of hydrology to carry out this plan with confidence. A lock canal, therefore, was chosen following the terrain rather closely. There was, however, in the plan sufficient water for mechanical power and it was utilized to run machinery in many factories which located along the canal route. An early question was whether to build a canal for ships or solely for barge operation. Finally it was decided that the length of the canal was such that the expense of providing a deep ship channel was greater than the advantage of not having to unload ships into barges at the lakes and on the Hudson River. This question continued to arise during canal enlargements until modern times.

The occasion of a major flood in the Mohawk Valley in 1817 resulted in several alterations in the planned route of the Erie Canal and provided a warning of the great damage floods could be to successful canal development. The potential impact of the canal on the environment of the region it served was given serious thought during the planning period. The environmental issues centered on the question of whether land clearing and other land developments along the canal might adversely affect the hydrology of the region leaving the canal without adequate water during the summer and making flood and drought more extreme. On this point, Langbein observes:

> The anxieties over the adverse effects of deforestation expressed by the Commissioners of 1811 were frequently restated by the others who followed. Indeed, one of the reasons given for setting aside the Adirondack Forest Preserve in the 1880's was to maintain a steady flow of water to the Erie Canal. By that time contrary opinion had emerged as stated, for example by the State Engineer. 'An idea seems to have found lodgement in the public mind, that the preservation of the forest in the Adriondack Region, is the only means by which an adequate supply of water for the state canals...can be secured for all time.' Although preservation would be justified for game, health, and recreation, the benefits would not include water supply which could be obtained from impoundments by dams. 'The facts show most conclusively that from fourty to fifty years ago when the forest of the Adriondack Region were in their primitive state, they were much less reliable as a source of water supply, than they have been during the past few years.'[7]

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[7] Langbein, W. B., Op. Cit., p. 50.

There was one important question which the seven Land Commissioners of 1811, headed by Gouverneur Morris and the Commissioners of 1816 under DeWitt Clinton, chose to put aside for the future. That was whether a canal of the type they proposed might not be soon made obsolete by the development of a steam railway. On this matter Langbein says,

> Less in the public view but, as things turned out of greater importance was an argument of a technological nature. The now classic arguments between the merits of inland seasonal navigation and those of railroads began even before rail lines existed. The controversy emerged with a published letter from John Stevens (1812), the Hoboken inventor, to Gouverneur Morris, Chairman of the Commissioners of 1811, advising that a relatively small research investment in a steam railroad would forstall the early obsolescence of the canal. Stevens explained the principles involved--for example, that the square law of resistence does not apply to motion on rails as it does to motion through water, and that a rail line is more flexible in location of route and is usable all year. The proposal was not taken seriously because canals, towpaths, and horses were known from long British experience to be a proven technology, whereas rails were still only an untested concept. Anticipation of technological change to this time is not a part of water planning in the United States (White, 1969).
>
> The clear and present advantage of building a canal seemed to be greater than the political, and technologic uncertainties of the future, so the project moved toward approval. The Commissioners of 1816 appointed to design a canal, needed only to address those engineering matters that were necessary to give physical bounds to their proposal--to adapt the project to the terrain. Thus they proceeded to resolve such fundamentals of water engineering as choosing between an Ontario Canal or an Erie Canal and between a ship or a barge channel, selecting the profile and the route location; and finally, the cross section--deciding on the width and depth of the canal.[8]

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[8] Op. Cit., Ibid, p. 10.

Looking back it seems clear that the New York Canal Commissioners could have had little comprehension of the significance of the inventions on which Fitch, Evans, Stevens and Fulton worked from 1785 to 1815. Even if the potentials for the steam railway and steamship had been understood, it is questionable if the social momentum in the canal concept could have been easily checked.

The political history of the Erie is almost as interesting as the dramatic engineering accomplishments. The idea for connecting the Hudson River with one of the Great Lakes--Erie or Ontario--came early. Sir Henry Moore, Royal Governor of New York, may have expressed the idea as early as 1768. The concept was promoted by Gouverneur Morris, Elkanah Watson, and Jessie Hawley before 1790. When the idea was finally put into action in 1810, DeWitt Clinton then mayor of New York--later Governor--was appointed to the Board of Commissioners studying the need for a canal. He became the leading supporter of the Erie throughout the construction of the canal. He was opposed in many of his efforts by Martin Van Buren; thus the building of the Erie Canal, as with so many later water projects, became a political contest filled at times with rancor and animosities.

The engineering profession was almost as publicized by the Erie Canal project as the political figures. Benjamin Wright, Chief Engineer, and James Geddes (a lawyer and self-educated engineer), were the leaders, along with Nathan S. Roberts. John Sullivan, John Jervis, Fredrick Mills, and Canvass White were young men of talent who became well known through their experience on the Erie Canal Project. The men trained on the Erie went on to build many of the major canals of Pennsylvania, New Jersey, Delaware, Ohio, Indiana and Illinois.

To get the project started, employment and purchasing offices were opened in Albany and New York. The excavation work was contracted usually in 10-mile segments. The state built all of the locks, bridges and aqueducts with directly hired labor. The prime contractors for excavation had many subcontractors. The Irish immigrants to New York furnished most of the labor for digging the Erie. In Canal Days in America, Harry Sinclair Drago says:

> We never tire of hearing how the Irish bogtrotters built the Erie. Certainly a great number of them--perhaps more than three thousand--put their sweat, blood and muscle into it. As they fought their way through the mosquito-and malaria-infested Montezuma marshes west of Syracuse, toiling in waist-deep muck and water, wearing only a shirt and slouch cap to shield them from the relentless sun, they write a page of human endeavor that has seldom been

> equaled. And for this they were rewarded with the princely wage of $8 a month--or to be more exact, for twenty eight rainless days of work--and the privelege of sleeping on the floor of a $15-shack along with a dozen others of their kind, their food of the cheapest and coarsest the contractor could provide. As a bonus a tot of whiskey was doled out to them every two hours--to keep them going.[9]

In order to show progess as early as possible, work was started on the two long level parts of the canal, those parts not requiring locks. The longest from Frankfort to Syracuse was 69 and one-half miles and the other extending from Rochester west for 62 miles. Excavation work on these moved fast, but there were many difficult problems to solve. The right-of-way had to be cleared. Stone had to be assembled for the locks and aqueducts. Deep cuts through rock had to be planned. Fortunately the many local farmers who came to the project looking for work brought with them a natural inventiveness which was also put to work. A long list of ingenious tools and implements were developed, some of which were used in field, forest, and construction for the next 100 years. The need for a hydraulic cement for use in making the stone locks and aqueducts was solved when Canvass White located with local help a deposit of trass, the volcanic pumice used to make cement resistant to water. Use of the Dupont Blasting Powder proved hazardous. The Irish were regarded as the best "blowers" on the canal but they were careless and there were many accidents with loss of life.

From Rome the canal went directly westward, crossing rather than paralleling the natural streams. Several of the crossings were major engineering projects. Drago says:

> Canal historians have described the beautiful Genesee River Aqueduct with its eleven Roman arches (originally only nine), but have had very little to say about the longer but somewhat less eloquent aqueduct at Cohoes. It was built on stone piers that carried canal traffic across the Mohawk River, twenty-five feet above the river's high-water level. Of the three Erie aqueducts, it was the longest; 1,188 feet; the Genesee measured 802 feet and the Little Falls Aqueduct 744 feet.[10]

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[9] Drago, Op. Cit., p. 173.

[10] Drago, Op. Cit., p. 173.

The crossing at Schoharie Creek also caused much worry until it was decided to build a dam to partly contain this stream.

The marvel of the canal was found at Lockport, where Engineer Nathan S. Roberts lifted the canal for 60 feet so that it could pass over the Niagara escarpment. This was done by building two tiers of five lock chambers each, one to take west moving boats up and the other to bring east moving boats down. In the locks the upper gates of the lower chamber acted as the lower gate of the chamber next above. Thus the name "Combines" originated. The double tier of combined locks saved time and water. The approach to these locks involved a deep rock cut which added to the public interest in this part of the canal. The approach to the Hudson from Schenectady was also interesting engineering-wise, as it took 27 locks in a distance of about 15 miles. To avoid these, passenger traffic on the Erie often started at Schenectady, making the trip from Albany by roadway coach rather than take the time to go through the locks.

Two additional features of the Erie need to be mentioned, the feeder canals that supplied water to the main canal from local streams and the many bridges that were built to accommodate local movements of people and livestock. There were hundreds of bridges; for the sake of economy, they were built low. A man standing on the deck of a canal boat had to duck or run the risk of being knocked down. The development of the feeder canals to keep the Erie supplied with water was a major undertaking. As it turned out the canal was short of water throughout most of its life due to seepage being greater than was estimated.

Like the building, the operation of the Erie Canal was a major task. Over 2,000 people were employed in regular operations--engineers, inspectors, toll collectors--and other tasks. The problems to be solved were legion, as the canal was working near capacity from the beginning. There were many delays in barge movements as repairs were made, washouts of culverts fixed, and many traffic jams straightened out. A surprising volume of passenger traffic developed and the demand for speed was great. Soon after the canal was opened, the Commissioners set the legal speed limit for barges at 4 miles per hour, having noticed that a speed of 5 miles per hour produced wavewash which eroded the newly dug banks. Up to 1824 the canal was navigated only in daylight hours. After this, the demands of boat operators forced the Commissioners to agree to day and night barge movements. Drago says:

> On the Erie, three types of boats were in operation: the fast, exclusively passenger-carrying packets; the long-haul freighters; and the

> small, individually owned short-haul freight boats that made a business of picking up and delivering mixed cargos whatever their destination. The fast traveling "line" boats, with their relay stations where fresh horses and crews were always waiting, and which were to lord it over the Erie eventually, had not yet appeared.
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> In their demand for greater speed on the canal, the boat lines, of which there were many, forced the Commissioners to keep the locks open day and night. Their fast-moving boats damaged the berm and towpath so frequently that a limit of one hundred miles a day was set. They ignored it, and when hauled into court, paid their fines and continued to defy the regulations. Perhaps the greatest offender was the Six-Day Line-six days from New York City to Buffalo. It was death on horses, but oftener than not the boats got through on schedule.[11]

Rapidly growing traffic resulted in a number of enlargements of the Erie from 1832 to 1865. The original location and levels were generally maintained with width and depth enlargements to make possible movement of barges up to 240 tons. Freight tonnage reached a peak in the 1880's. Early in the 20th century a further enlargement was made using the canalized Mohawk River. Known as the New York State Barge Canal, this system operates with motorized barges, capable of moving a thousand tons. It bears little resemblence to the old Erie, except as Langbein observes: "The old and the new have chiefly in common that they carry about the same tonnage." The success of the Erie led to a demand by communities across the state that lateral canals be built to serve them. The Lake Champlain connection was made more or less simultaneously and work was soon begun on additions to the system.

The New York State engineers report of 1853 describes this system as follows:

> The main canal of this system is the Erie Canal, occupying the valley of the Mohawk River and the southern slopes of Lake Ontario, running east and west nearly through the center of the State, and connecting the chain of western lakes with the navigable waters of the Hudson.

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[11] Drago, Ibid, p. 192.

The Chenango canal, occupying the valley of the river of that name, running from the southern border of the State, northward, connects the waters of the Susquehanna with the Erie Canal near the middle of the State.

The Black River canal (nearly completed) extends from the navigable waters of that river, and connects with the Erie canal, near the outlet of the Chenango.

The Oswego canal connects the most easterly harbor in the chain of great lakes with the Erie Canal at the center of the State, and forms the shortest line between the most easterly of these lakes and the tide-water.

The Cayuga and Seneca canals connects the Erie with the lakes of those names, and by means of the Chemung canal, extends the navigation of the Susquehanna.

The Crooked Lake canal completes the navigation between the lake of that name and the Seneca.

The Genesee Valley canal, (nearly completed) occupying the valley of that river, running south nearly to the southern border of the State, connects the Allegany river with the Erie canal about one hundred miles east of Lake Erie.

The Champlain canal constitutes an independent route, extending the navigation of the Hudson River to Lake Champlain, and thence by the improvement of its outlet to the Saint Lawrence, in the province of Canada.

Today the Erie, Oswago, Cayuga-Senecca and Champlain canals are now operated as the New York State Barge Canal System.

Engineers and economists are interested in learning some of the technical problems which the Erie Canal brought to wider attention. The canal has recently been studied by W. B. Langbein; his report, "Hydrology and Environmental Aspects of Erie Canal, 1817-1899," Geological Survey Water-Supply Paper 2038, U.S. Government Printing Office, Washington, D.C., 1976, outlines most of the major problems which engineers and economists dealt with during planning and construction of the old Erie Canal.

Water supply to make up for seepage proved to be the greatest problem of the old Erie, as noted earlier. Water for locks was a minor problem. The methods used in estimating the supply to be expected from feeder streams during dry weather were inadequate. Similiarly, floods from small streams crossing the canal often exceeded expectations and washed out culverts causing many delays and much damage. There were also hydraulic problems as the cross section of the canal was too small to move the large volume of water required to keep the canal supplied between the feeder streams. This condition was aggravated when the canal was crowded with barges. Throughout the whole history of the old Erie there was difficulty keeping the water levels adequate. The strong fears expressed in the planning phase for the local environment did not materialize. The canal was never seriously polluted. It contained fish which were regularly eaten. The land along the canal and inland was cleared to a considerable degree, but no water shortage could be traced to this work. Langbein concludes:

> The overriding fact that the initial anxieties of the planners proved unwarranted and that environmental conditions did not become intolerable by the standards of that time probably led to neglect of consideration of environmental risks in subsequent public works practice during the 19th century.[12]

This is probably true and it is certainly interesting to note that canal building programs following rapidly on the Erie expressed few environmental concerns. In fact, the word "environment" was scarcely mentioned for the rest of the 19th century where canal building was concerned.

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12 Langbein, Op. Cit., p. 2.

SUMMARY NOTES

This and other staff papers which will follow are preliminary and clearly not the basis for a set of conclusions. As the National Waterways Study proceeds and progress is made on the history of the waterways, there will be an opportunity to assess the waterway in the broad context of national transportation development and in terms of national objectives for the water resource. Now is the time for note taking and observations put down tentatively, recognizing that there will be a need to rethink as the work proceeds. With these qualifications, the following generalizations are made.

1. The improvement of navigable rivers and the building of canals were the first large scale engineering efforts in the field of water resources by the American colonies. In carrying out these works, numerous institutions, social approaches, and procedures--ways of doing things--were developed. Many of these have had a lasting impact on our national economy and society and on the development of the regions. It was on the question of internal improvements that the role of the Federal Government as a government of substance and action, compared with a government primarily of philosophy and policy, was thrashed out. Likewise the relations between the state governments and the Federal Government were first defined in terms of water resources development and management. The relationships among the states as they related to commonly held resources also found early definition in water resource arrangement such as the "Mount Vernon Compact."

In the same manner the role of private enterprise in developing public projects found a sharpened definition in working on the complex task of building a water transportation system for the nation. The complexities of melding private and public efforts is, of course, still with us and plays an important part in decisions affecting the present efforts toward improving the inland waterways and ports. But the system of private enterprise we enjoy today was shaped to a very great degree by the problems and issues faced in dealing with "public" resources such as the navigable waters of the nation. A long list of creative enterprises and projects now flow from the ability to combine private institutions and entrepreneurship with public resources and responsibilities. To use an early example: when the State of New York in deciding to build the Erie Canal as a State project also provided that the barges moving on the canal be owned and operated by individuals and companies, they set in motion a pattern which has had a profound impact not only on the future development of water transportation, but for a long list of public and private programs covering the full spectrum of American enterprise.

It is evident that in the adjudication of public and private interests pertaining to the water resource, the American colonies at an early date developed not only an engineering expertise, but launched a social experiment.

2. Turning to some of the principles that have gradually evolved in transportation planning, we find that some of these have roots in the early development of waterways and canals. The importance of increased integration in the transport system, the values of intermodalism and the essential character of the multiple purpose concept in both transportation and water resources planning are now widely recognized. Even the most casual review of waterways history will demonstrate that these concepts are as old as the national effort to provide for an effective transport system. In water transportation we find many early examples of how these planning objectives may be satisfied. The values, for example, of integration of systems including intramodel cooperation were not lost on Albert Gallatin. His report of 1808, "Roads and Canals," to the Senate contained, as Richard Waugh has written: "...the first proposal for a national system of integrated transportation." His plan for linking the navigable rivers of trans-Appalachia with coastal streams by means of turnpikes was a recognition that intermodal planning is an important element in meeting transportation needs. During the canal building period there were numerous examples of rail and canal "integration of objective" which made for more effective transportation. Passengers for Pittsburgh on the Pennsylvania Main Line Canal often left Philadelphia by coach (later by rail) to board canal packet boats at Columbia, Pennsylvania. These examples may seem amusing, but this type of enterprise gradually expanded and finally became one of the best transportation systems in any nation.

The multipurpose project also has a long history in water transportation. The Erie Canal furnished water for power to many New York industries along the canal. The recreational value of the canal was also utilized from the beginning.

3. Regional development, driven by the need for a rough comparability of opportunity among regions, has been linked with the transportation objective since colonial times. The regional objective has been associated with waterways projects in every part of the nation. The waterways moved the early Armies on their way to western posts. Settlers on the public lands of the south and west often used rivers and canals to move their families and their homestead goods.

When the steamboat made two-way water travel practical, the products of the nation's farms and factories began to reach the seaport markets in volume. Each generation has had its own

definition and requirements for regional growth and development. The flexibility of the water resources project, including the transportation project, in meeting regional development needs has been remarkable. A review of waterways history adds perspective to the variety of regional objectives the water resources development project has satisfied. But we must remember that over time regional goals change and that the navigation project today may not have the regional significance of earlier efforts to develop transportation.

4. Looking over the long history of public projects for water transportation cannot help but strengthen the general perception of the importance of careful planning and consistent management, particularly of the maintenance component. The Erie Canal was well planned. It was timely. It was kept up to date. It responded to multiple needs. Many projects did not have these characteristics. Maintenance management when of high quality can often find ways to correct the defects of faulty design. This lesson has been demonstrated scores of times in the planning process for the national waterways. It is thus strange that provision for maintenance, replacement and management are frequently left out of the planning process for water resources.

5. In studying the internal improvement projects of the 18th and 19th centuries in America, the importance of obsolescence quickly becomes apparent. Yet even today the water resources planner seldom anticipates the rate of technological change and its effect on resource use and management. How different our transportation history would have been if there had been a realistic approach to the use of railroads and canals as elements in a planned system, rather than a rush to steam powered railways with abrupt and wholesale abandonment of waterways, largely at State and Federal Government expense. Today we face somewhat the same problem in deciding on the role of slurry pipelines and how to combine this expanding technology with the waterway mode and with the more general water resource problems.

6. In the long history of the inland waterways, questions of environment have assumed a very uneven role. During the early 1800's there was great interest in how the Erie Canal would impact on the natural environment of New York State. It was feared that the lands along the canal would be deforested due to development and that this would lead to a reduced water supply for the canal. The fear did not materialize and the questions of environment were, for a time, forgotten. Later the Great Lakes became the center of environmental concerns and the work at Niagara Falls served to stimulate the discussions. But the uneven attention paid to environmental matters has served to

weaken the disciplines involved and has led planners to a mixed mind as to how to adequately deal with the genuine problems navigation efforts may hold for the environment.

7. Today the application of cost-sharing principles and user charges to the waterways is a major issue. The long history of tolls on American canals is, to say the least, instructive.

8. From the very beginning it has proved difficult to predict the use to which waterways may be put. Many of the early canals were justified on the basis of freight traffic, but in practice, passenger traffic became almost as important and in some instances more important. The movement of settlers west was certainly a vital function of the Erie and the Pennsylvania Main Line Canal. Today there are similar difficulties in making navigation projections. For example, ex-post studies of the McClellan-Kerr Navigation Project for the Arkansas River Basin demonstrate that the projections of use made at the time of planning are quite different from the waterway movements actually experienced.

9. The national system of transportation we know today serves many needs but it is far from completed in any ideal sense. The development of the natural waterways has proceeded slowly, driven to a considerable degree by regional needs and the desire to stimulate lagging economic sectors. Within the broad context of waterway development, the canal building period held a special place. Seymour Dunbar in his A History of Travel in America, New York, 1937, writes:

> ...The short period of canal construction which appeared in this country between 1817 and 1845 was largely the outgrowth of unusual circumstances, was begun and ended by conditions peculiar to the country and period, and can best be described as a sudden, sporadic, forced and exotic phenomenon instead of the slow and natural outgrowth of broad necessity. It is improbable that canals would have gained headway at all had there been even a dim general realization of the significance contained in the work performed with steam by Fitch, Evans, Stevens, Fulton, and others from 1785 until about 1815. And, once a really valuable though premature canal system was in working order--as was the case by the fourth decade after 1800--it would not have been allowed to disintegrate in large part had there been a general or governmental appreciation of the future needs of the country, coupled with a popular sense of business morality sufficiently strong to resist those blandishments which finally

> resulted in the crippling or outright abandonment of important, costly and useful public improvements. (p 770-771)

10. The study of waterways history and institutions has been sadly neglected. It is interesting to note that when the engineer and surveyor for the State of New York in 1905 wished to describe the canals of America, he had to turn to the work of a French writer, saying,

> The information to be obtained concerning the various canals of North America is somewhat meagre and a satisfactory compilation is extremely difficult. The most complete document on this subject is the report of H. Vetillart to the French Minister of Public Works. This report, entitled La Navigation aux Etats-Unis, has been used in preparing the present work, but considerable original research has been made also....

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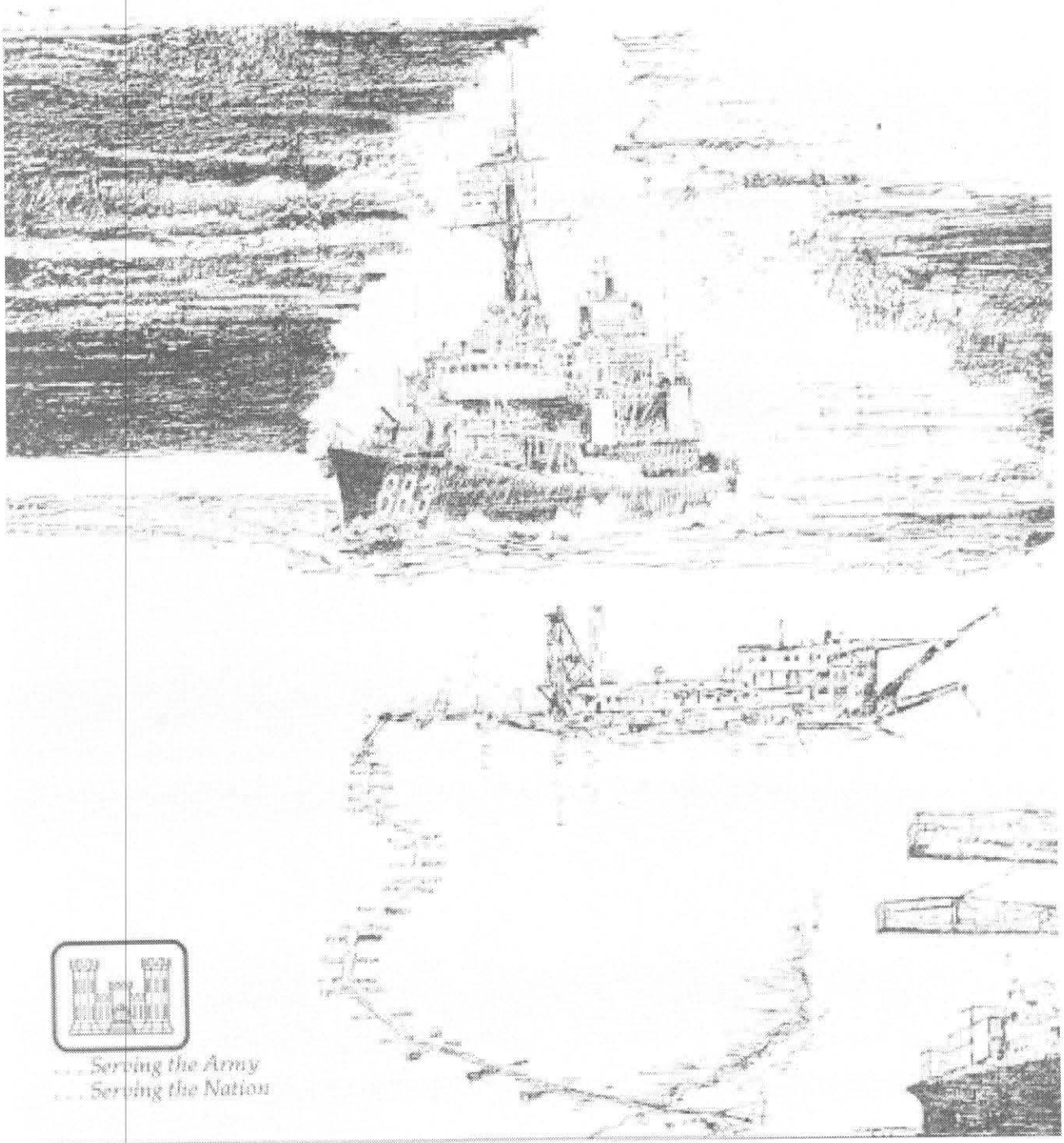

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