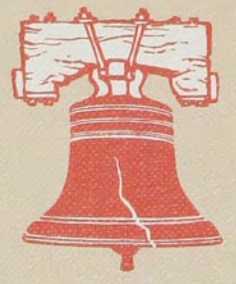
THE DISTRICT

A HISTORY OF THE PHILADELPHIA DISTRICT U.S. ARMY CORPS OF ENGINEERS · 1866-1971

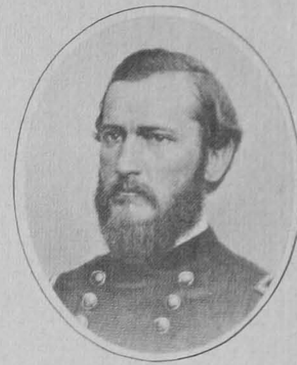
U.S. Army Engineer District Philadelphia



Lt. Col. C. S. Stewart
1866-1871

Lt. Col. J. N. Kurtz
1871-1877

Col. J. N. Macomb
1877-1882



Lt. Col. G. Weitzell
1882-1884

Maj. J. C. Sanford
1903-1908

Maj. C.A.F. Flagler
1905-1907

Maj. Herbert Deakyne
1908-1912

Lt. Col. Joseph E. Kuhn
1912-1913

Col. W. B. Ladue
1919-1921

Maj. L. E. Lyon
1921-1922

Col. F. C. Boggs
1923-1928

Lt. Col. G. B. Pillsbury
1928-1930

Col. H. B. Vaughan, Jr.
1940-1943

Col. A. H. Burton
1943-1944

Col. Clarence Renshaw
1944-1945

Col. Frederic F. Frech
1945-1949

Col. A. F. Clark, Jr.
1955-1957

Col. W. F. Powers
1957-1959

Col. T. H. Setliffe
1959-1963

Col. E. P. Yates
1963-1966

Maj. W.H. Heuer
1884-1885

Lt. Col. H. M. Robert
1885-1890

Maj. C. W. Raymond
1890-1901
1902-1903

Col. J. A. Smith
1901-1902

Col. George A. Zinn
1913-1916

Maj. J. C. Oakes
1916-1917

Col. Mark Brooke
1917-1918

L. D. Shuman C. E.
1918-1919

Col. Earl I. Brown
1922-1923
1930-1933

Col. J. A. Woodruff
1933-1934

Lt. Col. John C. H. Lee
1934-1938

Maj C. W. Burlin
1938-1940

Col. Earl E. Gesler
1949-1950

Col. Ralph E. Cruse
1950-1952

Col. Walter Krueger, Jr.
1952-1954

Col. R. J. Fleming, Jr.
1954-1955

Col. W. W. Watkin, Jr.
1966-1968

Col. J. A. Johnson
1968-1971

Col. C. D. Strider
1971-1973

Col. C. A. Selleck, Jr.
1973-

THE DISTRICT

A HISTORY OF THE PHILADELPHIA DISTRICT
U.S. ARMY CORPS OF ENGINEERS
1866-1971

by Frank E. Snyder and Brian H. Guss

U.S. Army Engineer District Philadelphia
January 1974

THE DISTRICT

LIBRARY OF CONGRESS CATALOG CARD NUMBER: 74-182918

THE AUTHORS

Frank E. Snyder, artist, historian and canal buff. Mr. Snyder is a retired employee of the Philadelphia District. From 1929 to 1935 he lived and worked as an artist in Italy, joining the Corps of Engineers as an illustrator in 1951.

Brian H. Guss, a Ph. D. candidate in English at Temple University, has travelled extensively throughout Europe and the Near East. Mr. Guss taught English at both Temple University and Cheyney State College, and has been associated with the Philadelphia District Office since 1972.

This is the DISTRICT

Its Mission is both Military and Civil.

It is headed by an officer of the United States Army: a Colonel of Engineers. The DISTRICT area is designated by a geographic discipline and defined by its drainage basins or watersheds: the drainage area of Delaware River and Bay and the contiguous reach of Atlantic Coast from Manasquan River to Cape May, and from Cape Henlopen to the southern border of Delaware.

The primary function of the DISTRICT is management of local water resources through protection, improvement and utilization for the benefit of the Community. It works to keep navigation channels open, to provide an unimpeded supply of water and to protect the region from floods.

The Military Mission, now suspended, once encompassed design and construction of airfields, camps, hospitals and defense installations. Area economic and recreational problems are subjects for DISTRICT study, as is the quest for ecological stability.

The DISTRICT is a practical working unit of the U.S. Army Corps of Engineers, where projects are planned, formulated and carried through to completion. It is at the grass roots level: accessible to senator and citizen alike.

FOREWORD

Since its establishment in 1866, the United States Army Corps of Engineers Philadelphia District has made important contributions to the growth, development and protection of our rivers, streams, and shores.

This volume will describe the major features of the Philadelphia District's activities, the details and methods of coping with the practical engineering problems of the day. Throughout each chapter will run the thread of imaginative thinking and creative ingenuity by both military and civilian as they met the challenges before them.

In the early years rivers were the primary trade routes of our nation, and the Philadelphia District was there—dredging and maintaining those navigable waterways in order that Philadelphia could become one of the country's leading trade centers. When floods came the Philadelphia District was there night and day, until restoration was completed and plans submitted for future protection.

Each chapter depicts a specific activity of the District and carries it through time, both in word and illustration. From the area's first public works ice harbor built at New Castle in 1803 by the Army Engineers, to safe ecological direct pumpout of dredged material, to the Corps' first use of multiported outlet structures at Beltzville Lake, to conservation of the wetlands, the Philadelphia District has stood first in public service and led the way in technological development.

Carrol D. Strider

CARROL D. STRIDER
Colonel, U.S. Army Corps of Engineers
District Engineer

AUTHORS' PREFACE

In the summer of 1866, an order from the Office of the Chief of Engineers established the Philadelphia District. But a true accounting of engineer activities in the District must reach back nearly a century beyond, to the Corps' founding in 1775.

Since then the stories of the Corps and of the Delaware Valley itself have been freshets feeding the same swift-running stream of American History, sometimes flowing smoothly, sometimes through dangerous rapids. This volume will attempt to trace that journey, to outline a story of determination and ingenuity, of an unending battle to protect a region and a nation from the ravages of war and of nature unchecked, and to facilitate the expansion of commerce and prosperity in what has become (partly through that Corps' efforts) the great Northeastern Megalopolis.

Written history is an attempt to derive pattern and meaning from the accumulated data of the past. To recapture any of the flavor of a period, one must balance the treatment of action and actor—while the Corps' achievements in the District encompass proud feats of ingenuity (the root word of engineer) and of plain engineering know-how, they are the works of men, not of a monolith. It is our insight into the lives of those men which lends true zest to any worthwhile history. This mixture our historians have attempted to portray. If we have succeeded it was the right recipe. If not, let your own wit provide the seasoning and time itself prove the proper judge.

Frank E. Snyder
Brian H. Guss

TABLE OF CONTENTS

NOTE OF APPRECIATION

This volume could not have been written without the cooperation of a number of past and present employees of the Philadelphia Engineer District, whose personal files, made available to us, and animated recollections of events in which they participated, helped the authors to survive a tortuous voyage through paper oceans of old Engineer records, out of which the bulk of this history has been culled. Rather than slight any of them by omission, we wish here to recognize their collective contribution to the work.

Photographs not specifically credited in the captions are from District files; drawings are by Mr. Snyder.

F. E. S.
B. H. G.

INTRODUCTION

The rich loam of Philadelphia history holds enticing secrets for the researcher willing to unearth them, beckoning him to browse engagingly along many an irrelevant bypath. Yet the story of any corps or body of involved persons must largely be the story of its people and its place of involvement. To research the Corps of Engineers' work in the Philadelphia District is to unfold a story rich with the life of a proud old American community.

Famous firsts abound in the area. Here were fashioned a new nation and a unique charter of freedom. The early history of American science and invention centers largely about Philadelphia, whose pioneers in engineering and applied science evolved new designs for the young nation: its first steamboat, first canal, first locomotive, first printing press, first engineer school; its many institutions of art, philosophy and medicine.

As the bell signalling birth of the nation first rang, the Corps was already a yearling, committed to a career of dedicated service which it has maintained for the nearly two centuries of its existence. Conceived as the technical arm of the military forces, it has developed into the world's largest engineering entity, with capabilities expanded beyond its original military mission, enabling it to respond to a variety of needs, from the prevention and relief of natural disasters to recreation planning.

The History of the Philadelphia District, Corps of Engineers begins offically in 1866. Since then the burgeoning eastern megalopolis in which it is centered has evolved into the most densely populated and industrially developed area in the Nation. This concentration of population and industry has generated formidable problems for the public welfare. These are of continuing concern to the Philadelphia Engineer District. The following pages contain a succinct and, hopefully, comprehensive account of that concern.

Prologue
1775 - 1866

General Louis LeBègue DuPortail

—National Archives

TO BUILD A NATION

General George Washington's appointment of a Chief Engineer for the Continental Army is generally regarded as the act which gave origin to the United States Army Corps of Engineers. Appointed on 16 June 1775, Colonel Richard Gridley was a logical choice. Firmly aligned to the American Cause, he was a mature officer of considerable military experience and probably the most gifted engineer then residing in the New World. As a military engineer he had planned the fortifications around Lake George, had supervised the construction of Fort William Henry. As Caption of Artillery in the British-Colonial Army, he took part in the expedition against Louisburg in 1745 and commanded the Provincial Artillery at Crown Point in 1755 and in the capture of Quebec.

Captain Gridley, British officer, had aided in fortifying the harbor of his home town, Boston, in 1746. Twenty-nine years later he was one of Boston's defenders against the guns of the British fleet. The day after his appointment as Chief Engineer, Colonel Gridley, American patriot, directed the erection of breastworks on Breed's Hill and furnished ordance to his unmilitary codefenders in the first major battle of the War for Independence, an engagement known to history as the battle of Bunker Hill. Wounded in that famous fight, the 64 year old Gridley did not again take the field but continued as Engineer General of the Eastern Department until 1780.

Developing an effective engineering force from native materials must have been frustrating. A school of engineering in the American tradition would not exist for another 50 years;[1] in 1775 there were only a few frontier surveyors, some practical men of yankee genius and a handful of trained Frenchmen. The latter were officers experienced in planning fortifications, who loaned their skills and their sympathies to the American Cause. With this motley and underequipped force the fledgling department of a threadbare army undertook to win a war. The urgency of the work to be done and the determination of the men who had to do it have come down to us in their motto, "Essayons" (We will try).

Ninety-one years elapsed before "Philadelphia District" became an official designation. Projects undertaken in the intervening period established precedents which provided the framework for subsequent area operations. At the beginning the military mission was paramount—and defense of the new seat of government had first priority. The Delaware River and Estuary were to be guarded from the threats of the British Navy by installing a warning system and building fortifications.

After the treaty of Paris recognized American Independence in 1783 the Continental Army Corps of Engineers[2] was dissolved. But in 1794 President Washington appointed another Frenchman[3] to command a new Corps, established by Congress and designated as the Corps of Artillerists and Engineers. A year later, the training of young officers and men in the art of military engineering began at West Point, N.Y., succeeding the first rough Engineer School established 17 years before at Valley Forge in 1777. The organization was to be short-lived. It had been created primarily to strengthen and extend east coast and Canadian border fortifications and to offset the possible spread of the French

Revolution and the French-English conflict to American shores. By 1802 that threat had lessened, and accordingly, the Corps was abolished by an act of Congress dated 16 March of that year, the Engineer School at West Point having been previously destroyed by fire in 1796.

That same act of 1802 established the present Corps of Engineers and an associated military academy located at West Point, New York. It is difficult to assess fully the significance of the contribution of Corps and Academy to the engineering profession in America or the value of their participation in the formative works of the nation. Seven distinguished Chiefs of the Corps were also Superintendents of the Military Academy between 1802 and 1863[4]; they propagated a tradition of lofty ideals and professional excellence which has survived to sustain their modern counterparts. One other Superintendent, not a Chief, was Major Sylvanus Thayer whose theories and systems of teaching, adopted after 1817, profoundly influenced the training of American engineers, both civil and military.

The Corps of Topographical Engineers, whose function since its inception in 1838 had been the surveying of roads, canals, lakes, rivers and harbors, combined with the main body in 1863 in a final consolidation of the Army's Corps of Engineers. Management of the Military Academy was opened to all arms of the service in 1866, when the Corps established its own engineer school at Willets Point, New York. Moved again in 1901 to Washington Barracks, District of Columbia, the Army Engineer School was finally transferred after World War I to Camp Humphreys, Virginia, now known as Fort Belvoir.

General DuPortail's sketch map was the original plan for the encampment of the Continental Army at Valley Forge in 1777. The Chief Engineer used a French scale of one inch to 130 toises; or, one inch to 780 feet, our measurement. This unusually accurate map places the inner line entrenchments and the two redoubts exactly in locations where they may be identified today by surviving traces. Phonetic bilingual spelling includes "Scoulkill Rivier" and "Vallé Crique".

—Historical Society of Pennsylvania

INSIGNIA OF THE CORPS

The configuration of a turreted castle has long been a familiar symbol of the Corps of Engineers, readily recognized and identified in all parts of the globe. Few however, claim certain knowledge of the exact time and circumstances of its adoption. Its earliest documented use seems to have been in 1839 on the uniforms of West Point Cadets. Although most familiar, it is probably not the oldest of the three Corps insignia in use today.

This seal of the U.S. Engineer Department appears on drawings dated as early as 1815.

The so-called "Essayons Button" is known to have been worn in the War of 1812. Much later a description of the device on the button appeared in official orders making it part of a new uniform:

> *----An eagle holding in his beak a scroll with the word "Essayons," a bastion with embrasures in the distance, surrounded by water, and rising sun; the figures to be of dead gold upon a bright field ---- General Orders, 7, AGO, 18 Feb 1840*

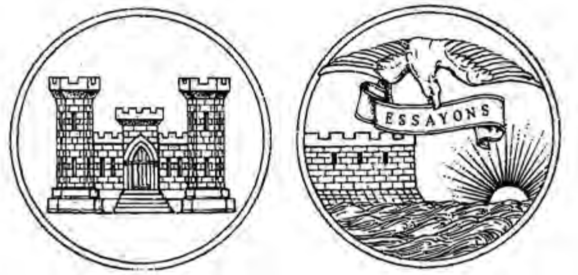
Chiefs of Engineers' letterheads bore this seal in the 1870's, 1880's.

Elements of that design were discovered[1] on the legend of a map drawn by Corps of Engineers Captain Alexander Macomb in 1807. The map represents New York Harbor; the survey was the responsibility of colonel Jonathan Williams, Commandant of the Corps of Engineers. A year earlier, on a map of Charleston Harbor, Captain Macomb had drawn the symbol of an eagle holding in his beak a flying scroll on which is written the motto "Essayons."

The current seal, adopted in 1866 and made official by order of General Wilson in 1897

No earlier evidence is extant concerning the origin of the heraldic elements which com-

Colonel Jonathan Williams
—National Archives



The Essayons Button was worn in the War of 1812. The Castle Insigne was first worn by West Point Cadets in 1839.

prise the Essayons Button. What authenticating records there may have been did not survive the West Point fire of 1838. Circumstantially, all known facts point to Colonel Williams and Captain Macomb as designers and adopters of the insignia, not the least significant of which was the button's official adoption in 1840 when Alexander Macomb was General-in-Chief of the United States Army.

The castle insigne was worn on the new uniform approved for West Point cadets in 1839. The uniform was designed by the academy's superintendent, Colonel Richard Delafield; the designer of the turreted castle has not been identified. Use of the castle on the new uniforms of Engineer Officers was recommended to the Secretary of War by Chief Engineer Totten in 1840.

The least familiar Corps of Engineers insigne is the official seal. Adopted after consolidation of the Corps of Engineers and the Corps of Topographical Engineers in 1863, the seal combines symbolic elements of all previous representative devices. Centering the large shield is a horizontal band, the dexter half embodying symbols of the old Essayons Button, the sinister emblazoned with the "TE" of the once separate Corps of Topographical Engineers. The poised eagle and Essayons banner are dominant. General Andrew A. Humphreys, a former member of the Corps of Topographical Engineers, is credited with initiating use of the seal soon after his appointment as Chief of Engineers in 1866. The seal was adopted officially by directive of Chief of Engineers General John Moulder Wilson on 6 April 1897.

The heraldic significance of the castle as an armorial symbol may be derived directly and logically from the original function of the Corps: the design and construction of fortifications. The form of castle-fortress adopted was not far-fetched. Many important early works were called castles: Castle Williams and Castle Clinton in New York Harbor; Castle Island in Boston Harbor; Castle Pinckney in South Carolina. Castle Williams was named in honor of its designer, Colonel Jonathan Williams, who appears to have been the co-originator of the insigne.

The Corps motto: Essayons, (We Will Try) was uniquely appropriate for a brigade of technicians faced with the need to accomplish a great many new and difficult tasks quickly. It suggests a certain respect for the magnitude of a mission which at times must have appeared overwhelming. Some have adduced the infusion of foreign sentiment into the Corps' ideals by reason of the French form of the motto. But the sense of the motto could hardly be more American, expressed in any language; the use of French may simply have followed the scholarly tradition of appending an arcane device to an institutional escutcheon, with an implied salute to the Gallic wellspring of 18th century engineering.

The crenelated bastion with turrets is a symbolic reminder of the simultaneous beginnings of Country and Corps. It is also a relic of engineering modes and methods which became obsolete many decades ago. Inversely, the motto remains fresh and current; its statement does not brashly assume an easy resolution of today's problems; in an era of disheartening complexity its simple determination and modest resolve express the fidelity of purpose which has marked the Corps since its inception.

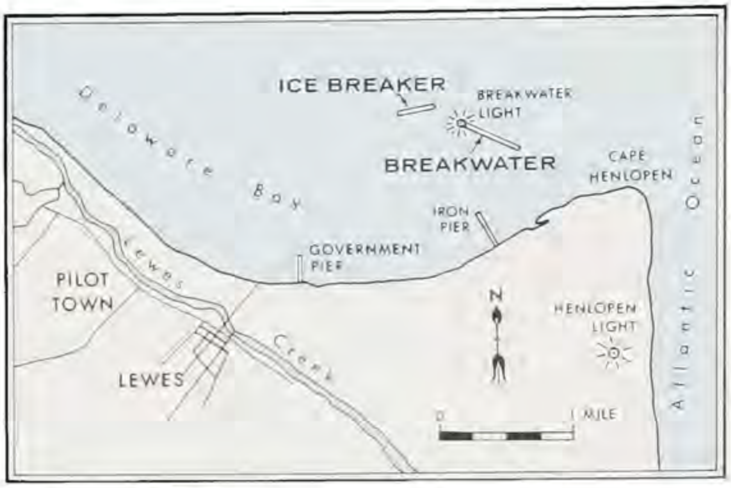
THE DELAWARE BREAKWATER AND ICE BREAKER

John Quincy Adams, sixth president of the United States, gifted orator and promoter of the Monroe Doctrine, was the first president to urge Federal improvements on a large scale. Among the public works sponsored by him, several of importance were initiated in the District area during his administration. One of these was the Delaware Breakwater and Ice Breaker.[1]

> *"The experiment in relation to this great work, has now been fairly made. It already affords a good harbor for the vessels engaged in transporting materials used in its construction, and for such vessels engaged in commerce as may take shelter under it in times of storm."*

This statement by the Quartermaster General in his report to the Secretary of War reflects satisfaction with the progress of the project in October, 1833, at the end of its fifth construction season. In this report, figures show 75 percent of the breakwater length laid down at levels varying from 15 feet above the sea bottom to five feet above high water. Even greater progress was reported for the ice breaker. An appropriation was requested for the 1834 work season in the unprecedented amount of $350,000. The QMG wrote to the Engineer of the Work: *"The energy with which the work has been prosecuted is unparalleled, and not a doubt can now remain as to its importance to the Commerce of the Country. If appropriations can be obtained it must be completed in 1835."*

The Department's optimism was amply justified. Since 1828, when first contract advertisements were published in newspapers of New Castle and Philadelphia, 518,733 tons of stone had been deposited in the waters off Cape Henlopen. A fairly workable system had been evolved, by trial and error, for dealing with contractors, inspectors and boatmen,



Crane for the Delaware Breakwater

The drawing shows a simple truss gantry made of iron-reinforced timbers, supported by two movable timber braces. The top arm of the pivoting truss is equipped with a pulley over which a chain is passed, then wound on a hand-cranked windlass.
Strickland's crane design was approved in January, 1831 and four rigs were built. They were put to work in the 1831 season; by then small sections of breakwater and icebreaker had been raised to the highwater line.

—Tennessee State Library

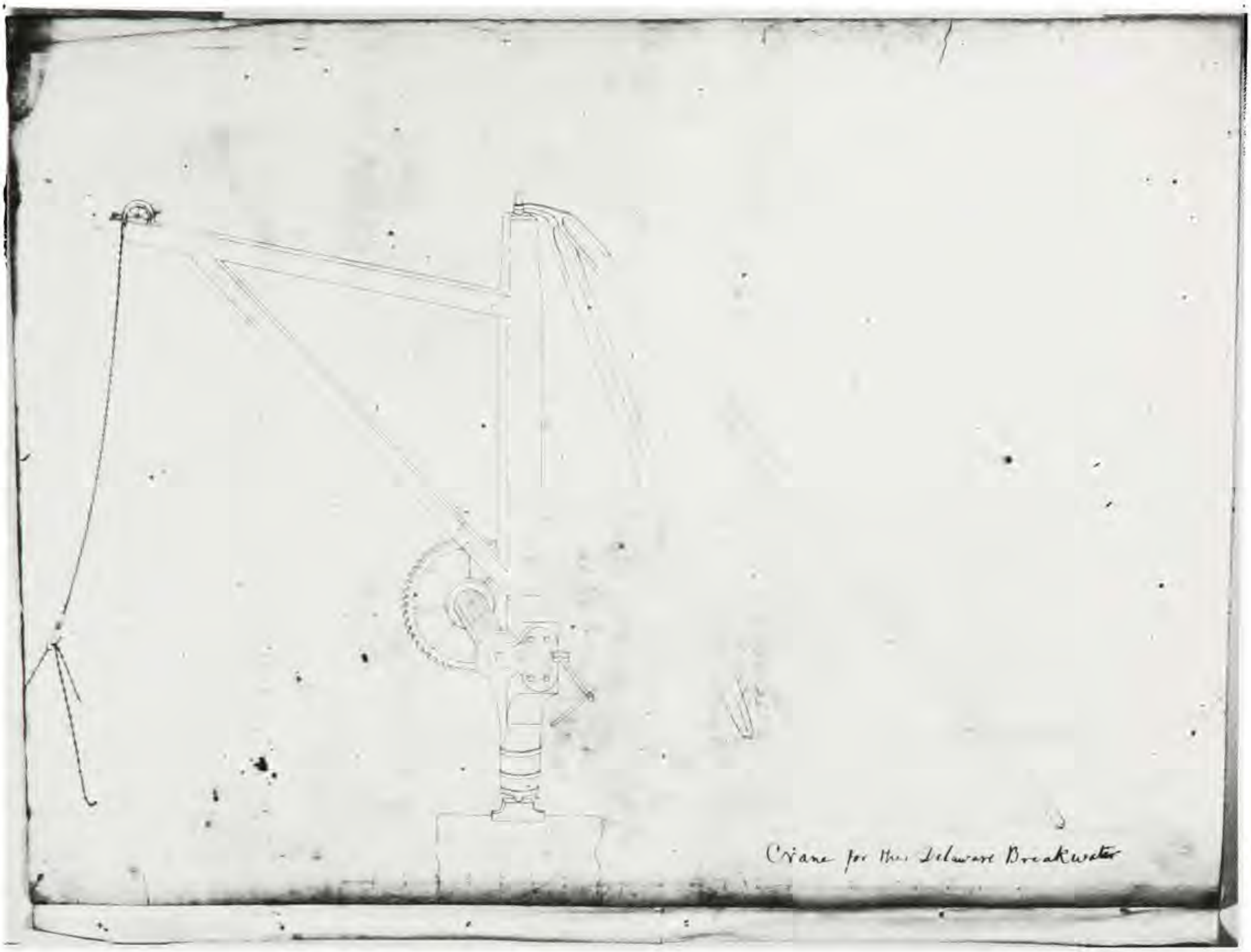
and prospects seemed to favor completion of the structure at the estimated cost of $2,216,950. The year 1833 had been the best in five; deliveries of stone to the site totalled 154,459 tons by September, bringing the work season to an early close with exhaustion of the year's appropriation. In the opinion of the Department, twice the tonnage could have been delivered if sufficient funds had been made available by Congress.

Difficulties experienced in the first years of the work are reflected in records of the quantities of stone deposited at the site: only 242,770 tons for 1829, 1830 and 1831. The unit of measure was tallied at first in perches, at 25 cubic feet or 2,700 pounds per perch. Initially, it was required that all cargoes be weighed, measured and marked before and after loading at the quarries and again prior to discharging at the breakwater. Stones weighing between one sixth of a ton and two tons were specified. The elaborate tally system, crude weighing devices and general inexperience of all concerned soon created situations vexing enough to stall the whole operation.

Halsey Rogers and Co., sole contractor for 1829, decided in early September to close down his quarry at the Palisades, North (Hudson) River New York with less than 25 percent of his quota delivered and six weeks of the season to go. The Department adjudged this act to constitute non-performance and recommended that H. Rogers' contract be voided. Canvass White and Company, also of New York, received the contract by transfer and started deliveries on 24 April 1830—minimum acceptable size of stone to be one quarter ton.

Important criteria changes made over the next 12 months affected inspection, the hiring of personnel, supervision and stone sizes. A new preference for a profusion of small suppliers[2] supplanted the sole contractor philosophy. Soundings made on the work site in spring 1830 proved that wave and tide action of the past winter had lowered the structure by six to fifteen feet. While an increase in stone sizes seemed in order, it was not required until February 1831, when a new contract with Leiper & Crosby specified 25 or 30 thousand perches of stone in pieces of 2-1/4 to five or six tons. A month previously Mr. Strickland's[3] design for a crane had been approved and four were constructed for handling heavy blocks at the breakwater.

William Strickland was advised of his appointment as Engineer for construction of the Breakwater by letter of the Quartermaster General dated 24 November, 1828. Strickland had served on the Commission appointed by the War Department to determine the feasibility of locating a Breakwater at the mouth of Delaware Bay. It is not clear by what criterion he was selected to superintend this rather important National improvement, but there is little doubt that his appointment, granted by Mr. Southard, at the direction of Mr. Adams[4] was regarded as superfluous by the Quartermaster General[5]. That officer, whose department was charged with administrative responsibility for the project, frankly expressed his disapproval[6]. The recurrent theme of his opposition dealt with Mr. Strickland's nearly total absence from the scene of operations. Doubtless, the engineer found it inconvenient, and possibly distasteful, to absent himself from Philadelphia, where he pursued a busy professional career which included superintendence of the Naval Hospi-



tal at a salary of $2,000 per year. Under like conditions and for similar reasons, Strickland had declined, in May 1827, to continue his services as engineer of the Pennsylvania Main Line Canal, in charge of its Eastern Division.

Since no amount of persuasion could induce Mr. Strickland to take up residence at Lewes, in March 1831 the Department assigned a young officer, Lt. Wm. M. Bell, to the Post, with the title of Assistant Engineer and full responsibility for supervision of the work. The beneficial effect was almost immediate. Much of the slack was removed from the delivery procedure, more efficient workmen were hired at the site and their problems became known and were resolved without undue delay. A scheme to boost carrier prices, concocted between Sloop Masters of the Delaware and Hudson Rivers, was nipped in the bud. The Department moved to segregate the two areas (Delaware River, Hudson River), requiring that contractors deal exclusively with quarrymen and carriers located in their own base areas.

The success of "The Man at the Scene" experiment was followed by further field assignments of Engineer Officers and responsible supervisory craftsmen. Bids for supply contracts were now invited for a minimum of 5,000 perches of stone "throwing the whole business open to all, in order that working men of limited means may become competitors."[7] Many small quarries along the Delaware River and its tributary creeks in Pennsylvania and New Jersey became scenes of renewed activity, their properietors or lessors uniting to become joint bidders. In February 1832 the Department awarded contracts to fifteen contractors for delivery of 120,400 tons of stone.

A majority of the House Ways and Means Committee in 1832 opposed further appro-

William Strickland

—Historical Society of Pennsylvania

priations for the breakwater, but the minority took the subject before the Congress and succeeded in obtaining the $270,000 which had been requested. In his annual report for 1831 the Quartermaster General stressed the extreme desirability of obtaining the full amount of the appropriation, "for the contingent expenses of the work are heavy, and are about the same whether we have a large or small appropriation." These contingent expenses multiplied as inspection and lading points were added at quarries and docks up and down the river. Lt. Dimmock at Lewes, Lt. Waite at the quarries and Maj. Bender in Philadelphia were meeting higher payrolls, due not only to an increase in personnel, but also because it was determined that "efficient men were cheaper at a higher rate of wages, than inefficient ones at very reduced terms." All of this made for a smoother operation, and indeed, the work was proceeding very well. It soon became apparent, however, that the prevailing method of letting many contracts over a widely dispersed area, though beneficial to "working men of limited means," was pushing overhead costs to unreasonable heights.

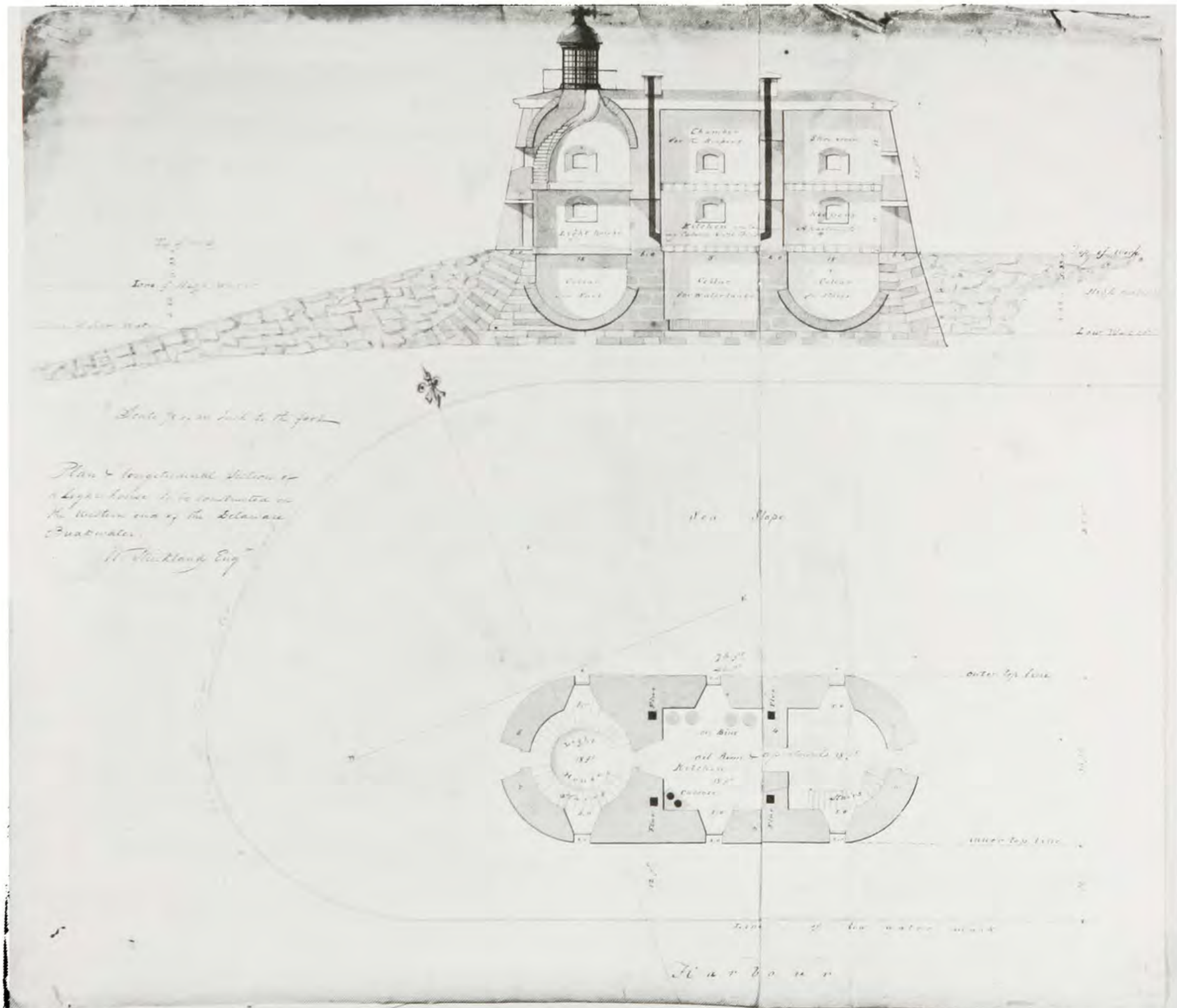
As a consequence the Department again made revisions in its contract philosophy, urged in specific terms by the Secretary of War,[8] who had declined to support a request to increase the breakwater appropriation for 1833. A precedent may at this time have been established for the pre-award survey and the approved bidders list. Perturbed by the high incidence of contractor non-performance, the Department ruled for inspection of the quarries of prospective contractors; proof of ability to perform was required and prior contractors who had failed were barred from competition. Furthermore, the minimum to be furnished by any individual or company was fixed at ten thousand perches (13,500 tons) and all contractors were to confine their activities to quarries which they worked themselves.

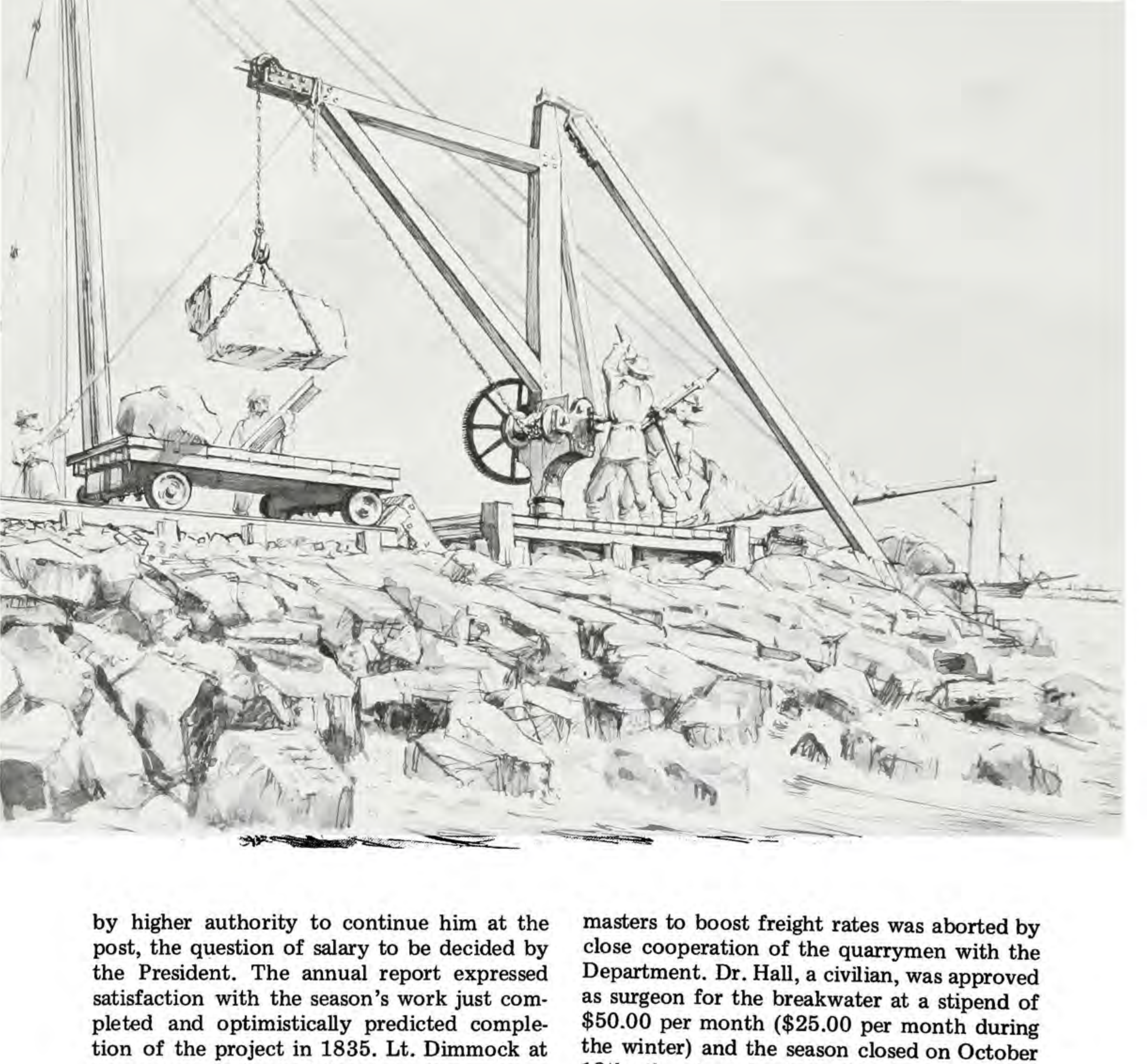
This device effectively separated the big ones from the little ones, with the result that the entire new procurement for 100,000 tons was awarded under one contract to Messrs. Leiper, Hill and Jacques. The work was now confined to the area of Delaware River and Bay, the New York people having been disqualified under the new regulations. Mr. Strickland was relieved of his duties as Engineer-in-Charge by Gen. Jesup's letter of 12 February 1833, and his position filled a week later by Lt. Charles Dimmock, an Engineer Officer. Then, on March 16 the Department wrote, by direction of the Secretary of War, to inform Strickland of his reinstatement and continuance for another six months. The Engineer was again urged to reside at the work site and to perform duty obligations as are required of all Officers-in-Charge. No mention was made of salary, so presumably it continued at $3,000, to which figure it was reduced at the beginning of his second year of employment. Previously, the salary was $3,500 per annum.

In October (1833) the Department requested Strickland to furnish plans and specifications for a lighthouse to be built on the western extremity of the breakwater, and a drawing and description of mooring buoys for the harbor. The Engineer's term of employment having again expired, the question of his reassignment recurred. Once more the Department recommended that Strickland be replaced by an officer and again was instructed

Plan and longitudinal section of a lighthouse to be constructed on the western end of the Delaware Breakwater.
William Strickland's drawing, submitted at the request of the War Department in October 1833. Western Union Telegraph Co. was given permission to occupy the light in 1876 for use as a telegraph station. The structure was removed after closure of the gap between the breakwater and the ice breaker.

—Tennessee State Library





by higher authority to continue him at the post, the question of salary to be decided by the President. The annual report expressed satisfaction with the season's work just completed and optimistically predicted completion of the project in 1835. Lt. Dimmock at Lewes was instructed to make the seasonal soundings, pay all bills and shut down for the winter.

In June of 1834 Lt. John F. Lane arrived at the breakwater as the new Assistant Engineer. William Strickland was reconfirmed in the principal engineer's post by direction of the Secretary of War "in consequence of the unanimous recommendation of the Chamber of Commerce of Philadelphia." The stone contracts for the season were awarded to Leiper and Co. of Ridley Creek Quarries, Pa. and J.F. Hill, of Crum Creek Quarries near Chester, Pa. Another attempt by the shipmasters to boost freight rates was aborted by close cooperation of the quarrymen with the Department. Dr. Hall, a civilian, was approved as surgeon for the breakwater at a stipend of $50.00 per month ($25.00 per month during the winter) and the season closed on October 18th, the stone boats having hauled down a total of 122,995 tons.

There was alarm and disappointment in the Department's correspondence of Autumn 1834. Shoaling at the west end of the work had unaccountably accelerated; late season surveys showed a general shallowing of the harbor of three to ten feet. The annual report recommended, with detectable reluctance, that construction be suspended, or at least curtailed, pending the results of new studies of the tides and currents off Cape Henlopen. An appropriation of $100,000 was requested for 1835 "to bring the whole of the work

Construction proceeded simultaneously on the breakwater and the icebreaker. There is no evidence that mechanical power was employed—vessels under sail delivered the stone, which was loaded on and off by manpower, the heavy pieces by man-powered cranes. Weather was an important factor in the construction schedule and the work season was limited to an average five months, usually from late April through September.
Marker lights were provided at the close of the first work season and Delaware Bay shipping availed itself of whatever shelter was afforded by the structures from the earliest stages of their development.

already founded to its destined height." The prior year's appropriation was $270,000. Extension of the structure eastward was to await a re-evaluation of the sea's behavior patterns in the project area.

An inspection team consisting of Gen. Jesup, Quartermaster General; Col. Joseph G. Totten, Corps of Engineers and Col. S. Thayer, Corps of Engineers visited the breakwater between the first and tenth of November. Mr. Strickland was requested to accompany the team, but there is no record of his having complied. The team's report was signed by the three officers named above and submitted to the Secretary of War under date of 10 November. The report corroborated the findings of Lt. Lane's survey and recommended extensive observations of the waters of the lower bay.

In lieu of a firm criterion of procedure, the Department's instructions to Lt. Lane implied that nothing should be overlooked, no pains be spared; . . . . "*As the day has passed by when results could be arrived at intuitively, and opinions taken for ascertained facts in science, the more minute and particular your observations the better, however unnecessary or even frivolous they may appear to ignorant pretenders.*" The theory that a beneficial scouring effect, produced by the action of tides and currents, would naturally keep the harbor dredged out, was discredited. The idea may have been generated by the Strickland Report of April, 1830, made subsequent to the annual Srping survey, which cited an erosion of the Point of Cape Henlopen. General Jesup siezed upon the fact, rejoicing that ". . . . . *The wearing away of the Point of the Cape was a circumstance more to be desired than any other circumstance that could have occurred—we have no longer to fear the filling up or obstruction of the harbour, for the fact stated proves that the deposite by the tide is more than counteracted by the current and the ebb.*"[9]

By the fall of 1834 a total of 640,520 tons of stone had been deposited at the breakwater and ice breaker. The work was stalled and would not resume for an entire year, and then at a reduced pace. General Jesup wrote: "It seems strange that there should have been so large a deposite of mud and sand during the last winter and no deposite during the preceding years." Seeming to attribute some culpability to the Engineer, Jesup found occasion to exercise his surgically keen logic in an analysis and rejection of Strickland's proposal for installation of mooring buoys in the breakwater harbor. But the Engineer stayed on the payroll, and the General conceded resignedly in a letter to Lt. Lane that—"If Mr. Strickland leave the service, it will be by resignation and not by removal—of the latter there is no intention."

The Delaware Breakwater was the first structure of its kind to be attempted in the Western Hemisphere. There were precedents in Europe: The breakwaters of Cherbourgh, Plymouth and Kingstown were subjects of study and observation by the American builders. Available writings on the subject were not profuse, possibly limited to M. Cachin's *Memoir on Cherbourgh Breakwater*, an article on Plymouth Breakwater in Dupin's *Naval Force of Great Britain* and the work of Erney on the *Motion of Waves.*

Utilizing rubble mound construction (pierres perdues), stone was dumped on the bottom of the Bay along a base averaging 160 feet in width, with side slopes angled at approximately 45 degrees to a top width of 22 feet. The crest was about 14 feet above mean low water but the whole of the work was not brought to this height unitl 1869. Stone deliveries made between 1835 and 1839 consisted predominantly of large sizes and were placed almost exclusively on the seaward face of the breakwater proper. A final appropriation in 1838-38 brought the original construction period to a close. The last delivery was loaded September 2, 1839 at the Crum Creek Quarries of William I. Leiper. The cargo was 53 tons, all sizes, taken on the sloop *Lady Jackson*, Michael Yonker, Master and discharged at the breakwater on September sixth.

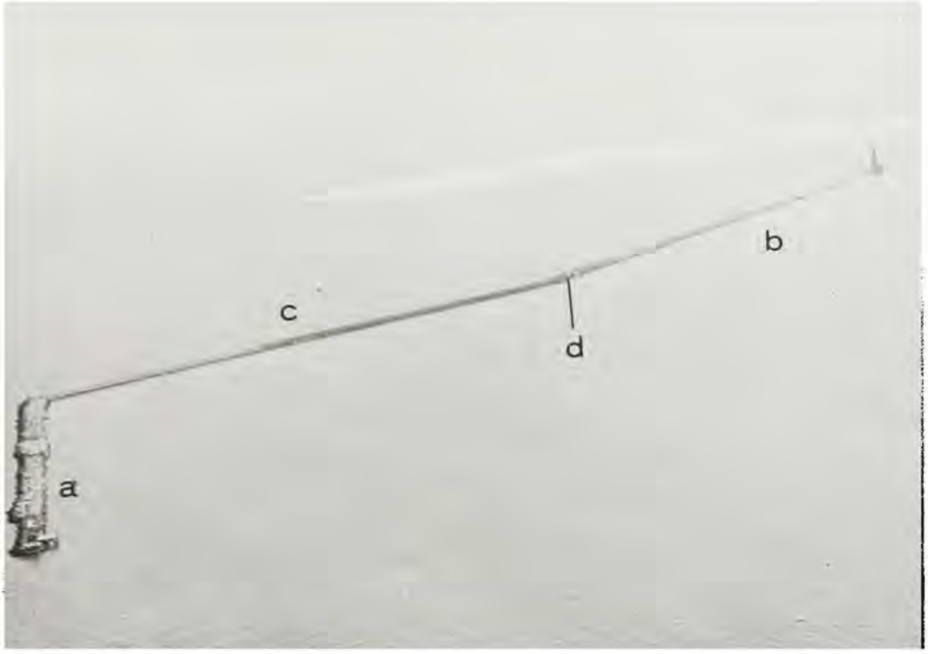
The total of 835,000 tons of stone had been deposited in the Bay since the Spring of 1829 at a cost of $1,880,000. The breakwater's length at base was 2,586 feet—far short of the intended 3,600 feet.

The ice breaker, too fell 99 feet short of design length, and achieved full height for a mere 100 running feet of its length, requiring 9,000 tons of stone for completion. Three unfinished portions of the breakwater, totaling 652 running feet, required 10,500 tons to reach final height. Whatever it lacked, it was the second greatest structure of its kind in the world (on a par with Plymouth Breakwater) and in 1840 William Strickland could say: "The Work may be considered now so finished as to have accomplished materially the purposes for which it was projected."

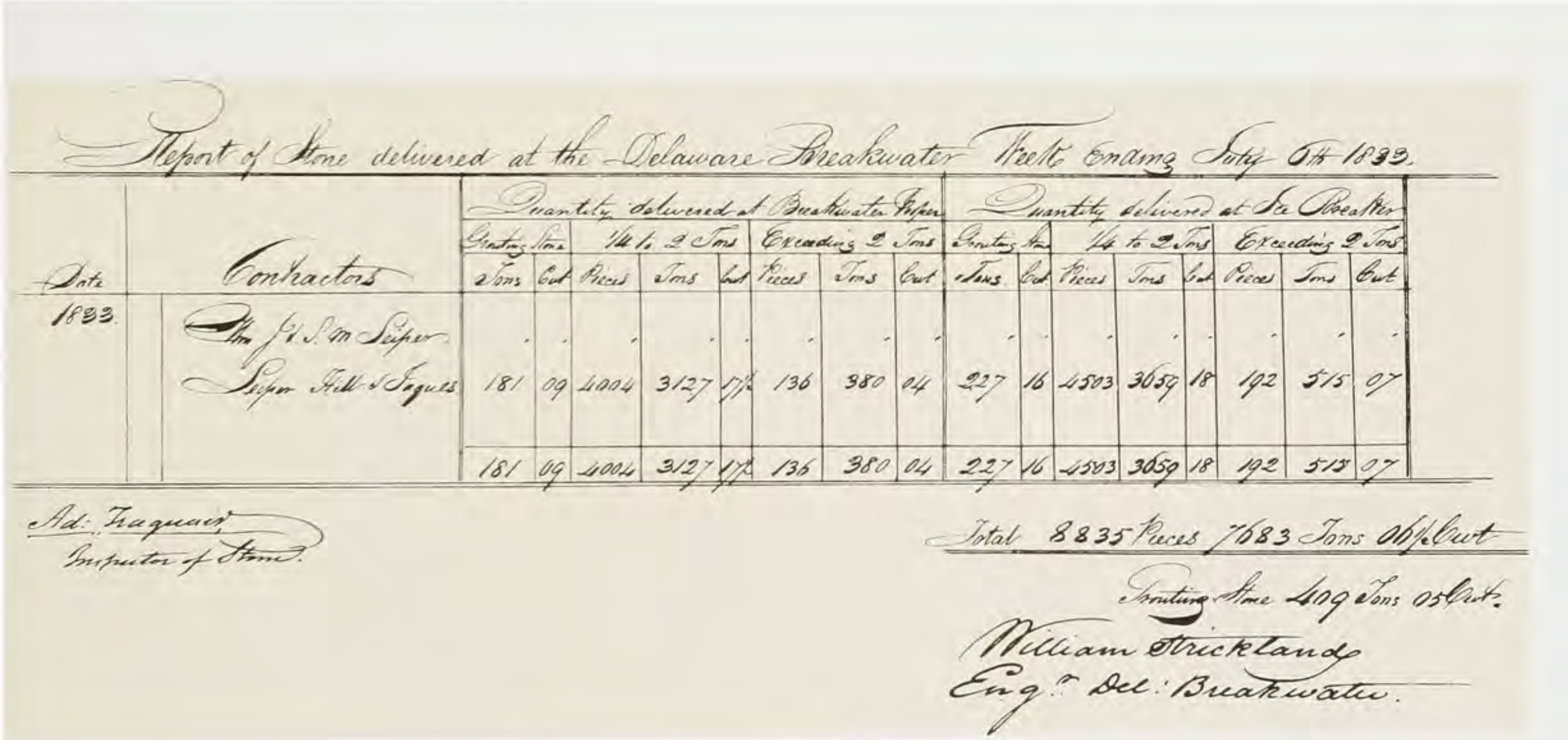
There is a distinction to be drawn between the Delaware edifice and its models at Cherbourgh and Plymouth. The latter were designed for military purposes while the Delaware Breakwater's intended function was, from the beginning, to benefit trade and commerce. The table reveals something of its usefulness during the latter seven years of construction.

Number of Days' Shelter[10]

Years	Ships	Brigs	Schooners	Sloops	Pilot Boats	Total
1833	22	178	372	167	127	886
1834	48	315	667	303	411	1,744
1835	133	569	1,719	461	644	3,526
1836	301	1,027	2,719	620	767	5,434
1837	227	478	2,777	629	732	4,843
1838	165	732	3,191	765	685	5,538
1839	165	504	3,561	734	697	5,661
Total	1,061	3,803	15,006	3,679	4,063	27,612



The old breakwater as it appears today, looking seaward. The icebreaker (a) was originally separated from the breakwater proper (b) by a 1,350-foot interval. The "Gap" structure (c) was completed in 1897. William Strickland's lighthouse was located at d, then the western end of the breakwater. The point of Cape Henlopen, seen in the distance, continues to encroach upon Breakwater Harbor, shifting northwestward. In 1879 Captain Ludlow, C of E, calculated its advance at 800 feet in 50 years, or an average rate of 16 feet per year.



Report of Stone delivered at the Delaware Breakwater Week Ending July 6th 1833.

Date	Contractors	Quantity delivered at Breakwater Proper								Quantity delivered at Ice Breaker							
		Grouting Stone		1/4 to 2 Tons			Exceeding 2 Tons			Grouting Stone		1/4 to 2 Tons			Exceeding 2 Tons		
		Tons	Cwt	Pieces	Tons	Cwt	Pieces	Tons	Cwt	Tons	Cwt	Pieces	Tons	Cwt	Pieces	Tons	Cwt
1833.	Wm. J. & S. M. Leiper																
	Leiper Hill & Jaques	181	09	4004	3127	17½	136	380	04	227	16	4503	3659	18	192	515	07
		181	09	4004	3127	17½	136	380	04	227	16	4503	3659	18	192	515	07

Ad: Traquair
Inspector of Stone.

Total 8835 Pieces 7683 Tons 06½ Cwt

Grouting Stone 409 Tons 05 Cwt.

William Strickland
Engr. Del: Breakwater.

The Quartermaster General became resigned to Engineer Strickland's absentee supervision, but remained adamant that the Engineer should personally sign all reports. This form, one of a considerable variety written in the clerk's fine hand, lists quantities and categories of stone delivered at the Delaware breakwater for the week ending July 6, 1833. It bears the signatures of William Strickland and the estimable inspector of stone, Adam Traquair.

—Federal Records Center, National Archives, Philadelphia

Early log books for Delaware Bay. 1834 book at top records wind, weather and triangulation data. At bottom, left and right, are books 2 and 3 of Major Bache's Survey in the Vicinity of the Delaware Breakwater, 1842.
—Historical Collection, Philadelphia District

A survey of Breakwater Harbor conducted in 1842 by Major Hartman Bache of the Topographical Engineers produced a detailed report on the harbor bottom and the protective structures. Major Bache's observations recorded the dimensions already cited and some disturbing trends in the shoaling patterns. He found the harbor already too shallow for vessels of the largest class and the gap between the two structures serving as a channel for most violent tidal action and the primary cause of shoaling. The gap nullified the ice breaker's effectiveness in embracing a "Harbor of Refuge" and destroyed an estimated 50 percent of protected harbor space. In his view, vessels seeking shelter below the barriers were vulnerable to running ice; instances were cited of a while occupying fleet being swept out to sea by floating ice masses. Major Bache proposed completion of the existing structures to their originally intended dimensions and closure of the gap.[11]

A $30,000 appropriation a dozen years later, in fiscal 1851-52, was just enough to supply 7,000 tons of stone and to replace the deteriorated handling equipment. Major of Engineers J.G. Barnard urged further appropriations in sufficient amounts to immediately prosecute the work's completion and closure of the gap, to save it from becoming a national disgrace instead of a national benefit.[12] Major Barnard requested $300,000 for fiscal 1854-55 to accomplish a construction program which he quite specifically defined. He considered it feasible and economical to build the linking structure largely of stone removed from the existing breakwater, of which "the accumulated mass is twice that necessary." Major Barnard found the original design to be a blind copy of the Cherbourgh slopes and considered "the profile and principles upon which (it was) based radically vicious." He recommended a top width of twelve feet only, finished off with rather monolithic pieces of dimension stone and careful placement of materials in the zone of the tide range. Underlining the urgent need for a true Harbor of Refuge, Major Barnard pointed to the great increase in coastal trade and to the observed fact that, within a few hours of a storm threat more than 200 sail had crowded into the harbor at one time. A tabular statement of vessels for the ten-year period 1840-49 showed the harbor to be used by an average of 25 vessels daily.

But "The Gap" remained; shoaling reached a more or less stabilized condition, and occasionally a vessel foundered in the bay. The fiscal wheels ground slowly on, eventually producing the required appropriations in 1864, 1866 and 1867. With these funds the breakwater and ice breaker were completed to the design height but not to their originally intended lengths. In 1869, forty years after the first Palisades stones were dropped in the bay off Cape Henlopen, the old breakwater chapter was closed. The total cost to the Government amounted to $2,123,000. Construction had spanned the terms in office of 12 Presidents. Ex-president Millard Fillmore still lived and the incumbent was Andrew Johnson.

THE CHESAPEAKE AND DELAWARE CANAL

As the first stone boats were discharging their cargoes in Breakwater Harbor, water was being let into the Deep Cut of the new Chesapeake and Delaware Canal. The date, 4 July 1829 marked the culmination of an arduous effort which had begun on 15 April 1824. The inaugural celebration of this "Great National Work" was held 17 October 1829. Regrettably absent from the ceremony was the first "Public Works" President, John Quincy Adams, who had participated with such evident relish and oratorical flourish at other canal inaugurals: the Chesapeake & Ohio (ground breaking 1828) and the Erie, greatest of American canals, at its completion on 2 November 1825.

Although the cutting of the canal required just over five years, its consummate goal of joining the waters of Chesapeake and Delaware Bays had been anticipated for more than a century and a half. A colorful manuscript map representing Virginia and Maryland "*as it is planted and inhabited this present year 1670, surveyed and exactly drawne by the only labour & endeavour of Augustin Herrman, Bohemian*" was for sale in 1673 at the shop of the king's hydrographer in London. The author, whose engraved portrait appears near the mouth of Delaware Bay, was among the first to suggest the considerable navigational and commercial benefits to be derived from a canal cut across the narrow neck of the peninsula. A glance at this map, one of the first of any accuracy to show the area, would make and indeed must have made this possibility apparent to many; subsequent more exactly drawn maps continued to do so.

In 1764 the American Philosophical Society of Philadelphia proposed that route studies be undertaken, with a view to establishing closer contact between the Chesapeake Bay country and Philadelphia. An attempt made by Pennsylvania in 1784 to interest Delaware and Maryland in a canal project was met cooly. Opposition was exerted by Baltimore interests who suspected Pennsylvania of attempting to attract the trade of Maryland and the Susquehanna River to Philadelphia, and away from the port of Baltimore. In 1799 Pennsylvania's proposals were more favorably received, and on 7 Dec. the State of Marlyand drafted an act to incorporate a company "for the purpose of cutting and making a canal between the River Delaware and the Chesapeake Bay." Books were opened 1 March 1800 for a $500,000 stock subscription. Four-fifths of the capital stock was taken within a year.

By 1802, the Chesapeake and Delaware Canal Company was incorporated in the three states and sufficient capital stock had been sold to justify hiring engineers to begin surveys. Regrettably, both progress and available funds were short. Stockholders learned that the cost of surveys and a feeder, plus fees for water rights along the route had already taken $100,000. Nothing had yet been done on the main canal which, it now appeared, would cost considerably more than had been estimated. An appeal to the three states in 1805 elicited favorable endorsements but no financial aid. At this time American engineering was in its infancy, but the stirrings of an awakening industrial giant were being felt throughout the land. Necessity prodded native genius to accomplish feats beyond the scope of its training. These early planners and builders possessed a bare minimum of theo-

retical and practical knowledge, scarcely enough to prepare them for the mammoth projects which they brashly undertook.[1] Their cost estimates could be wildly inaccurate—frequently 300 per cent too low, as in the case of the Chesapeake and Delaware Canal.

The directors of the Canal Company exerted extensive efforts to persuade the National Government to support the canal as a vital link in a system of internal improvements. From the logic of geography they argued that such a canal would surely lead to the building of the long-proposed canal across New Jersey, the Delaware and Raritan Canal, and to the extension of the Dismal Swamp Canal down to the bays and inlets of North Carolina. Economically, it was obvious that a great traffic would ensue between North and South in the exchange of mutually needed products at ever-decreasing prices. Boatmen at the head of Chesapeake Bay would be separated from the Delaware only by 21 miles of Chesapeake & Delaware Canal instead of 500 miles by sea route around Cape Charles. Forty-three miles of canal via the Delaware and Raritan would save 300 miles and the risks of the open sea off Cape May.

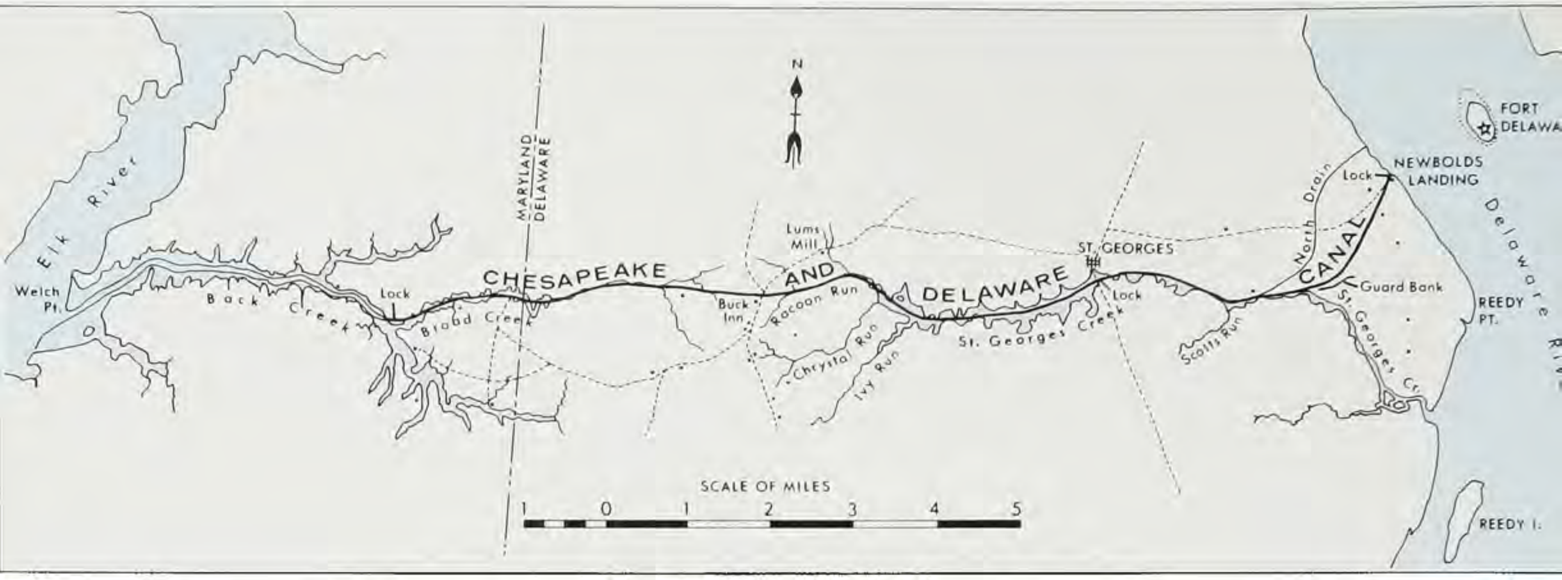
These and other persuasive arguments brought no immediate action from Congress. In 1807 that still indifferent body approved examination of the matter by the Secretary of the Treasury. Mr. Gallatin[2], ardent patriot and expansionist, gave a full year to the

Augustine Herrman's map of the Delmarva Peninsula, dated 1670, is oriented with North to the right. Herrmann acquired 10,000 acres in Cecil County, Maryland and named it "Bohemia Manor"; he was among the first to survey the area and to advocate a cross-peninsula waterway.

—Cecil County Historical Society, Elkton, Maryland

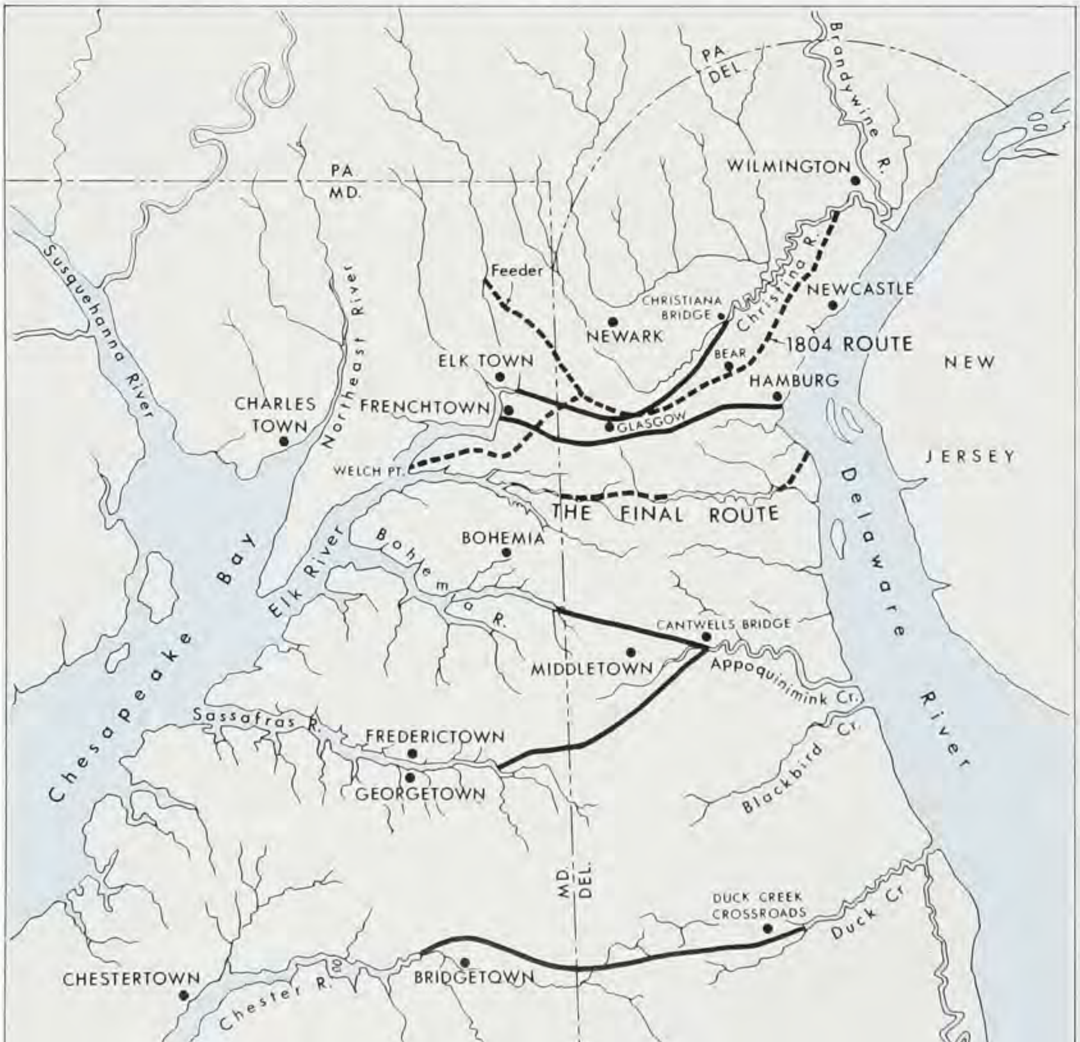
survey, which resulted in the historic Report on Roads, Canals, Harbors and Rivers presented on 4 April 1808, a document at once comprehensive, imaginative and prophetic. It outlined not only the communications needs of the times but also envisioned future trends and developments. It recommended: the creation of an inland waterway from Massachusetts to North Carolina; development of eastern rivers for navigation linked to midwestern rivers by a network of turnpikes; and the construction of canals to connect the Great Lakes to the St. Lawrence River and the Eastern Seaboard. The Chesapeake and Delaware Canal was among the internal improvement projects for which federal aid was specifically recommended. Bills for the purpose introduced in 1810 were defeated by both Houses.

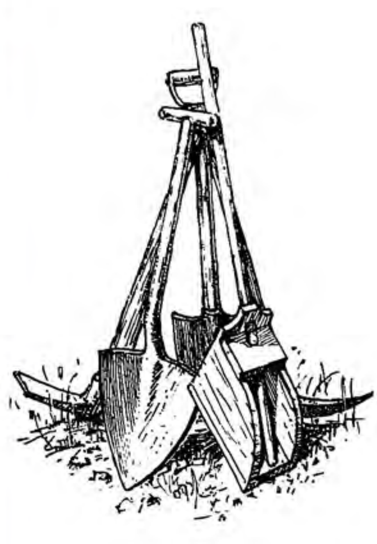
A dozen years passed before an effective move was made to revive the Canal Company and get the work underway. A new board of directors was elected in 1822 and Benjamin Wright, a former frontier county judge, was engaged as chief engineer. Judge Wright was one of the three principal engineers in charge of construction of the Erie Canal. That great work in its fifth construction year was justly causing concern to Pennsylvanians that New York would preempt trade with the west. Canal mania, which would culminate in the thirties, was beginning to gather momentum. Pennsylvania, already committed to vast internal improvements of her own, deemed the Chesapeake and Delaware project sufficiently important to subscribe the sum of $100,000. The State of Maryland subscribed $50,000 and Delaware $25,000. With an additional $450,000 from the Federal Government and



The final route connected Back Creek with St. Georges Creek and for eight years utilized natural stream flows for its water supply. The original map upon which the above is based was drawn before the terminal towns, Delaware City and Chesapeake City, were established.

The map below is adapted from one drawn by Francis Shallus in 1799. The heavy solid lines trace five proposed routes which had been surveyed prior to that year. A sixth route, surveyed in 1804, proposed linking Elk River at Welch Point with Christina River at Mendenhall, just below Wilmington; digging was begun on the feeder, but was abandoned in 1806. The final route was determined after 1822.





nearly half a million from public subscription, the work was reopened in 1824 with a capitalization of $1,000,000. New cost estimates valued the project at $1,239,159, a sum twice the original estimate but barely half the amount eventually required for its completion.

A new survey had been made in 1822 but its route was opposed by John Randel, Jr., newly-appointed to supervise the work while Judge Wright was busy with the Erie. Randel, another Erie Canal product, had run his own levels and decided that a route farther south would provide a more adequate water supply and would require less excavation and less lockage. The Company directors, with an eye to the budget and confident in the adequacy of the existing survey, disagreed. Randel was judged incompetent and discharged. The young engineer brought legal action against the Canal Company and won his case, collecting damages and realizing the satisfaction of seeing his route adopted.

Other young men came down from the Erie "School of Engineering" to lend their skills to the C & D; among them, Canvass White, Judge Wright's protege and assistant, who had walked the canals of England for two years, making notes and sketches for use in the Erie construction. White made the first discovery of domestic hydraulic cement deposits in Madison County, N.Y. His "waterproof lime"

CHESAPEAKE
AND
DELAWARE
CANAL.

Notice is hereby given, that this *CANAL* is
NOW OPEN FOR NAVIGATION.

The Locks are 100 feet in length, by 22 feet in width, and the Canal can be navigated by Vessels within those dimensions, and drawing 7 feet of water.

The rates of Toll have been fixed so low, as to make this the *CHEAPEST* as well as the most EXPEDITIOUS and *Safe* channel of communication, between the waters of the Chesapeake and Delaware.

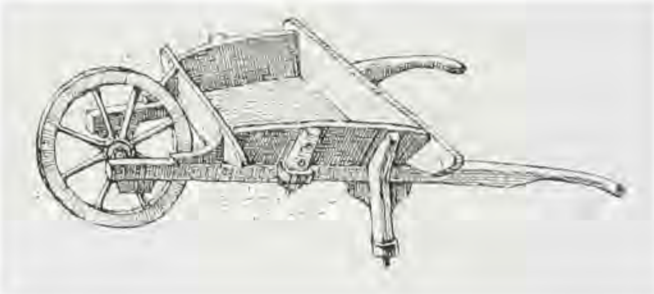
Horses for towing vessels may be hired at reasonable prices at each end of the Canal.

☞ Any information in relation to the Canal, rates of Toll, &c. may be had, on application at the Company's Office, No. 44 Walnut Street, Philadelphia.

ROBERT M. LEWIS, *President*
Chesapeake & Delaware Canal Company.

H. D. GILPIN, *Secretary.*

1829 Broadside announcing the Canal's Opening.
—Historical Society of Delaware



The old canal through the Deep Cut looking westward from Summit Bridge about 1860. The towpath, on the right, was frequently blocked by slides from the steep unstable slopes.
—Historical Collection, Philadelphia District

was the mortar that effectively bonded the masonry of the Erie locks and revetments. Physically frail, he spread his energies among all of the notable canal projects of the East, dying at 44. Nathan Roberts, surveyor become engineer-of-necessity, who devised the spectacular five-level, double lock structure at Lockport, N.Y. also contributed his experience to the Delmarva cutting.

Compared to the Erie, the Chesapeake and Delaware Canal seems a minor undertaking. Its length was 13-5/8 miles, the Erie 363 miles. From Albany to Buffalo boats were raised through 83 locks for a total lift of 675 feet. Summit level of the C & D required a maximum total lift of only 16 feet employing a tide lock at each end and one other lift lock. Neither these figures nor the relative prism dimensions[3] give reliable clues to the cost-per-mile divergencies of the two projects. The total cost of $2,250,000 made the Chesapeake and Delaware the most expensive canal of its time. One of the shortest, its cost-per-mile was 8.5 times that of the longest, the Erie Canal. Canals were expensive despite ready availability of low cost labor and materials. Here are cost-per-mile figures for original construction of most of the early canal projects:

Erie	$ 19,255.49
N.Y. State Canals, Average	17,367.57
Delaware & Hudson	20,655.00
Lehigh	33,610.00
Pennsylvania State Canals	22,113.00
Schuylkill	16,741.26
Union	18,518.51
All New England Canals	12,838.71
Middlesex Canals	19,000.00
Ohio & Erie	10,000.00
Miami & Erie	12,000.00
Chesapeake & Delaware	165,000.00

Manpower was the prime mover on the C & D as on all other early nineteenth century construction. Excavation was accomplished by the muscle power of more than 2,500 men using pickaxes, hand shovels and some primitive lifting devices. In some sections horses were put to use, drawing man-guided bucket scoops. Excavation with explosives was minimal, the great obstacle being instability of terrain rather than massive resistance of rock. The course of the channel ran westward from its eastern terminus at the Delaware River across eight miles of low lying plain, of which more than a mile was tidal marsh. Borings made in this section to a depth of 54 feet disclosed a foundation consisting principally of massive deposits of water-bearing sands interspersed with strata of tough blue clay—but no rock. From mile eight to mile eleven cutting penetrated a low ridge which ran down the middle of the peninsula. Here was dug the famous "Deep Cut" regarded in its day as "one of the greatest works of human skill and ingenuity in the world."

The great volume of material removed from the Deep Cut was probably the single item most responsible for the canal's enormous cost. The heterogeneous formation of boulders, gravel, sand and marls was underlaid by thick beds of sand bearing copious flows of water, alternating with tough clay strata. The overburden was laboriously excavated in barrels dragged up over the 90-foot summit by rope. The long slopes, intended to be pitched 1-1/2 on 1, continually sagged and slid. East of the Deep Cut, materials had to be imported for construction of the banks 10 to 20 feet higher than the existing terrain. The agonizing reverses caused by instability of the geologic base are cryptically described in the 1829 commemorative tablet which may be

seen outside the wheelhouse of the old pumping plant at Chesapeake City:

> *"In its progress through the Eastern level large sections of embankment sunk 100 feet below the adjoining surface, and the bottom of the excavation rose 40 feet above its natural position. On the Deep Cut more than 375,000 cubic yards of earth slipped from the regulated slopes of the sides and passed into the chamber of the Canal."*

The Eastern half of the canal was put to use in 1828, a year before water was admitted to the Deep Cut. Heavily laden sloops plied the navigable 6-7 miles, the boatmen enjoying the 10-foot depth of channel, unusual in eastern canals. In the summer of 1829 the entire canal was opened for navigation, with another year needed to bring it to completion.

The canal's lower level extended 4.39 miles from the Delaware City lock to St. Georges lock; it was maintained at about elevation 7.66 above mean low water of the River at Delaware City. The entrance lock at Delaware City, somewhat protected by docks and pilings admitted vessels directly from the Delaware River. It had a lift of 6 to 8 feet, although its chamber afforded an ungated passage with a good tide. St. Georges lock provided an 8-foot lift to the summit level, which extended 9.32 miles to the western terminus at Chesapeake, (later Chesapeake City). The Chesapeake or Maryland lock was just over 1-3/4 miles west of the Delaware-Maryland state line and lowered vessels an average 16 feet from summit level to tidal Back Creek. All of the locks were 100 feet long and 22 feet wide, of masonry rubble construction over grouted timber cribbing, resting on a puddled base. They probably were originally gated at both ends by balance beam miter gates, as this type was popular with Erie engineers. Drop or fall gates, developed by Josiah White on the Lehigh Canal, were later adopted to enclose the lock chambers at the high level ends.

Water supply, the great bugaboo of canal engineers, soon became a major problem for

Barges unloading cordwood near Delaware City.

the C&D. Initially, the sumit level was replenished by natural watercourses along the route, trained to flow by gravity into the channel. Vagaries of the seasons, from droughts to floods and washouts made it imperative to seek a new supply. Then, too, traffic was increasing annually, requiring greater quantities of water to flood the locks. In 1837 a steam pump was installed at Chesapeake City in a stone building erected for the purpose. Scant knowledge is available as to the exact nature of this engine. A personal recollection of the period described it as a "large horizontal pumping engine, the cylinder and pump of which were in line on the same rod but with a flywheel and crank to measure out the stroke,"[4] apparently a contemporary locomotive type with firebox, boiler and cylinder combined.

While annual tonnage for the year ending June 1, 1837 was 100,000 tons, a decrease of 14,680 tons from 1836, an increase was recorded in passages through the canal from 2,467 to 5,433. Tonnage figures stepped up the following year and increased at a fairly consistent rate through the 1840's. Tolls were high and were so regarded down to the last days of the Lock Canal. Up to 1837 little competition was offered by the railroads and vessels of numerous types streamed through in increasing numbers. Cargoes included virtually every item of human necessity. Those which added the most volume to tonnage statistics were cord wood, lumber, flour, wheat, corn, cotton, iron, oysters, fish and whiskey. Passenger packets tallied 1,232 passages through the canal in the first year of operation, accounting for one fifth of total transits. Regular passenger service was soon established between Philadelphia and Baltimore, with stops at half-a-dozen intermediate points. The Philadelphia & Baltimore Steamboat Co., organized in 1844, initiated a day-night passenger and freight service with its new Ericsson Line of screw propellers. Transit of the canal was a part of their scheduled route. Freed of sidewheels, their slim hulls and shallow drafts were fitted to the locks. Figures for 1844 indicate a continuing traffic increase: 8,413 vessels passed through; 188,410 tons were hauled. A rival line, The Frenchtown and Newcastle Railroad, with steamboat connections at Elk River for Baltimore and at Delaware River for Philadelphia had been in operation for a dozen years. Its swifter overland service probably competed for the canal's passenger business but did little to affect its swelling freight statistics. Great shots of lumber, barges with decks tiered six-high in Tidewater farm produce, and later, coal scows from the mines of Pennsylvania and Virginia kept lockkeepers busy around the clock.

Company reports for the years 1851 through 1855 show rather large sums "expended on betterments." Transits numbered 13,582 for 1851, a few thousand less then the peak[5] which would be reached in 1871. The 14-year-old pumping engine could no longer supply the water demanded. Merrick and Sons[6] of Philadelphia was engaged to install a condensing beam engine with Stevens valve gear, capable of producing 175 horsepower. It was housed in a stone building provided with boiler room and wheel house. In the latter a huge wooden liftwheel was installed to raise the water 14 feet into the summit level of the canal. The boilers were of the type used by Oliver Evans in his high pressure steam engines of 1814: riveted wrought iron tubes set

There were few hoof-prints on the towpath in 1910. Mules had given way to steam tugs which towed strings of barges across the peninsula. Steam packets maintained a passenger service which was operative a decade before the Civil War. Mechanical propulsion, long shunned by most American canals, was adopted early on the Chesapeake and Delaware.

in brickwork and underfired. Water was channelled from Back Creek into a deep well under the 12-bucket liftwheel, from there raised to an upper race which carried it into the canal at a point about 960 feet east of the lock.

The company disbursed $9,599.32 on "betterments" in 1851, the new pumping plant accounting for most of the amount. This was just a start. In 1852 the Merrick people erected machinery that got the great wheel pumping 20,000 gallons per minute at a cost of $30,659.73. In the same column for 1853-54 a total of $149,261.12 was spent for capital improvements, in this instance a complete rebuilding of the three locks. The new dimensions of the lock chambers were: Length, 220 feet; width, 24 feet; depth over the sills was 10 feet. Tonnage for 1854 went over the half-million mark.

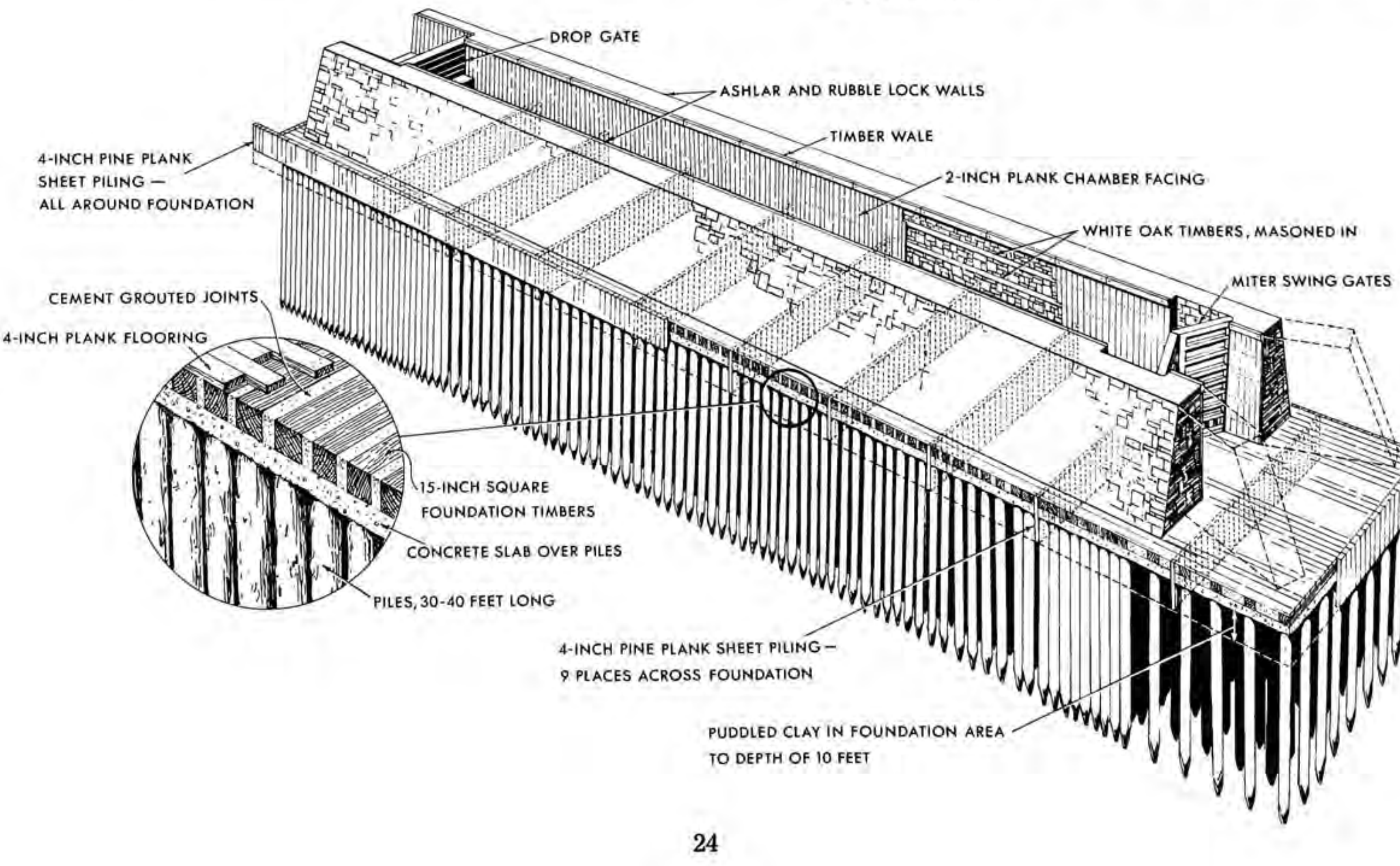
Traffic was discontinued in winter on the C&D. The shutdowns were needed for periodic major repairs and in seasonal deference to the elements. The old engines, preserved intact at their original site bear evidence of having done rugged work. Cracks in the bed plate, patches under the crank shaft pedestals, a welded connecting rod, and a wedged-out beam strap resulted from overwork and strain and such crises as ice jams in the wheel pit, when, according to Greville Bathe, "everything was brought up standing." It being determined that a single engine was not adequate to lift the great weight of water under abnormal conditions of weather and tides, in 1854 a second engine was contracted for from Merrick & Sons and another engine house was built east of the wheel. Equipped with the Sickels expansion or cut-off valve gear, an arrangement somewhat more sophisticated than the Stevens gear, the engine effected a noticeable economy of operation. The year of its installation (1855) marked the highest annual expenditure for improvements: $219,959.23. The year also recorded the only known tragedy to occur in the pumping plant: a man working on the pistion of the second engine was killed when rigging holding up the cylinder head gave way.

The character and extent of the canal's plant and appurtenances were now fairly established. The old wrought iron tubes were replaced in 1865 by a pair of locomotive boilers which gave 30 years of service, until in 1895 Pusey and Jones of Wilmington installed two large round return tube boilers with a combined capacity of 500 horsepower, which did duty until the plant shut down in 1927. Sometime around 1865 two Sewell direct acting steam pumps were installed in a small brick building between the engine houses. These auxiliaries were used to pump water out of the wheel pit and to circulate cold water to the condensing system. A saving basin had been constructed adjoining the Chesapeake City lock to help relieve the heavy demand for water. Half the lock's requirements were received from this basin through a gate at the bottom, the other half through the wickets of the summit gate. On emptying, half of the lock's contents were returned to the basin.

The old canal proved its strategic military value in one memorable episode. On 17 April 1861, Virginia seceded from the Union and started her troops marching on Washington. The National Capital was undefended either by troops or fortifications. Federal troops entrained for Washington from the north were stopped in Baltimore on the nineteenth and that night all bridges from Baltimore to the Susquehanna River were destroyed by Confederation action. All seaboard rail communications to the Capital were severed.

On 20 April the Government commandeered all the propeller steamers in Philadelphia capable of negotiating the locks of the Chesapeake and Delaware Canal. The troop-laden vessels steamed down the Delaware and through the canal, arriving at Perryville, Maryland at dawn of the following morning. By rail to Baltimore, then by steamer to Annapolis and again by rail, the troops arrived in Washington as Confederate outposts arrived at the Virginia end of the Long Bridge. For the next sixty days the C&D was the vital link in a lifeline through which troops and supplies flowed to bolster the Army of the Potomac in defense of the Capital. This continued throughout the Civil War and was repeated when the C&D aided the transport of munitions in the First World War.

The locks were rebuilt in 1853-54, following installation of the liftwheel pumping plant at Chesapeake City. Together, these works comprised the most extensive capital improvement in the Canal Company's history. Capacity of the locks was more than doubled by the improvements, made at a time when railroads were bringing serious competition to waterways. The hundreds of timber piles punched into the foundations dispel all theories that the canal builders were then considering their structures as other than very permanent.



1969 view shows the edge of the sea-level canal within 40 feet of the pumphouse, its surface 14 feet lower than the old lock canal. The waters of Back Creek in the background which were once channeled into the wheelhouse and pumped up to the canal's summit level, now serve as a depot anchorage. The buildings have been designated a National Historic Site and function as a museum, in which the old liftwheel and beam engines are preserved.

A total of $26,690.50 was expended for betterments in the year ending 1 June 1872. This was the peak year for tonnage, with 1,318,772 tons hauled, and dividends paid out amounting to $114,372.44, the highest in the canal company's history. Steam was the principal power source; horse and mule tows were becoming fewer, though a few would still be plodding the towpath after the turn of the century. Steam was also the canal's greatest rival. Railroads were spreading their vast networks across the country at a rapid pace. For the decade 1870-79 railroad mileage increased by 41,454, nearly half the United States total. The competition of rail freight was no longer an imaginary threat. In addition, eastern ports were increasing trade with Europe in larger, deeper draft vessels under steam and steam-and-sail. A line of transoceanic passenger steamers was making scheduled crossings. The Port of Baltimore felt the restrictions of her partially landlocked situation. The Delmarva Peninsula loomed as an obstacle to North Atlantic navigation. In 1871 Baltimoreans petitioned Congress for a ship channel across the Peninsula.

The Chesapeake and Delaware Canal was just one of the many waterways then confronted with the decision of whether to make expensive renovations or to accept an inevitable decline. Americans were on the move and they wanted to get there faster. The meaning was clear: canals, which in more leisurely times had floated whole populations on their way to new settlements in the midwest, could not compete with smooth rails and the mania for speed.

A gradual diminution in tonnage totals is shown in annual reports following 1872. A brief recovery in the years 1882, 1883 and 1884, when figures again topped the million mark, was succeeded by progressive decline and a leveling off to around three-quarters of a million tons annually through the last years of service. The last dividend was paid in 1877: $37,618.00. The canal was then a profit-making entity in form only, its solvency becoming more precarious as installations depreciated and maintenance costs multiplied. A disastrous flood in 1874 nearly put the canal out of business. As a commercial carrier, the C&D had reached the limit of its potential.

The terminal towns, Delaware City and Chesapeake City, never saw the fulfillment of growth anticipated by their grandiose names. They were canal towns almost wholely dependent upon navigation of the waterway at their doors. They grew with the canal and with the canal's decline lapsed into the backwater status of picturesque country villages. Other waterways of the era succumbed to speed and efficiency; their channels, abandoned, became overgrown nostalgic ditches; their busy, roistering towns—sleepy hamlets. But the Chesapeake and Delaware never quite died. It never stopped operating, though it went out of business. In its transformed state as a toll-free waterway, the sea-level Chesapeake and Delaware Canal now carries the ships of the world from Bay to Bay.

DELAWARE CITY, Delaware, eastern terminus of the Chesapeake & Delaware Canal. The Ericsson Line's Steamboat PENN is about to lock through to the Delaware River on its run from Baltimore to Philadelphia. Circa 1910.

ICE HARBORS

Among the earliest works of Harbor improvement undertaken in the District were the ice piers at New Castle, Delaware, built in 1803. They were rectangular, four in number, of stone-filled wooden crib construction.[1] Available records do not reveal the name of the engineer in charge of this project. A drawing in the District's historical files bears a legend stating simply that the piers were built by the United States. They were apparently among the first federally-supported non-military works of improvement.

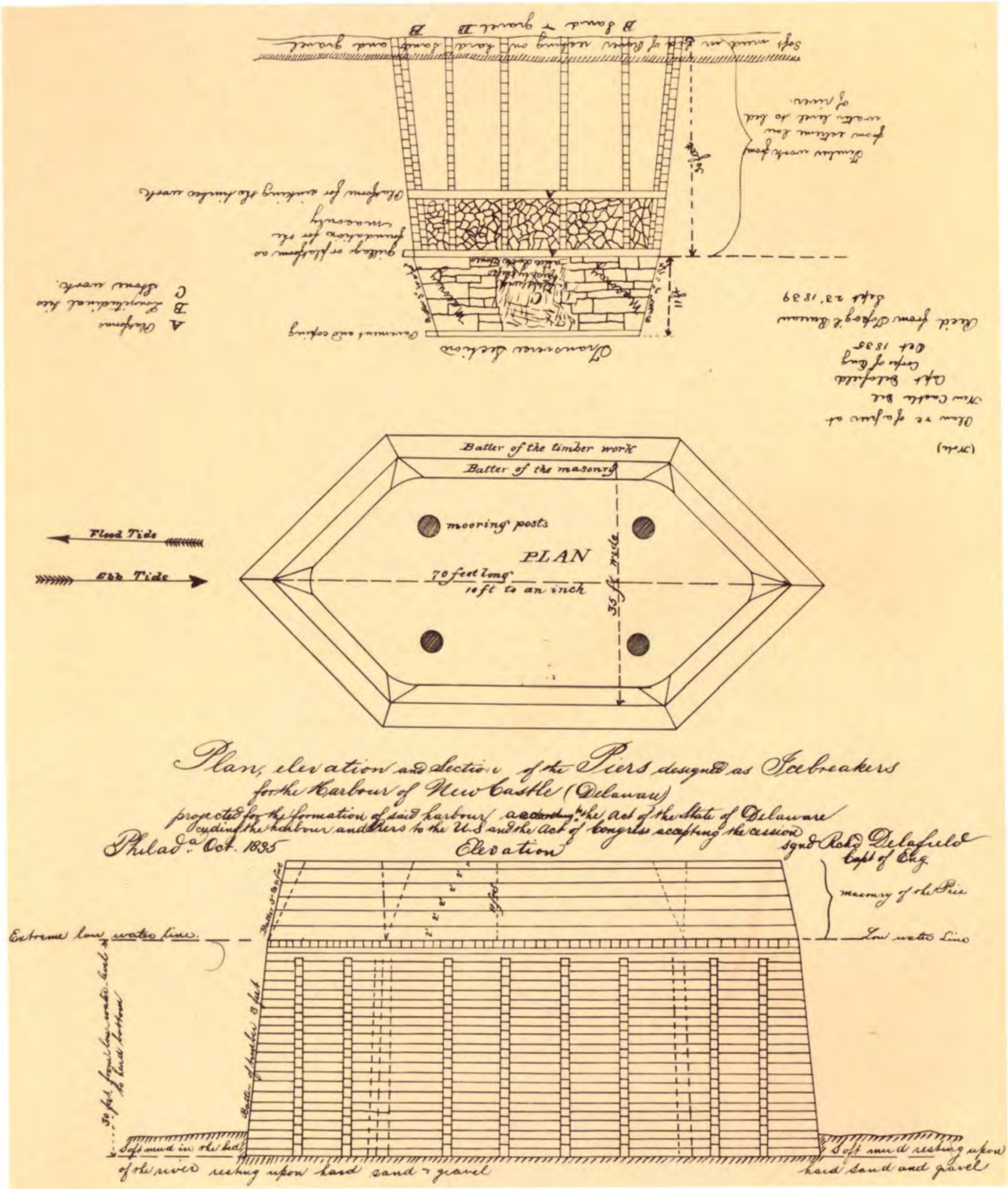
Major Samuel Babcock is credited with construction, in 1827, of timber piers which joined two of the ice piers to the wharves and filled up two sluiceways. "The effect," according to Major John Sanders, "was to fill the harbour with mud[2]." Harbor configuration had changed by 1835 when Major Delafield[3] started construction of two hexagonal ice piers farther offshore. He razed to low water the two outermost of the original, rectangular piers and rebuilt them with cut stone superstructures. The 1827 timber connecting structures were removed at this time and the sluiceways reopened. One of the two ice piers begun in 1835 was completed by Major Delafield in 1837. The other remained unfinished for lack of funds.

A plan of New Castle Harbor dated 1854 shows it several feet shallower than in 1835 and proposes construction of three additional ice piers. The plan bears the signature of Major John Sanders, who since 1848 had supervised the reconstruction of Fort Delaware. A crib pier, built in 1853-1854, is shown about 200 feet south of Major Delafield's unfinished pier. Major Sanders proposed cannibalizing the unfinished pier to provide materials for the construction of another according to his revised harbor plan.

Appropriations for harbor repair and construction of new ice piers at New Castle were approved almost annually from 1826 to 1838. Starting again in 1852, eleven separate appropriations provided a total of $148,100 for the improvement of New Castle harbor. The last, in 1890, defrayed costs of dredging and repair of the piers. Dredging in the spring of 1887 had removed 30,015 cubic yards of material. By then, the wharfline had advanced to absorb two of the oldest piers and the ice harbor had reached its final pattern.

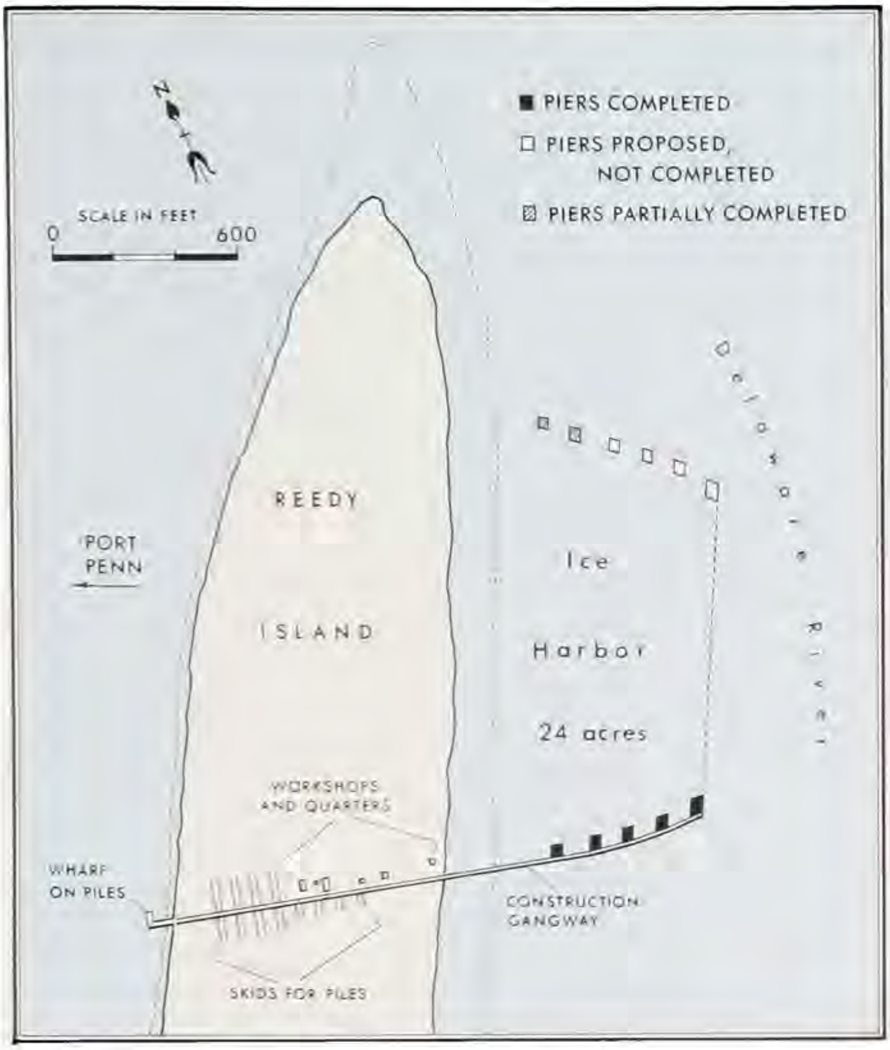
Although the oldest, New Castle was not the only ice harbor in the Delaware River. Crib piers at Port Penn, Delaware received benefits annually from 1828 to 1835 in appropriations which provided also for improvement of the harbors of Marcus Hook and Chester, Pennsylvania. A chart of Port Penn Harbor, dated 1882 shows investigation of the remains of six old ice piers of various sizes and proportions; all had been worn away as much as seven feet below low water.

Congress authorized construction of an ice harbor on the east side of Reedy Island in August, 1852 with an appropriation of $51,090. Major John Sanders, then in his fifth year as Resident Engineer at Fort Delaware, received approval of his plan for the harbor on 9 April 1853. Dubious of the adequacy of available funds, Major Sanders produced a design which envisioned a final development through future appropriations, since in his words, "*permanent structure and small outlay are incompatible in works of such unavoidable magnitude.*" His scheme for a harbor of about 15 acres was detailed at a cost estimated to fit within the budget, accompanied



Plan, elevation and section of the piers designed as icebreakers for the harbor of New Castle, Delaware. Signed, Richard Delafield, Captain of Engineers, Philadelphia, October 1835.

—Historical Collection, Philadelphia District



Ice Harbor, East Side of Reedy Island
Construction of 1853-54

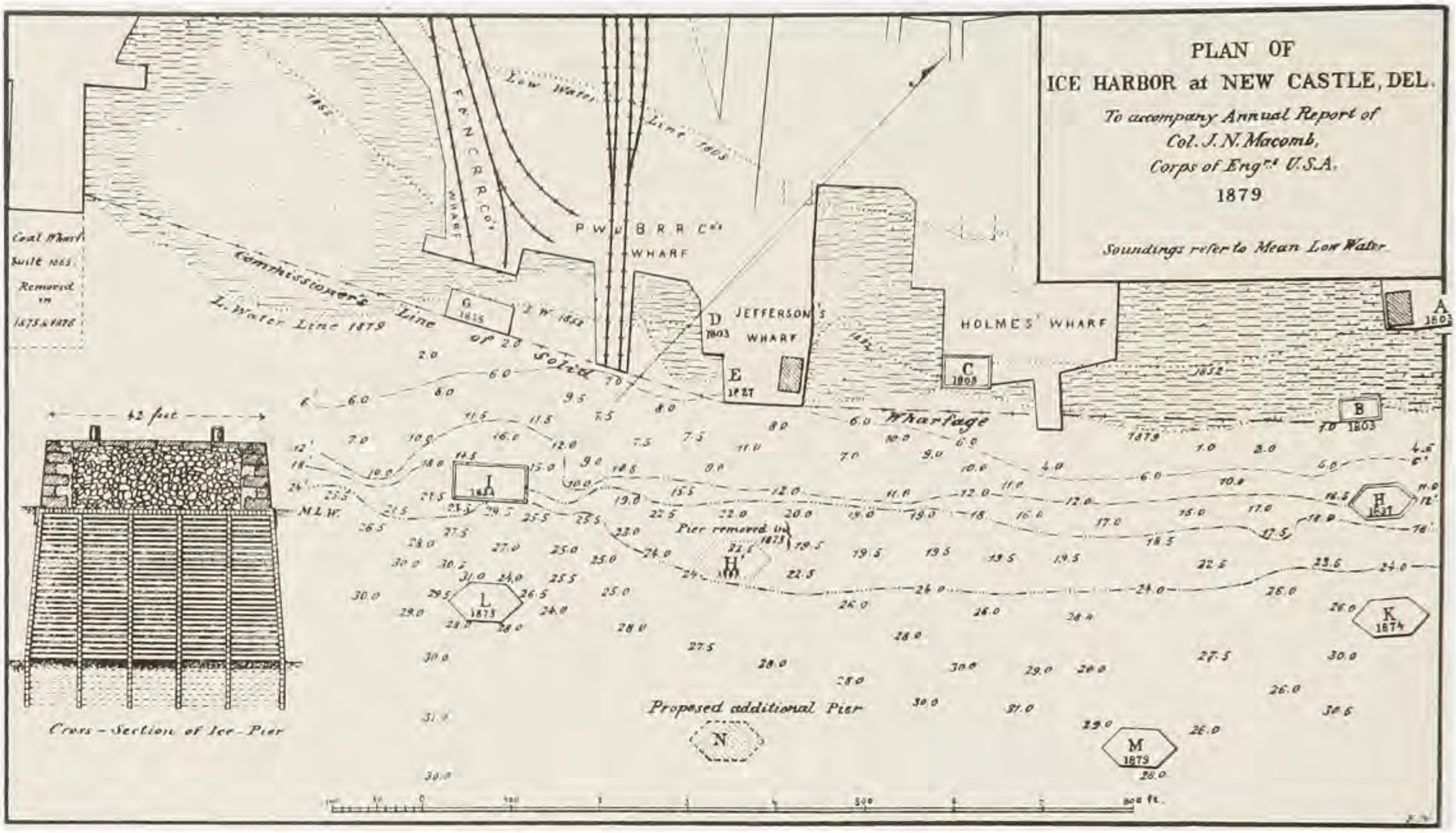
". . . . Solely to offer and furnish ample shelter readily accessible to vessels when stopped or endangered in their passage up or down the river by fields of running ice . . ."—John Sanders, Bvt. Maj., C. of E. The harbor, with depths ranging from six to twenty-one feet, was considered adequate to admit the largest vessels then sailing on the Delaware River. It was intended that the piers eventually should be cut off at the low water line, capped with solid timber grillage and topped with cut stone.

by misgivings for the "*unforeseen expenses which to the disappointment and mortification of engineers so often arise in carrying out new and untried plans.*"

The plan called for twelve piers arranged in two lines to extend from the island channelward at converging angles. Work was started in early May, 1853 with construction of shops, workmen's quarters and a gangway extending across the island and over the beach and water. White oak and yellow pine logs 60 feet long were floated in rafts through the Chesapeake and Delaware Canal from Chesapeake Bay to the work site. In his report of June 30, 1853 Major Sanders wrote: "I must now candidly state it (the appropriation) will not suffice for the construction of the twelve piers I projected."

Two steam engine pile drivers were brought from Fort Delaware and an engine platform requiring 56 piles was built out from the bluff shore in four and one half feet of water. The first pile for ice pier No. 1 was driven the first week of July, 1853. The yellow pine and oak logs, hewn to twelve inches square at the butt end, were punched into the deep mud in eight parallel rows about three feet apart. An average of 150 piles were driven for each pier. Ice piers previously built in the Delaware were of stone and stone-filled crib construction; Major Bache had proposed using hollow cast iron screw piles for Reedy Island Harbor and, as recently as January, 1853 Major Sanders had sought information upon which to estimate the probable cost of wooden piers filled with stone. Undoubtedly, the simple arrangement employed, of wood piles clamped and braced, was never regarded as more than an initial phase of the installation.

The work season carried late into cold weather to complete driving the piles for the lower harbor line and for piers No. 1 and No.



Chief of Engineers Annual Report, 1879

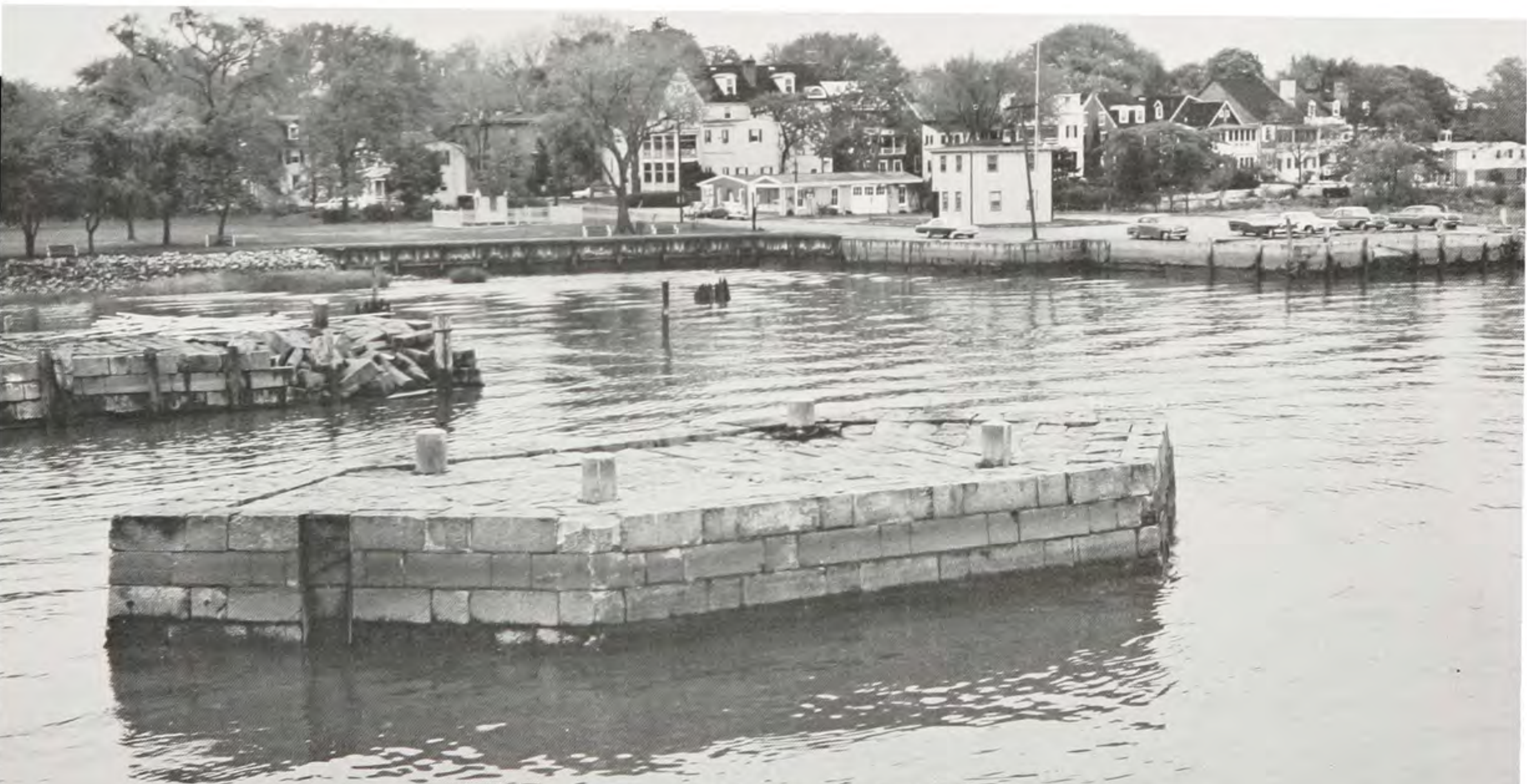
2 of the upper line. All work was suspended two days before Christmas and the crew of 70 workmen departed the island, leaving only a watchman. A balance of $3,611 remained for for the project. In summing up the year's operations Major Sanders wrote: *"This ice harbor in its present incomplete and unfinished state will prove to be, if the present winter should turn out to be a rigid and severe one, the most useful work ever built on the Delaware."*

The winter of 1853-54 was the most severe in many years. By February Reedy Island was completely submerged, the harbor works subjected to the severest battering of gales and ice; 100 vessels sought shelter below the piers. When work was resumed by a twelve man crew in April it was observed that while some valuable planking stacked on the island had floated away, the wooden piers had survived the winter with no perceptible damage. The small work force continued clamping and bracing until 22 July when operations were closed, applicable funds having dwindled to a balance of $600. The two piers of the upper line remained unfinished.

A final report headed "Condition of Piers" dated 21 Feb. 1855 lists some damage to all but three of the seven piers. No mention is made of repairs and no further appropriation was designated for the construction of Reedy Island Ice Harbor. In lieu of corroborative records one may only conjecture as to the reason for abandoning Reedy Island Harbor in a time when appropriations were being continued for New Castle, Chester and Marcus Hook. Compelling factors may have been its extreme susceptibility to shoaling and the prohibitive cost of the deep water dredging necessary to maintain its usefulness. A chart of Reedy Island dated 1872 demonstrates the harbor's obsolescence after only 18 years; seven "old piers" are located in depths which, according to the updated soundings, render the area useless as a haven for shipping.

Typical top course features are the mooring posts, butterfly key headers and wrought iron ties for the outside stones.

Twentieth century Newcastle Harbor has 1875 ice pier in the foreground, 1854 pier at left beyond.

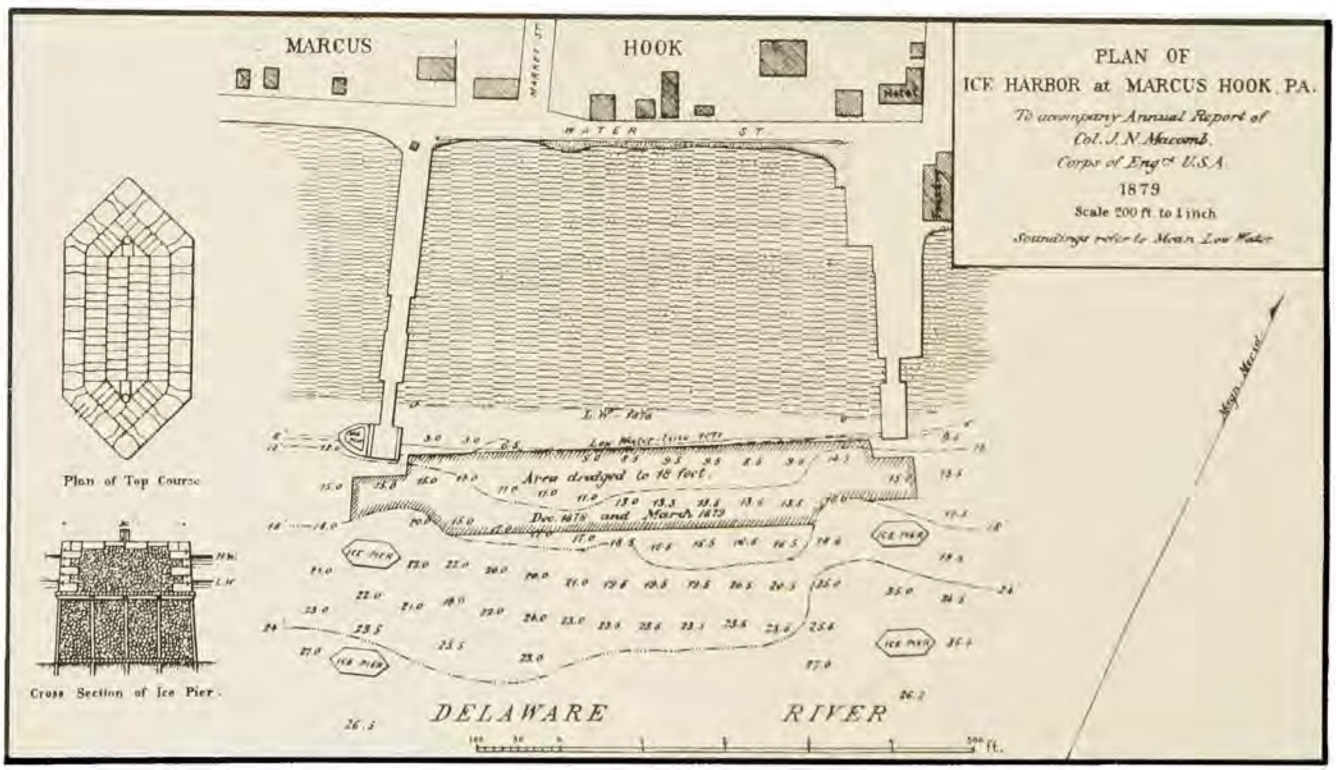


The ice harbors at New Castle and Marcus Hook appear to have been the most useful of those built on the Delaware. Construction of a final pier for New Castle Harbor was proposed in 1879; Marcus Hook Harbor was considered to be complete in 1889. The annual costs of maintaining the two were deemed trifling compared to the benefits rendered to shipping. The first harbor works at Marcus Hook were installed by the Commonwealth of Pennsylvania in 1785 in the form of continuous timber piers extending out from shore. These works were ceded to the United States prior to 1829, in which year the Engineer Department executed repairs and harbor clearance at a cost of $5,000. Construction of detached, masonry-capped piers was begun in 1866.

As late as 1882, funds were appropriated for "commencement of work on an ice harbor at the head of Delaware Bay." Twenty five thousand dollars was expended on surveys and removal of sunken piers, remnants of John Sanders' old Reedy Island ice harbor and some ancient crib piers in the back channel off Port Penn. Site plans shifted about and became lumped together with considerations for a proposed Reedy Island dike, a project which aroused much opposition from riparian Delawareans. By 1885 no site had been selected; the estimated $406,000 cost loomed large and the District Engineer proposed postponement until "the Reedy Island dikes are completed and the river in their vicinity has reached its fixed regimen."

This final ice harbor did not materialize; the Delaware River navigation channel took preference in the planning of subsequent years, with highest priority for appropriations. Ice Harbors were anachronisms in the lexicon of an approaching twentieth century.

Not for many years has the Delaware River frozen over between Philadelphia and Camden. Steel-hulled vessels incur little or no risk of damage from running ice in the Delaware today. The surviving ice piers are rugged relics of another time, other values, and just occasionally with a heavy fog are a navigational nuisance.

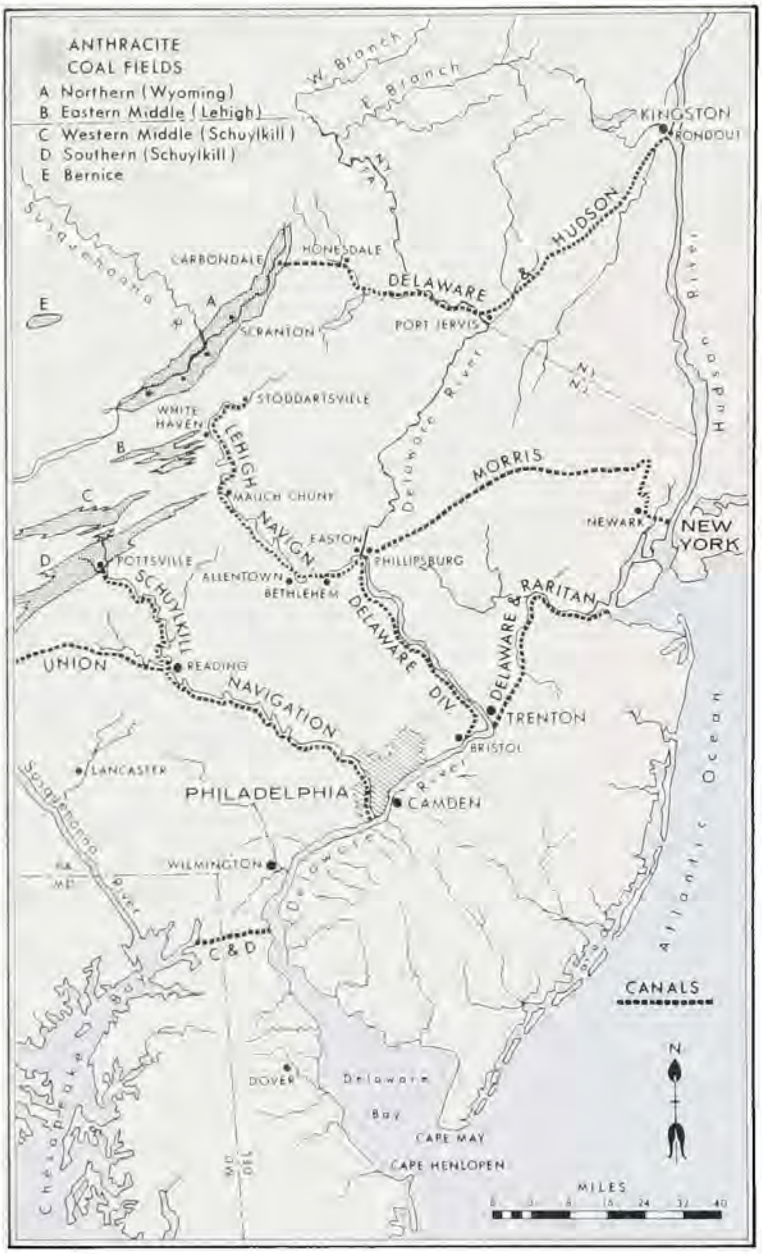


Chief of Engineers Annual Report, 1879

THE UPRIVER CANALS

The impact of canals on the American scene can be assessed most effectively by reference to a historic timetable. The American pioneer canal era belongs to the early Nineteenth Century; removed from this context any effort to evaluate it results in distortion. The early developers and their principles ranged the human gamut from lofty public interest to the barest self-serving greed. Politicians lauded or denigrated programs for traditional political motives. Many of the early works thrill by the daring of their concept, and the aptness of their solutions. Others were ill-timed, ill-conceived and wasteful, and not a few were products of engineer virtuosi with a Mt. Everest syndrome, who did it "just because it was there."

The canals served the needs of the people when those needs were for communication, expansion, growth and development. That they served well their very obsolescence attests, for their essential product was an acceleration in the momentum of living and a new climate of progress which could be supported only by more evolved systems replacing the old. Though blundering, extravagant, wasteful and frequently scandalous — they were successful in this: They laid the considerable foundation for all future American transportation systems, which bound and strengthened a developing Nation.



The upriver canals eventually hauled every kind of cargo, but their motivating purpose was transportation of coal from the anthracite fields of Eastern Pennsylvania to the large city markets.
Although separately owned and operated, the several links of the network developed into a system of interdependent common waterways.

Union Canal[1]

A limestone bed situated west northwest of Reading, Pennsylvania will be part of the storage basin for some 4.7 billion gallons of water when Blue Marsh Dam is completed. Concerns of Philadelphia District engineers in this area today are akin to those experienced by Union Canal engineers in 1824, when Loammi Baldwin and Canvass White had to solve the problems posed by the filtering characteristics of the limestone base. The old Union's 77-mile ditch and 91 locks are long abandoned and the eight miles of its blurred remains in the Reading limestone area will soon be submerged by the waters of the Blue

Schuylkill Navigation lock below the falls at Fairmount, Philadelphia, as it appeared just prior to its removal. The site is now occupied by the Schuylkill Expressway.

Marsh impoundment. Still surviving, are records of those early engineers' solutions to problems which, in the context of their times, seem staggering.

The Union Canal was one of seven upriver pioneer navigation routes undertaken within the precincts of the District in the initial period of the Country's internal improvement. Six of these (the Union excepted) comprised the Country's first network of transportation routes devised as a system. The system's intended function was primarily to haul coal. Today its function is superseded, its facilities outmoded, but the purpose for its creation and the genius which planned it provide background and a credible link to the wonders of modern engineering. Canvass White did not succeed in finding a solution to the leaky limestone bottom — a solution quite accessible to today's engineers, backed by experience in geology, hydrology and soil mechanics. White's answer was to provide more and more water. A 45-foot high dam was built across Swatara Creek, creating a reservoir with an area of 700 acres, from which water was pumped into a 22-mile feeder canal starting at Pine Grove and emptying into the summit level at West Lebanon. Along with this virtuousity White produced another showpiece in America's second tunnel, then the longest at 729 feet. The purpose of the tunnel was not showcase, but avoidance of a costly series of locks over a long ridge which could not practically have been skirted.

The original purpose of the Union Canal was the transport of farm produce, lumber, food commodities and general merchandise. Coal, the prime cargo and motivation of the other six upriver canals, was generally unknown in 1762 when the Union's first route was surveyed between Middletown and Reading under charter of the "Schuylkill and Susquehanna Canal." In 1831, its fourth year of operation[2], it still carried more grain, iron, whiskey and lumber than coal, although huge quantities of anthracite had been streaming down the adjoining Schuylkill Navigation since 1825. The small locks, 8-1/2 feet wide and 75 feet long, could not accommodate the coal boats of the Schuylkill, where locks were twice as wide and 90 feet long. It is said that the first boats to ply the Union Canal were built six miles away and hauled to the water on hay wagons. Although enlarged in the 1840's the Union remained a secondary traffic route.[3]

Benjamin Franklin was writing from London to S. Rhodes, the Mayor of Philadelphia in 1772 when he offered his opinions concerning certain contemplated canal works. With special reference to the projected Schuylkill and Susquehanna (later Union) he wrote:

> *"I think it would be saving money to engage by a handsome Salary an Engineer from here who has been accustomed to such Business. The many canals on foot here under different great Masters are daily raising a number of Pupils in the Art, some of whom may want Employment hereafter, and a single Mistake thro' Inexperience in such important Works, may cost much more than the Expense of Salary to an ingenious young Man already well acquainted with both Principles and Practice."*

The "single mistake" in the Union's planning was in the restricted scale of the lock chambers and channel prism. The choice was made deliberately by an ingenious young man of considerable experience, governed principally by the prospect of a strictly limited water supply. White had theories, too, about the need for a line of small vessels, to carry loads which would exact light tolls and attract a great volume of light traffic. This could happen only while the canals held sway as the supreme transportation medium. When railroads began to compete, inroads were first made on the canals' light freight and passenger business. The survivor canals were those capable of remaining competitive by cheaply transiting heavy bulk freight.

In the same letter, with respect to development of the Schuylkill River for commercial navigation, Dr. Franklin expressed misgivings:

> "*. . . Locks in Rivers are subject to many more Accidents than those in still water Canals; and the Carrying away a few locks by Freshets of Ice, not only creates a great Expense, but interrupts Business for a long time till repairs are made, ... Rivers are ungovernable things, especially in Hilly Countries. Canals are quiet and very manageable.*"

Schuylkill Navigation

Franklin did not live to see the completion of any of the canal projects which had captivated his interest. The Schuylkill River was developed between 1816 and 1825; it was called the Schuylkill Navigation and consisted of a series of slackwater pools, dams and short canals. As Poor Richard might have predicted, it underwent numerous changes, most occasioned by the seasonal rampages of the river itself. In 1825 its length was 108 miles from Mount Carbon to Philadelphia, with 38 dams and 116 locks. By 1905 navigation had been curtailed above Port Clinton, reducing its length to 90 miles. There remained 19 dams and 44 locks, some of which had been rebuilt several times.

A renowned feature of the Schuylkill Navigation was the first tunnel built in the United States, a 400-foot shaft through the end of a low ridge just above Pottsville. An object of curiosity and tourist interest, for which it was obviously intended, its excavation could have been avoided by a minor shift in the channel's course. Of more than passing interest are the names of the three brothers who contracted to build it: Job, Samson and Solomon Fudge.

Lehigh Navigation & Coal Co.

Some of the early river "improvements" could more accurately be termed exploi-

Josiah White

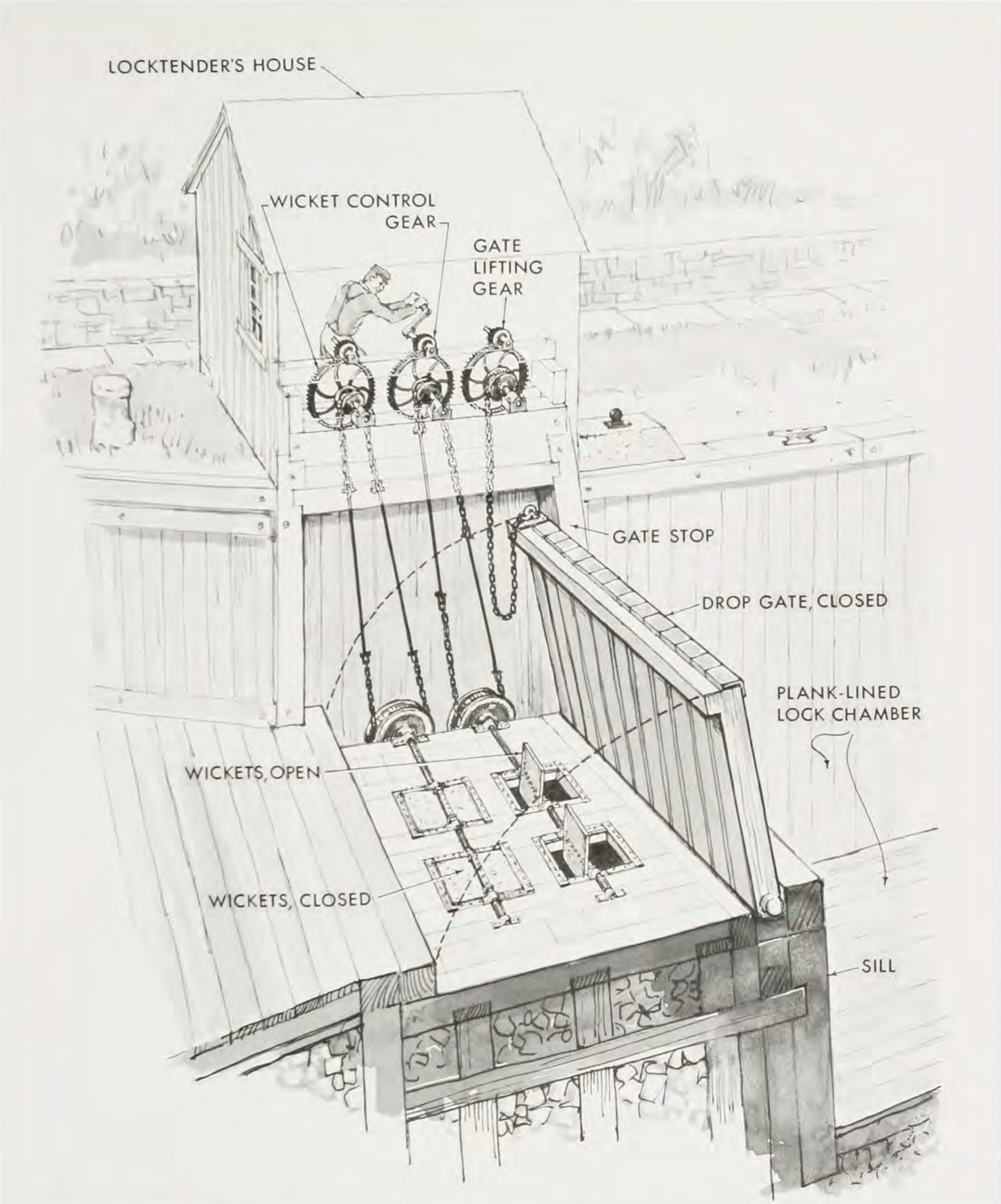
tation. The first works on the Lehigh, for instance, were intended solely to facilitate the transport of coal, to the benefit of many, no doubt, but grounded more in profit than in public interest. The prospect of using the Lehigh as a navigation route required the vision and doggedness of such a rare individual as Josiah White. Rocky, full of rapids, and steeply pitched as were few other eastern rivers, the Lehigh was totally unnavigable in the dry season. With the spring thaws and autumn rains it became a raging torrent, rendering passage on it extremely perilous. Its potential as an avenue of commerce was held in such low regard in 1818 that Pennsylvania legislators only reluctantly granted White's petition to improve it, assuring him and his partners they were being allowed the "privilege of ruining themselves."

Josiah White, born in 1781, appears to have been one of those rugged pioneers, possessed of prodigious gumption and ingenuity, who shaped early Nineteenth Century events with the irresistible momentum of a juggernaut. With his partners, Erskine Hazard and George Hauto, White organized the Lehigh Navigation Company in August, 1818 and persuaded a number of Philadelphians to invest $50,000 in the enterprise on a speculative basis. Since 1817 the trio had been lessees of a charter titled Lehigh Coal Mine Company, under which 10,000 acres situated on the upper Lehigh River could be mined. The charter required rental payment of one ear of corn per year and stipulated that annual shipment of 40,000 bushels of coal to Philadelphia should begin within 3 years.

White and Hazard explored and surveyed the river from Stoddartsville to Easton in the Spring of 1818, on foot and using levels borrowed from a Benjamin Morgan. Their first idea was to narrow the channel and thus raise the water level, by piling stones along the sides of the stream. This scheme was quickly replaced by a plan which White called his "system of artificial freshets." Dams of timber cribbing and rock were built across rapids; these dams were shaped in a vee pointed downstream with a gate at the vertex. A succession of dams formed a series of pools in steps. Loaded coal arks were passed through the gates[4] as the next lower pools became sufficiently filled. Construction was begun in the summer of 1818 with a crew of 13 and White himself the hardest worker. "I was in the water as much as out of it for about 3 seasons --- my cloths dried on my back." By the end of summer the work force numbered seventy.

River arks were 16 to 18 feet wide, 25 feet long, of rough timber reinforced with iron work. It was soon found that hitching boats together would increase profits. Eventually, strings of arks up to 180 feet long were floated down to the Philadelphia markets. After delivery of the cargoes the arks were broken up, the lumber sold and the iron work carried back upriver with the boatmen on Company wagons. This crude type of navigation was continued through 1824. That year the Lehigh boatmen delivered 9,500 tons of anthracite to Philadelphia and the market demand was increasing. The imminent completion of the Erie Canal was stirring expectations of great prosperity and surveys had been made for the Morris Canal, which would start at the mouth of the Lehigh and cross New Jersey from Phillipsburg to Newark Bay.

The partners decided they needed a canal; the growing demand for coal could not be



Introduction of the drop or fall gate brought a great improvement to canal operation. Its origin is attributed to the "bear trap" gate first used by Josiah White in 1818 on the Lehigh River. Eventually, the drop gate became the standard head gate for the locks of most American canals.

Each canal had its own variation of this basic arrangement. When closed, the gate was held in place by the head of water. The wickets were opened to admit water to the lock through sluices in the sill. When the water level in the lock reached the upstream level and pressure was equalized, the seven-to-eight ton gate dropped by gravity to its open position on the top of the sill.

In this conjectural rendering the near wall of the lock and part of the locktenders' house are omitted.

satisfied by the precarious open river navigation. Accordingly, new funds were raised and Canvass White was engaged as chief engineer. With Josiah White as superintendent the construction got started in 1827. The Company was then known as the Lehigh Coal and Navigation Company and had thus been incorporated in 1822. Under this name the Company still operates, one of the oldest corporate entities existing in the United States.

The new work followed the system used on the Schuylkill Navigation: dams, slackwater pools and canals with locks. From Mauch Chunk to Easton 37 miles of canal were constructed. In this reach there were pools for a cumulative length of 9 3/4 miles. On the upper reaches, Mauch Chunk to White Haven (24 3/4 miles), and thence 13 1/2 miles to Stoddartsville, the old system of navigation was maintained. The canal had a surface width of 60 feet, bottom width of 45 feet and a depth of five feet. The locks were 22 feet wide, 100 feet long and were built of stone found along the river. A fortuitous asset to the project was the discovery of large deposits of limestone suitable for processing into hydraulic cement. A mill was set up by the Company at Lehigh Gap (now Palmerton) where the rock was of superior quality. Samuel Glace operated the mill from 1826 to 1830 and later operated another cement mill at Siegfried's Bridge (now Northampton). Glace was a section supervisor on the Canal until 1841. From his records we learn that the stone was roasted in "draw kilns," crushed by a "machine like a corn crusher" and ground like grain by burr millstones. The cement was hauled in scows to wherever needed on the canal; much of the mill's output was used to bond the native stone of the locks. Lehigh cement would become a huge industry in the valley; in 1837 Seigfried's Bridge Mill had a capacity of 10 barrels per day.

The canal was completed in July 1829; the packet boat "Swan" was put into the canal the same day the water was introduced. Two days later several coal barges arrived at Easton and the price of coal dropped. Cost of the canal was $800,000. In 1830 the Canal hauled 41,750 tons of anthracite. A year later the last of the arks made the trip. Seventy thousand tons were hauled in 1832, the year the Delaware Division Canal opened between Easton and Bristol.

Disaster struck in January, 1841 with the worst flood of record in the Lehigh Valley. Destruction of the canal works was almost total. Josiah White, age 60, moved through slush and snow for two days examining a 34-mile stretch of devastation between Easton and Lehigh Gap. His decision was to rebuild, but his stockholders viewed the situation as hopeless. To raise money the company mortgaged all of its assets. Reconstruction was started immediately and the company was back in business within two years, after spending $600,000 on repairs.

Josiah White died in 1850 in his seventieth year. His life and interests had spanned the eras of the turnpike, the canal and the railroad. All three had benefited from his ingenuity and drive. White had lived to see the Old Company exceed an annual haulage figure of 700,000 tons of anthracite. The first train of the Lehigh Valley Railroad ran from Easton to Mauch Chunk in 1855. The road was built by another man who was going places, Asa Packer,[5] former boatman and miner with the Canal Company. Annual tonnage figures continued to soar despite the railroad's competition, reaching an all-time peak of 1,338,375 tons in 1860, a year which records 2000 boats in operation on the Lehigh.

The flood of 1862 destroyed the dams above Mauch Chunk had caused abandonment of the reach to White Haven, a section which had always been most difficult to navigate. Reconstruction was contemplated, but recent legislation prevented it, the lawmakers contending that collapse of the upper dams had been responsible for the disastrous flooding. By 1923 silting due to mine outwash caused partial curtailment of traffic between Mauch Chunk and Slate Dam (formerly Siegfrieds Bridge), a distance of 23 miles or one-half the remaining canal. In 1924 one hundred thousand tons of anthracite coal were hauled by canal; dredges, operating above Slate Dam for the same period recovered 175,000 tons of slack coal from the river bottom. In December of 1931 the last "*Chunker*" of the Old Company made the trip down to Easton, then through the Delaware Division Canal to Bristol.

Delaware Canal

Contrary to Josiah White's advice, the Delaware Canal[6] was not constructed after the pattern of the Lehigh and Schuylkill systems. Its 60-mile length was man-made channel all the way. To White's keen disappointment, completion of the Delaware Division lagged several years behind the opening of his Lehigh Navigation, causing serious revision of plans; arks had to continue in use for the river haul below Easton; attention had to be given the leaky channel and barges of special design had to be furnished for passage through the narrow Delaware locks. This link in the system was strategic to the efficient operation of the anthracite line to Philadelphia. White's recent appointment as Canal Commissioner for Pennsylvania gave added meaning to his concern for the canal's efficient performance.

In order to supply adequate draft for 100-ton barges it was found expedient to add thirty inches to the height of the banks. Lehigh cement was brought down to plug up the leaks, some of which were due to shoddy workmanship. Although a boat had made the passage between New Hope and Bristol in December of 1830, that section of the canal (about one-half) was not opened to traffic until 1831. Digging had begun at Bristol in 1827 and had progressed favorably across the nearly flat terrain, one section of which, below Yardley lock became known as "seven mile level." From New Hope northward the going was more difficult. Nine aqueducts were required to carry the channel across streams and guillies and a greater amount of digging was required through the hill country. For miles the channel edged narrowly between river and bluff and at Nockamixon Narrows one of the double locks appeared dwarfed beneath a sheer cliff of shale 500 feet high.

The canal opened for business in September, 1832. Water was received at the Easton summit from the impoundment of a low dam across the mouth of the Lehigh River. From this pool an outlet lock gave access to the Delaware River and to the entrance of the Morris Canal on the New Jersey side. The Morris had begun operations only a few months previously. The drop from Easton dam to tidewater at Bristol Basin was 165 feet, an average of seven feet for each of the 24 locks. A junction was made with the Delaware and Raritan Canal in 1840; using a current-operated cable crossing between New Hope and Lambertville, boats were able to enter the Raritan feeder and shorten the route to Trenton, New Brunswick and New York. At New Hope, a wing dam and liftwheel were installed in the river to raise water to the canal. The statistical record of the Delaware Canal is largely a carbon copy of Lehigh Navigation figures, since its prime cargo was anthracite, its major function an extension of the route from the mines to Philadelphia. The fortunes of the two lines became inextricably linked.

The Delaware Canal entrance at Easton was a teeming transportation junction. Its gates gave access to the traffic of three canals, the Lehigh, the Delaware and the Morris and admitted feed water to the high level of the Delaware Canal. Three railroads rattled overhead on bridges spanning the canal and the Delaware River. The Easton locks were restored recently and a museum of canal memorabilia was installed nearby.

The "protected" channel of the Delaware Division was vulnerable to the same great storms that nearly wrecked the Lehigh in 1841 and 1862. David Connor, superintendent at Easton reported to the Canal Commissioners on 9 January 1841:

> "...*The water in the Delaware and Lehigh Rivers rose so rapidly on the eve of the 7th inst., and speedily inundated the lower part of our town, so that it is with difficulty that those living in that section escaped with their lives, their property nearly all destroyed. The Delaware rose to the unprecedented height of 32 feet, which is seven feet higher than it was ever known to have been within the recollection of the oldest inhabitants. The bridge across the Lehigh at this place has been swept away, and in fact every other bridge on the Lehigh so far as we can learn...*"

Superintendent Harmon reported:

> "*I hasten to inform you that we have one of the most awful rivers that has been known by our oldest residents...it has swept all before it. All the bridges from Easton to Trenton are swept clear. Houses and barns and even men were swept down the furious element.*"

Damage to canal installations was extensive. The Easton dam stood up, though impaired, but the basin embankment, lock house, collector's office and outlet lock were washed away. Stretches of channel were filled with debris and wrecked boats; the river side embankment was breached in many places.

The Delaware Division resisted change right up to its final years. A major expansion of its works was never undertaken as had been done on other canals. The locks were of two sizes: 12 single locks 90 feet long and 12 feet wide and 13 double locks 90 feet long and 22 feet wide. Experiments with steam traction, attempted in the early 1900's, revealed that even minimum speeds of tugs caused a wave wash highly injurious to the canal banks. The plodding mule retained the tow line to the last trip. The canal had various owners other than the Commonwealth of Pennsylvania. It went to the Sunbury and Erie Railroad in 1858 and soon thereafter came under control of the Delaware Division Canal Company.

In its last years it was operated by the old company that had always been its nearest concern, the Lehigh Coal and Navigation Company. Following the close of business in 1931 the Old Company returned it again to the Commonwealth, which has designated it a State Park and has undertaken its preservation and restoration.[7] Preserved along its route, together with the locks and ditches, waste gates and bridges are the splendid scenic setting and the history, lore and legend with which the very soil and air seem impregnated. To walk its banks in a fair season, to breathe hay-scented air of a gentler time - the handwrought, time worn appurtenances induce a kind of bucolic rapture and a hundred or more years fall away.

Morris Canal

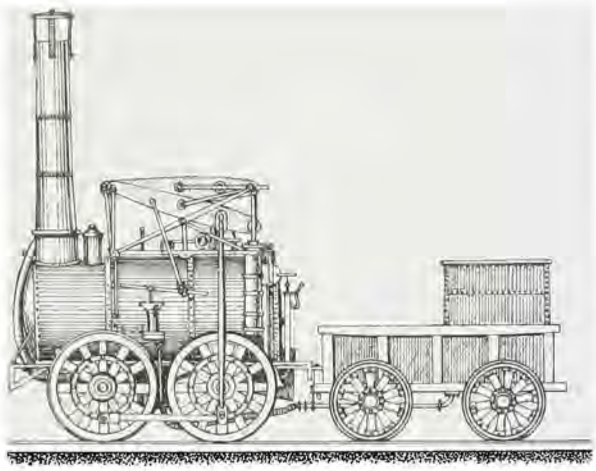
Another in the chain of anthracite waterways, the Morris Canal was completed in November, 1831, a few months ahead of the Delaware Division Canal. Among the old canals the Morris attained the third highest altitude:[8] 913 feet above sea level at its summit near Lake Hopatcong. Its fiscal career followed a less elevated course, trending

A freight boat begins the ascent of an inclined plane on the Morris Canal at Boonton, New Jersey. As an alternative to surmount this lift of 82 feet, nine or ten locks would have been required.

rather downward from the outset. The basic error made in laying out its original structures was a repetition of the Union Canal's costly mistake. Only the reason was different. The anticipated potential water supply for the Morris far exceeded its needs; the small channel and locks were the result of a dearth of funds - not a lack of water.

English engineer James Renwick resolved the grade problem by adoption of a system of inclined planes, twenty-three of which were required to surmount the major elevations. An equal number of conventional locks negotiated the lesser grades. The canal's circuitous course stretched out 102 miles from Phillipsburg to Newark Bay for a route which measures 55 miles by air. The channel section was 32 feet wide at top, 20 feet at bottom and four feet deep. Robert Fulton, ten years deceased, had endorsed the use of inclined planes, which he predicted would replace canal locks, and by which "the most mountainous region and the most appalling elevations will be traversed with ease." Inclined planes did, in fact, prove to be more efficient and less expensive than locks, at least in the case of the Morris. Lifting power was provided by turbine water wheels fed by Lake Hopatcong's prodigal supply.

The Morris Canal and Banking Company went into bankruptcy in 1841, only ten years after the Canal's opening. Reasons for its failure included spurious promotion of the project's assets and potential, leading to the disenchantment and eventual desertion of financial backers; wildcat speculation and



The Stourbridge Lion, first steam locomotive to run on rails in the Western Hemisphere.

certain criminal promotion schemes carried on by the Banking Company. For three years the canal existed in a kind of limbo, operated by transient lessees. A new company was formed in 1844 and the canal was given a needed refurbishing. Enlargement of the locks permitted transit of 44-ton boats, the former capacity having been 25 tons.

Renovations made between 1847 and 1860 boosted handling capacity to 60 - 70 ton units by rebuilding the planes and replacing hemp rope with wire hoisting cable. Tonnage for 1860 was 707,631; the total for 1845 had been 60,000 tons. The new improvements were effective, but historic hindsight tells us they were too late. A scant half dozen years remained to reach the peak of traffic: in 1866, 900,000 tons, mostly anthracite, were hauled. At this time freight trains of the Lehigh Valley Railroad could complete in eight hours a trip requiring more than four days for canal boats. In 1871 the Lehigh Valley Railroad took a lease in perpetuity on all the properties of the Morris Canal and Banking Company. Traffic dwindled thereafter to 90,000 tons in 1902, and a year later the State of New Jersey assumed control of the canal works. In 1924 the State ordered the canal's elimination. The work of effacement was thorough.

Delaware and Hudson Canal

The original plan of Benjamin Wright and his survey engineers John L. Sullivan and John B. Mills was to use slackwater navigation on Lackawaxen River between Honesdale and the Delaware River. Economy dictated this plan and others, namely to terminate the canal at Honesdale, 17 miles short of the mines and to build the locks of wood. Fair fortunes and good management favored the Delaware and Hudson from the beginning. Good luck in the form of cement, discovered in Lower Rondout Valley, brought about a timely decision to build the locks of stone. Addition of John B. Jervis to the staff secured the valuable engineering experience of yet another Erie Canal man. Initially assistant to Chief Engineer Wright, he quickly succeeded to the Chief's post, as that busy man moved to other projects. A review of the Lackawaxen's characteristics persuaded engineers that slackwater navigation was impracticable. The decision was made to cut a canal along the entire route.

The canal's length was 108 miles, of which about 60 miles were in New York State, between the eastern terminus at Rondout on the Hudson River and Minisink Ford on the Delaware above Port Jervis, where it crossed the Delaware by means of a dam and slackwater—and later, by a unique suspension aqueduct. Here, at the mouth of Lackawaxen River, the canal started its steady climb to Honesdale. The last leg of the route, 16-7/8 miles across the 850-foot high watershed divide, was traversed on rails by John Jervis' ingenious system of inclined planes. Five of the planes powered by stationary steam engines, covered the ascending trip to the mines at Carbondale; descending, the loaded cars rolled by gravity down three planes, one of which had a pitch of 500 feet to the mile. Jervis devised a propeller of canvas on frames and mounted it on the cars, so articulated to the running gear as to effect a reverse rotation of the propeller and drag the cars' speed down to an average four miles per hour.

The men who guided the affairs of the D & H through the early years seem to have been a consistent breed. Single-minded, long-headed and tenacious, all apparently concentrated their undivided efforts on financial success: the Wurtz brothers, William and Maurice, who bought Wyoming coal lands in 1812 at prices of $.50 to $3.00 per acre; who hand-mined the black stones and with fanatic zeal expounded their excellence to Philadelphians and New Yorkers; Phillip Hone, the Company's first president and subsequent Mayor of New York; John, the third Wurtz brother and second president, whose administration (1831-58) went through a business depression, miner's strikes, competition wars and a cholera epidemic and saw the Company reestablished, paying an eight percent dividend in 1839 and on the way to prosperity.

Consistent too were the Erie engineering talents: White, Mills and Jervis; and later on, President Bolton and engineer Horatio Allen. Their basic formula for success may have been grounded in the strategic timing of major company's moves. The original canal, built between 1825 and 1828, had prism dimensions of 32 to 36 feet at waterline, 20 feet at bottom and was four feet deep. Its 110 locks had an average lift of ten feet, accommodating 30-ton boats. The Canal was twice rebuilt, eventually enabling it to handle vessels with a capacity of 140 tons. These same men engineered improvements on other canal projects which had subsequently languished; with the D & H each change was followed by a spectacular increase of business. From a depression year low of 43,000 tons in 1834 the Company began its uninterrupted climb to the highest annual tonnage in the canal's history: 2,930,333 tons in 1872.

Two years prior to that peak year the Delaware & Hudson purchased the Albany and Susquehanna Railroad. Typically realistic, the Company prepared to phase out a transport system which was showing symptoms of obsolescence. Railroads were everywhere proving their value and the D & H was in the "Lackawanna Coal" business - not the canal business. Their first railroad venture had been similarly unsentimental. In August 1829, Horatio Allen had tested the famous "Stourbridge Lion" at Honesdale, Pa. The trial runs of the English-built locomotive over the gravity railroad's tracks of hemlock stringers and strap iron were reputedly the first operations of any railroad locomotive in the United States. The tests proved the eight-ton engine too heavy for the railway; the cost of rebuilding the road was considered exorbitant. With a practical sense of unhistory the "Lion" was dismantled, its boiler sent to work in the Company shop at Carbondale and the rest of it left to rust in a shed alongside the tracks.

With the letting of contracts on 5 October 1870 for construction of the Lackawanna and Susquehanna Railroad the D & H launched into a program of railway construction and acquisition, accumulating 900 miles of railroad by 1930. The anthracite business was better than ever, but the canal had become an unnecessary burden. In April 1899 the New York State Leglislature permitted abandonment of the canal works and excision of "canal" from the corporate name. In June of that year, Mr. S.D. Coykendall of the Cornell Steamboat Company bought the Canal for $10,000.

John Roebling designed the suspension aqueduct which carried the Delaware and Hudson Canal across the Delaware River at Lackawaxen, Pa. Built in 1847, it bore boat traffic until the canal was abandoned in 1898. Today, stripped of its wooden trunk, it serves as a link for vehicular traffic between New York and Pennsylvania.

Today, little remains of the upriver canals except pictures, records and a few vague ditches and crumbling locks. Commerical navigation and passenger transport are minor considerations in the new plans for exploiting the basin's tributary streams. While on another plane, the new projects are no less vital to the region's economic and sociological well-being than the 19th century canals had been. The projects, including protection against floods and pollution and maintenance of area water supplies, continue the tradition of stream utilization for the public good.

REBUILDING FORT DELAWARE

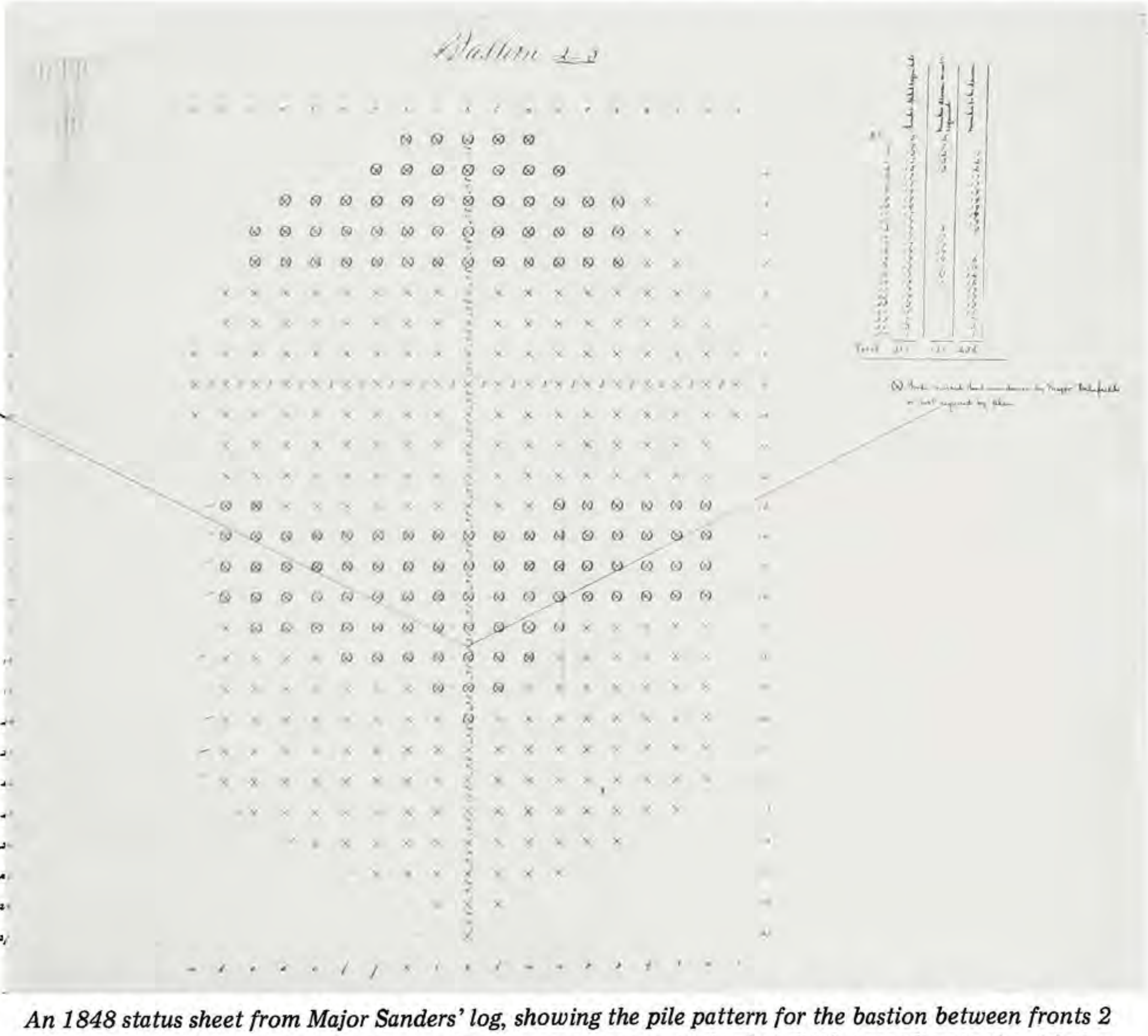
Pea Patch Island has had many shapes, has always been vulnerable to the alternate scour and shoaling action of the tides and currents. Its meager "fast land"—about 80 acres—was once contained by a stone-revetted dike; in 1863-64 it impounded 12,000 war prisoners, damply, on its "general level three feet below low watermark". Major John Sanders started the building of Fort Delaware in 1848 on "this mud island, upon which there is no stability" and died here ten years later, the work still unfinished.
An eighteenth century legend tells of a vessel laden with peas which foundered and broke apart on a submerged shoal; the cargo sprouted, the vines flourished and collected mud to raise an island — Pea Patch Island.

An alluvial mud shoal in Delaware River about a mile from Delaware City is intersected obliquely at its base by very ancient channel tracings of sand and gravel, probably pleistocene. In 1834 the depth of mud over the sand stratum, as determined by borings, was more than forty feet. Before that the shoal had grown to a few feet above mean high tide and was shown on maps as Pea Patch Island.

The compressible mud bank was selected by the War Department as the site for a large modern fort. A structure erected here between 1817 and 1825 by Major Samuel Babcock deteriorated because of inadequate foundations, its walls suffering "great and unequal subsidence;" its destruction was further advanced by fire in 1831. Captain of Engineers, Richard Delafield, was assigned in 1833 to reconstruct Fort Delaware, along with other area duties. In April, Captain Delafield wrote to his Chief, General Gratiot, from Cumberland, Maryland requesting $10,000 to be used for taking down old work and erecting temporary quarters and workshops on Pea Patch Island.

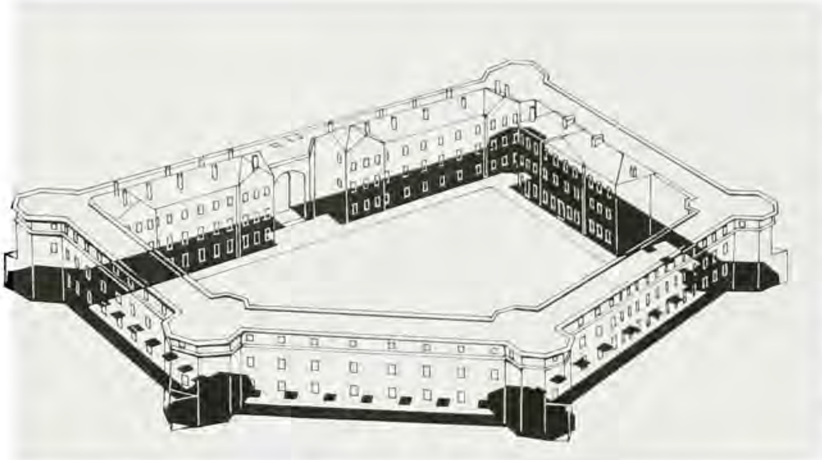
Cumberland was a junction point on the National Road[1] then under construction; the second east of the Ohio River was in Captain Delafield's charge. An Engineer Officer's field assignment in the 1830's covered a variety of duties similar to those of today's District Engineer. Supervision and administration of harbor improvements at New Castle, Chester and Marcus Hook and works at Fort Mifflin were some of the area responsibilities. Before summer of 1833 a work force of 100 men was on Pea Patch Island, employed primarily in razing the remnants of Major Babcock's fort and making protective works around the island against tidal inundations. On 18 April of that year, general order #32, done under the hand of Major General Macomb, declared that the fort on the Pea Patch should thereafter be known as Fort Delaware.[2] The site was visited on 2 July 1833 by a lawyer who demanded a list of the island's tenants. He was declined by Mr. Belin, Captain Delafield's able civilian assistant, but promised on departure that he would return in a few days with a "writ of ejectment." Then began the litigation for ownership of Pea Patch Island between the State of Delaware and New Jersey Proprietors. While legal opponents were lining up, work continued at Fort Delaware; 1,095 piles were driven before operations were halted. Large orders for bricks and stone were sent out in July and September of 1836 in anticipation of the imminent completion of the foundation work; grillage timber was ordered in October. But progress was slowed by the singular properties of the Delaware mud. With less than one-fifth of the required piles installed, construction was suspended in 1838 to await settlement of the ownership controversy.

Brevet Major John Sanders was given the assignment of rebuilding Fort Delaware in 1848, following settlement of the drawnout case, which finally awarded proprietorship of Pea Patch Island to Delaware. Graduated second in his class from the Military Academy in 1834, Sanders directed improvements of the Ohio River above Louisville, Kentucky, 1836 - 1841, and served with honor in the Mexican War, participating in the seiges of Vera Cruz and Monterey. For "gallant and meritorious conduct" in the latter engagement, he was promoted to the rank of brevet major. Afflicted with diabetes, which he had



An 1848 status sheet from Major Sanders' log, showing the pile pattern for the bastion between fronts 2 and 3. The encircled piles were driven a decade previously by Major Delafield, according to the old plan. The new plan called for 387 piles, of which 256 remained to be driven.

Federal Records Center, National Archives, Philadelphia.



apparently contracted during the Mexican campaign, Sanders suffered from ill health throughout his long stay on Pea Patch. General Totten[3] charged his new Resident Engineer emphatically with the importance of securing an absolutely reliable foundation for the new construction, now redesigned and intended to be the largest modern fort in the country.

An inventory of materials found on Pea Patch Island as of 1 March 1848 reported considerable deterioration having taken place during the ten years since the project's suspension. The four steam engines required extensive overhaul and replacement of brass and boilers; the grillage timber, lumber and a half-dozen scows were rotted beyond salvage. Forty-two thousand feet of pile timber was mostly usable, as were 1.3 million bricks and 19 thousand tons of stone. Much of this material had to be moved as it was in the way of the new plan of excavation.

Initial diking work began with the construction of a revetted embankment around the periphery of the island for a length of one and one-third miles. For this purpose some stone was bought, with the greater part obtained from the debris of Major Babcock's old masonry. So extensive was the accumulated debris requiring removal that Major Sanders likened the site preparation to rock excavation, the conditions being, however more difficult than on a fresh site. A large work force was kept on through the first winter and excavation for the foundation was completed in April 1849. The pentagonal plan was laid out covering an area of about six acres. Captain Delafield had driven 1,095 piles of an estimated required total of 6,594.

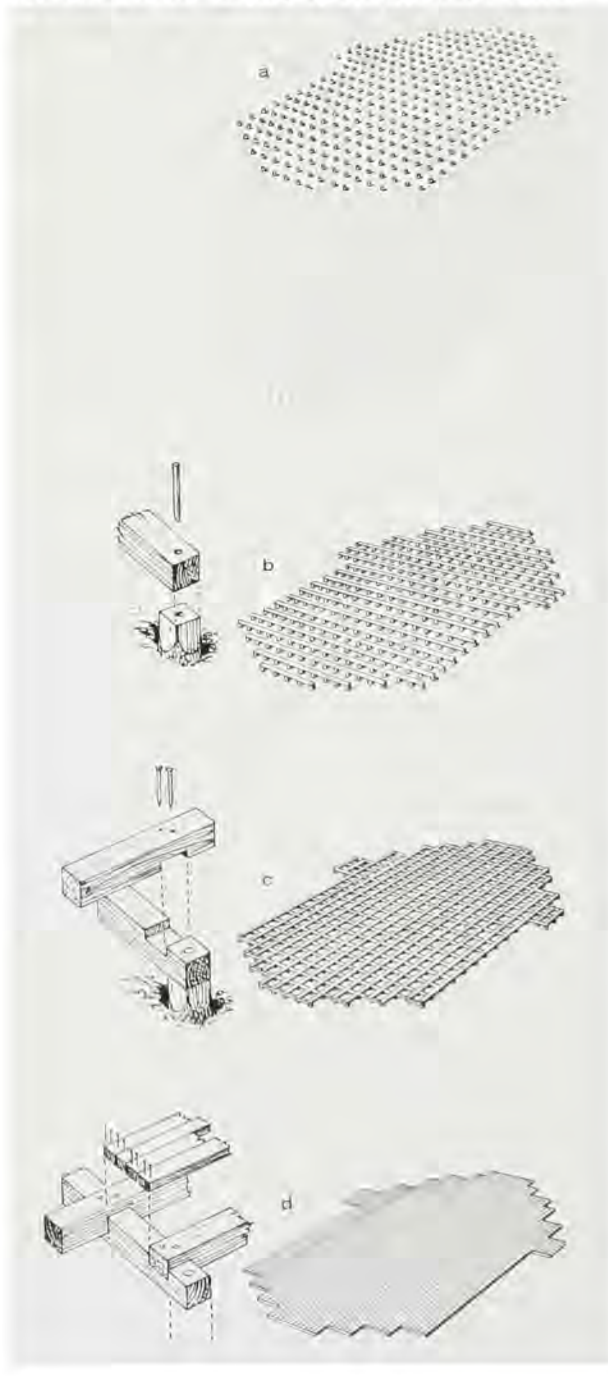
a. It required three years to complete the pile and grillage foundation. A literal forest of logs was driven into the Delaware mud, one to each 10-1/2 square feet of surface, some to a depth of 70 feet.

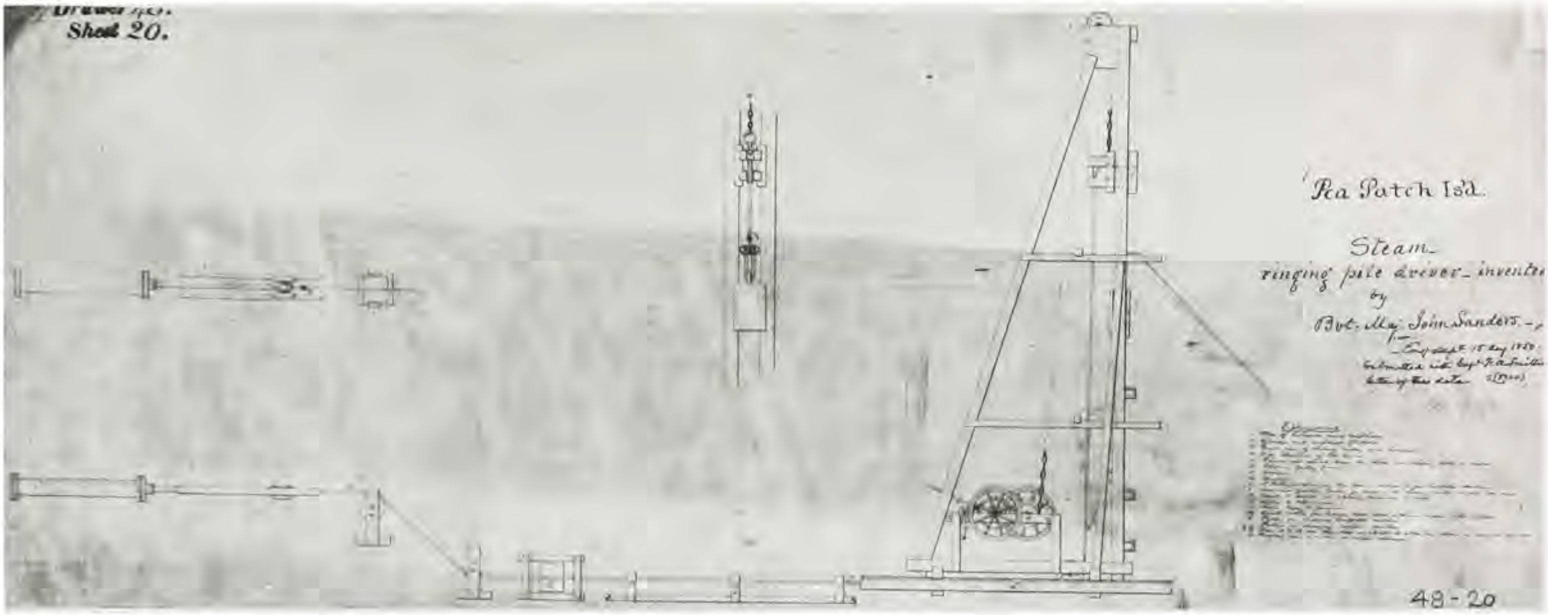
The piles were topped level; earth around pile heads was excavated to facilitate the cutting. Topping off was done by whipsaw after attempts to use a steam-driven circular saw were abandoned.

b. The lower tier of grillage was secured to the pile heads with oak treenails 18 inches long, two and one half inches in diameter.

c. Foot square timbers for the upper tier were notched and spiked to the lower tier at three and one half foot intervals, then earth was placed and rammed around the pile heads and grillage timbers.

d. Finally, four inch thick planks were spiked to the lower timbers, completing the smooth grillage platform upon which the masonry of the fort was erected.





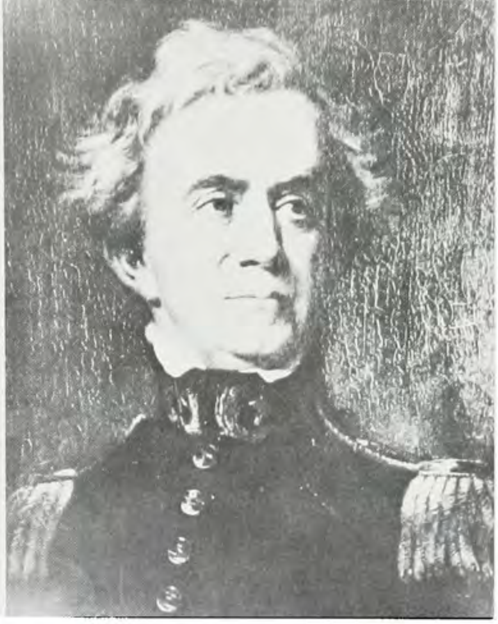
As superintending officer for the construction of Fort Delaware, Major Sanders exercised boundless curiosity and ingenuity in devising improved methods and systems for prosecution of the work. His schematic drawing of a "Steam ringing pile driver", shown here, was submitted to the Engineer Department in August, 1850. The device, capable of delivering 30 blows per minute with a 2,000-pound ram, was already in operation and would prove to be the most effective tool used in construction of Fort Delaware's foundation.

—National Archives

Major Sanders began driving piles 1 May 1849. The excavation was flooded to facilitate the work by floating the logs about and maneuvering the scow-mounted pile drivers. Logs 45 feet long of white oak and yellow pine were driven into more than 40 feet of mud and then a few feet into sand, using machinery left on the island by Captain Delafield eleven years previously. Overhauled and modified, the rigs proved adequate to the task. In October, with only 400 piles yet to be driven, Major Sanders began negotiations with Susquehanna timbermen for delivery of logs and planks for the grillage. Contracts would have to be drawn up speedily so that timber could be cut during the winter and floated down on the spring freshets. Fully anticipating an early completion of the pile-driving and confident of a new appropriation from Congress, Major Sanders strove to dovetail expeditiously all phases of the construction schedule. Stonecutters were already engaged in tooling face beds and joints on foundation stone.

The most minute data were recorded for all pile driving operations and reported punctiliously to the Chief Engineer. On the other hand General Totten allowed no doubt of his determination to avoid a repetition of the Babcock foundation fiasco. The Totten-Sanders correspondence reveals a remarkable rapport between the two officers and an awareness by both that they were venturing on relatively uncharted terrain and might be held accountable for establishing precedent text. Many testing schemes were devised; some were tried with uneven results. Piles driven years before were observed to have extruded several inches; recently driven piles could be repunched to greater depths with a small volley of blows; others seemed to subside spontaneously. Sanders reported to his Chief: "The whole matter perplexes and embarrasses me. I wait with some solicitude for your views." It was decided, finally, to re-punch every pile in the foundation using a procedure which combined mathematical formulas of Poncelet[4] and Major Sanders' own innovation, the "ringing" pile engine. The tedious work required an additional 18 months. Up to three splices, each of ten-to-fifteen-foot lengths were required for the 1,594 piles which were punched to additional depths; some were driven to 70 feet.

Susquehanna timber contractors were allowed extensions of their delivery dates, their shipments having been delayed on account of

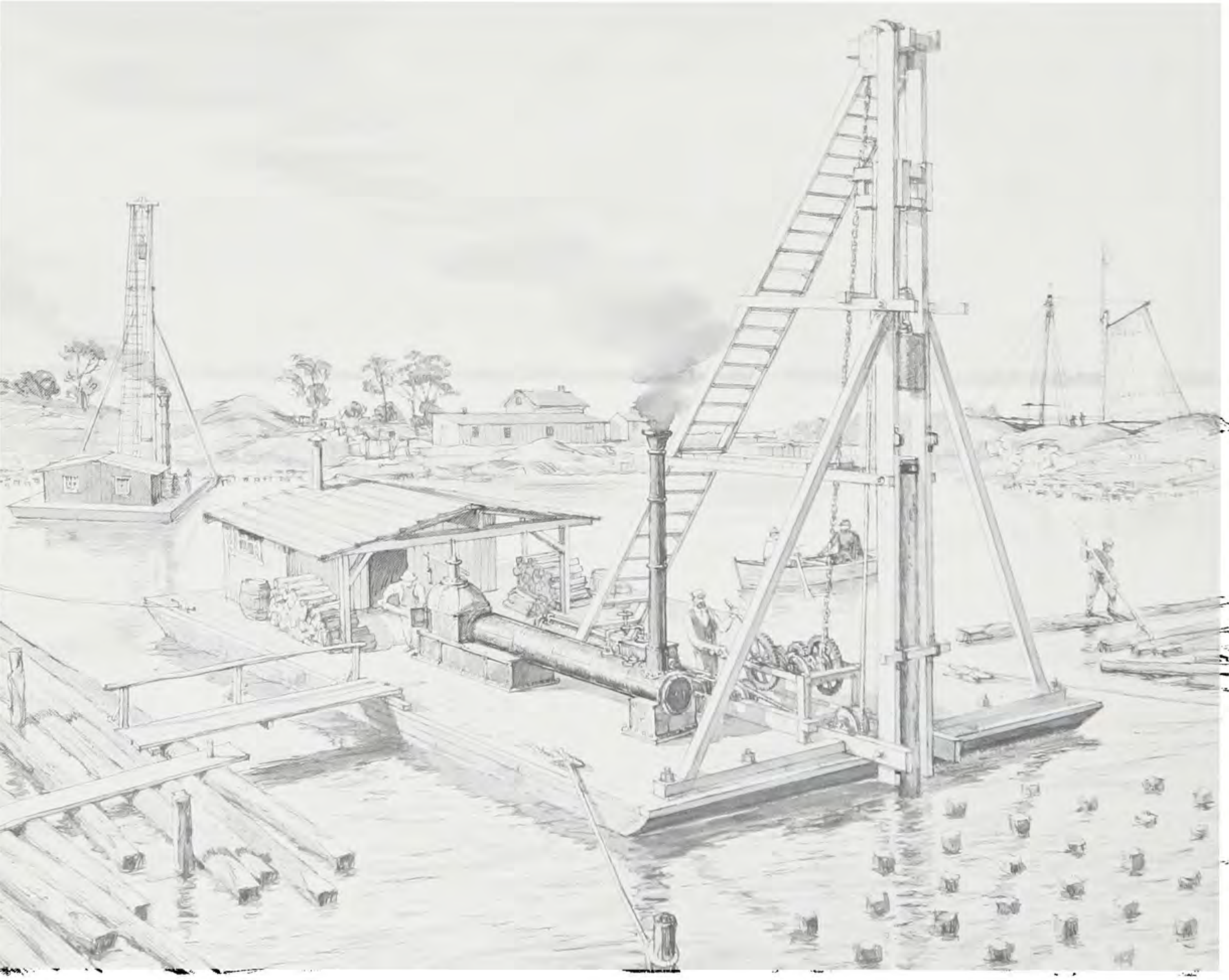


Major General Joseph G. Totten

—Corps of Engineers Museum, Fort Belvoir, Va.

Some equipment and materials left on Pea Patch Island when work was suspended in 1838 were found salvageable ten years later, when the new Fort Delaware was begun. Three of the four old steam engines were refurbished and put to work driving piles in the flooded foundation.

This conjectural view of the 1849 operations follows descriptions by Major Sanders in his reports to General Totten.



insufficient water in the river to float timber rafts. Several lockings of the 12" X 12" white pine grillage logs finally got through the Chesapeake and Delaware Canal and were towed out from Delaware City on 27 June 1851. By 25 August, James Given of Columbia and Bigler, Wright & Co. of Clearfield had delivered all the grillage timber and a large force of wharf builders was at work laying the lower tier. Earth was excavated around the pile heads to facilitate topping them off level by whipsaw. Backfill around the pile heads was Pea Patch mud, to the regret of Major Sanders, whose proposal to use concrete, or at least sand, was overruled.

The last planks of the grillage were spiked down on 14 May 1852, exactly three years after work was begun on the foundation. The whole plan of the fort was visibly defined by the compact wooden platform supported by more than six thousand piles and covering an area of almost four acres. Upon this substantial base lines were laid out for the masonry of the five fronts and bastions, using an instrument borrowed from Major Bache of the Topographical Engineers. The platform level stood at about low tide or seven feet seven inches below extreme high water, 1836 datum. Most of the piling had been exposed for several years to atmospheric action and Major Sanders decided to submerge the foundation, if the current session of Congress should not grant a substantial appropriation for continuation of the work. When reconstruction was resumed in 1848 there was an applicable balance of $20,000 in unexpended funds from the Delafield phase. Since then, to autumn 1852, three appropriations of $50,000 each had been made. Of this $170,000 total, more than $100,000 was expended on the foundation. At the closing of operations on 12 December 1852, remaining expendable funds were $9,500. Major Sanders took up residence in Philadelphia at Mrs. Levely's and rented the director's room of the Philadelphia Library for his office.

Congressional fact-finding activities[5] produced favorable results late in the session and with the new appropriation Major Sanders was back on Pea Patch Island in April, 1853. The foundation was pumped out and the grillage platform readied for the stone masons. Thirty stone cutters shaped the blocks left exposed on the island 15 years before. The Quarryville stone worked up readily, but 1,200 blocks of Port Deposit gneiss, "very hard and of a firm and durable quality—seems to have been quarried contrary to its natural bed — is easily as hard as iron; the best workmen so far only cut one superficial foot an hour." Cement came by schooner in barrels by the outside route from New York; deliveries were sporadic and one 500-barrel lot contained such quantities of adulterants as to be unusable. Despite the reverses, nearly all the Delafield Quarryville stone was set before frost, sufficing to build the scarp wall to the six-foot reference line or first offset, containing about 8,000 cubic yards of masonry.

The population of Pea Patch Island then numbered over 200 persons, including Major Sanders and his two assistants, Lieutenants Morton and Casey.[6] Residency on the island was continuous — no commuting to the mainland. With the large force, maintenance of public health became a matter of urgent concern, especially since in 1850 the War Department had issued regulations prohibiting

1960 view westward across Pea Patch Island, showing Fort Delaware at age 100 years. In the foreground may be seen remnants of the peripheral revetment, eastern wharf and jetties. The southern half of the fort (light area) is much altered from the original design by addition of 12-inch gun emplacements and ammunition storage, installed in 1898. The marshy, desolate character of the island is apparent.

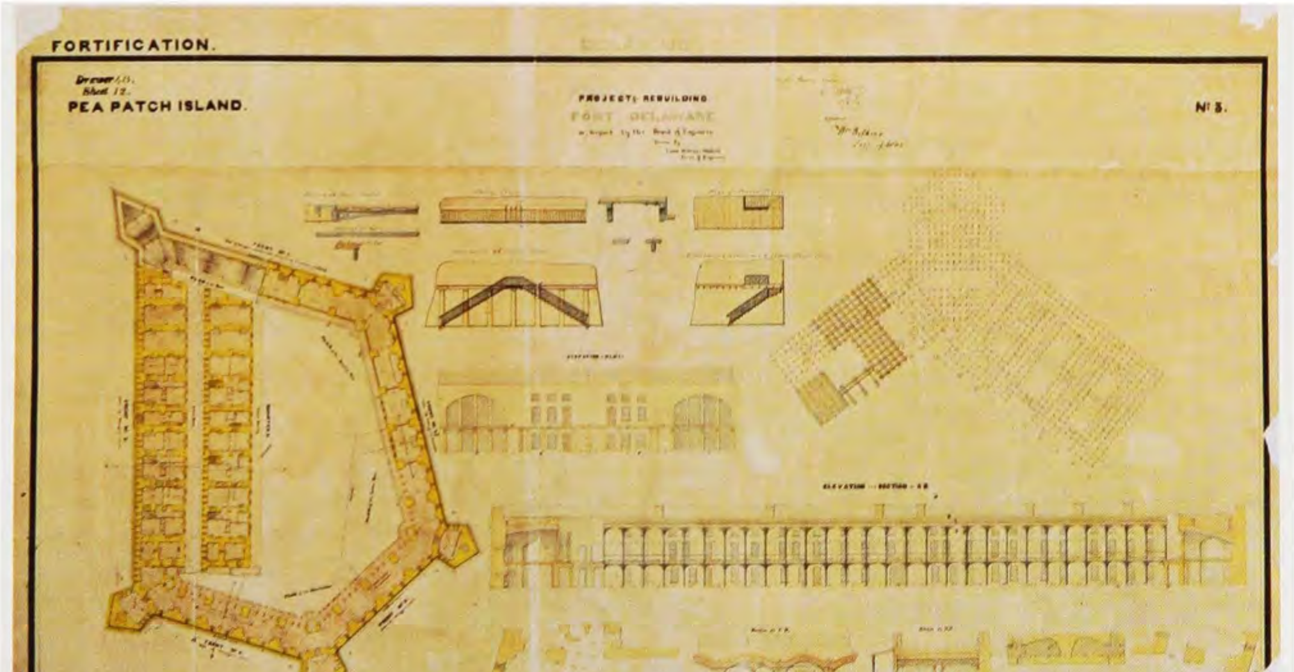
the supply of medical assistance to civilian personnel at government expense. Major Sanders' request to rescind the regulations and provide authorization for employment of a resident physician was swiftly acted upon and within 20 days Dr. Hamilton of Delaware City was under contract as the Post Medical Officer. It took two years to get the four-bed hospital started; quarters provided by the Post Commander were furnished and stocked with medicines by the mechanics and laborers, organized as the Fort Delaware Employees Mutual and Sick Fund. Workmen's contributions were disbursed on such items as "Paid to Brookfield who fell from crane and broke his arm $10.00; "For funeral expenses of Patrick Powers who died in hospital $23.55" and "$5.00 for relief of Timothy Collins," who was just a little short between paydays.

Considering the communication facilities available at mid-nineteenth century, it is understandable that Pea Patch Island was regarded as a remote post. Access to the river's shores was solely by means of rowing and sailing boats across a mile in either direction of frequently turbulent water. In winter high winds and floating ice made the crossing impossible for several days in succession. There was a telegraph office in New Castle, and a bank in Delaware City, "which city is in fact a very small and unimportant village." Steamboats ran between the coastal ports, making stops at Pea Patch Island on the

Location of the Work—1848

Three superimposed plans show the relationship of the various fortifications attempted on Pea Patch Island. Blue indicates the limits of the Star Fort begun in 1817 and destroyed by fire in 1831. Captain Delafield's plan — red outline — was laid out in 1833, construction was suspended in 1838. The pentagonal plan (shaded line) overlaps elements of both previous works and is the final shape of Fort Delaware built between 1848 and 1861. Drawn by Lt. Meigs.

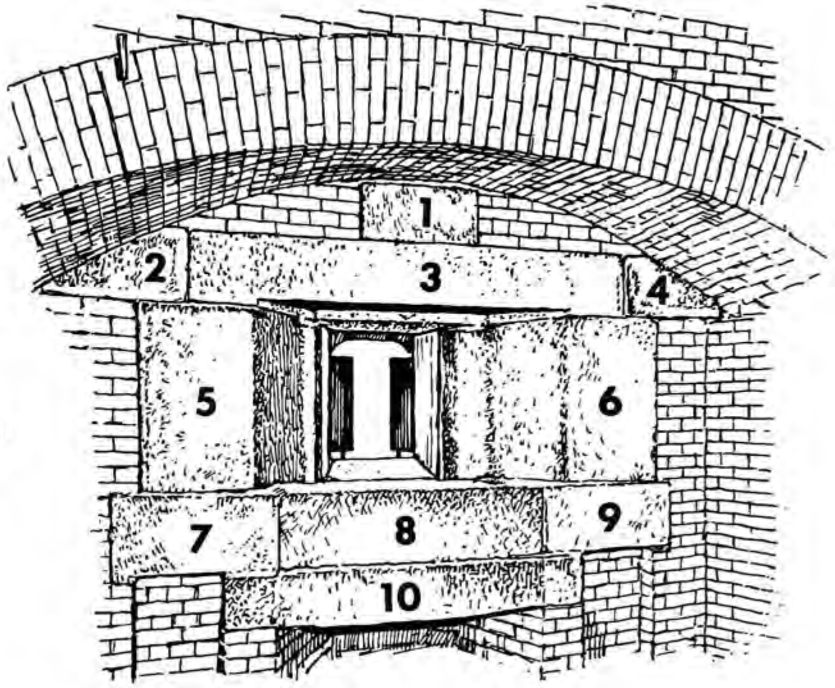
—National Archives



Fort Delaware as designed by the Board of Engineers was signed by the new Chief Engineer, Lt. Col. Totten and approved by the Secretary of War, William Wilkins. This pentagonal plan emerged in 1839, the year after construction of Delafield's fort was suspended. The draftsman was Lt. H. Wager Halleck, who later earned distinction as a combat officer in the Civil War.

—National Archives

Major Sanders reported on construction of the gun embrasures in June, 1856. Of the ten stones required for each embrasure, all but three were wrought from blocks of Quarryville granite which had originally been prepared for construction of Brandywine Shoal Light. Lintels (3) and cheekstones (5 and 6) were ordered from Vinalhaven, Maine. Embrasure irons were furnished by Parrott's West Point Foundries at $450 per set. The cost of a complete embrasure was $874.



inside run to and from Philadelphia; a line of steam packets transited the Chesapeake and Delaware Canal on a day and night schedule between Philadelphia and Baltimore. Cement, purchased in New York and consumed at the rate of 80 barrels a day, was shipped in coasting schooners for a four-day trip (weather favorable), or in barges via the Delaware and Raritan Canal in five to six days.

The working day at Fort Delaware was ten hours long and was calculated in days and tenths of days. Laborers received $1.00 a day; mechanics $2.00 to $2.50 a day; clerks and draftsman, $80.00 and $90.00 per month respectively; and the physician, $86.00 or less, depending on the size of the work force. Base rates were paid for all work performed until, in 1856 Major Sanders requested that the Department establish an official working day limited to ten hours and payment of time and a-half for overtime. The men were paid monthly in gold and silver specie, sums being withheld from those who boarded at the laborer's mess and handed over to the boarding master. Initially, the Commandant drew a check for the monthly payroll and exchanged it for gold and silver at the Delaware City Bank. By June, 1855 the payroll was up to $10,500 for a force of 297 men. Nine denominations of coin from 3 1/2 cent pieces to double eagles overtaxed the small Delaware City Bank's facilities; this and subsequent payrolls were drawn on the Philadelphia Mint and delivered to the work site by an Adams Express Co. courier for two dollars a thousand.

The middle fifties were good years in the land; immigrants poured in to get a share of the prosperity. Jobs abounded in every category and Major Sanders sought the most skilled mechanics available. His work list included German wharfbuilders, ships carpenters from the Liverpool docks, a lock builder from the Delaware and Raritan Canal and a roll call of laborers which reads like the County Cork census. To insure retention of this crack crew, the highest current pay rates were obtained and work was offered for the winter months, when some categories ordinarily would have been shut down. Stone cutters were kept on at piece work; carpenters building new shops; smiths making wheelbarrows and repairing machinery. Before frost in the fall of 1854 the scarp wall was raised to nine feet, eleven inches, three courses above the bench course at the six-foot reference. Fifty to sixty laborers toiled throughout the winter and spring to build up the parade ground, hauling by horse and ox cart the mud of the river excavated at low tide and the mounds of earth which Captain Delafield's excavation had thrown up in digging the ditches.

Behind the stone scarp the wall mass was constructed of rubble concrete, into which was cast the considerable remnant of the obdurate Port Deposit stone. Behind the rubble came the brickwork; casemate piers and arches, barracks and parade wall. Bricks were ordered in lots of 20 to 30 thousand each from a dozen suppliers in Wilmington, Chester and Philadelphia. Stone masons were setting one course of stone per month or 1,500 running feet of wall; the exclusive output of John Leiper's Quarries[7] was engaged until September. Besides the granite stretchers and headers for much of the scarp wall, Leiper's Quarries furnished "white stone" lintels and fine blocks for the unique circular staircases. Some of the handsome dressed granite blocks used to build the sally port and postern gates came from Quincy, Massachusetts; Quincy granite and other granites of superior quality were wrought for gun embrasures, lintels and coping. Quarries at Vinal Haven, Maine worked out large slabs of "platform stone" for Fort Delaware's tower stairs and the Lighthouse Board transferred title for 673 blocks of superb Quarryville granite which had been cut and dressed for use in building Brandywine Shoal Light. The stone had laid for many years at the quarry accruing ground rental, unused because of a design change.

In his annual report of 1855 Major Sanders forecast the Fort's readiness for armament and garrison by autumn 1858, depending necessarily on provision of appropriate funds. At a point midway in construction the work picked up momentum and its strategic significance began to capture the public's interest. Tangible evidence of a well-wrought project kept the Congress in a mood to see the job through. Most of the nagging problems had been resolved; periodic readings at established benches showed no subsidence of the structure, although some alarm was caused by the results of a typical foundation compression test.[8] In closing his report Major Sanders warned against letting the public have the impression that "this work as now building will, when finished suffice for the defense of the passage up the Delaware."

From November 1856 to June 1857 Major Sanders was absent from Fort Delaware on assignment to Fort Taylor at Key West, Florida. Levellings taken that summer began to show subsidence, especially on the southern flank, where it had gone down nine-tenths of an inch. Efforts to repair the leaky cisterns were postponed to await completion of the fort and, hopefully, culmination of the structure's settling. The Major expressed his despair of "this mud island, upon which there is no stability."

Pea Patch Island consisted of less than 80 acres of fast land which at this time of peak activity confined the lives of more than 300 people, some of them children. The Commandant was the community leader and guardian as well as first officer of the post and paymaster. Maintenance of discipline among workers and overseers, arbitration of differences and preservation of morale and the

Lower tier flagging was originally to be laid directly on the earth; Major Sanders substituted this more substantial method:

a. Using the mud as centering, an arch was built of stone unfit for fine cutting.

b. The arch was filled level with rubble concrete.

c. The flagstones were set in "asphaltic mastic".

Circular stairways, located in the parade end of the bastions, gave access to second tier casemates and the ramparts. The simple design was executed in circular brick wells using wedge-shaped stones from Lieper's quarries for the steps and large platform stones from Vinal Haven, Maine.

general health were some of his more paternalistic duties. A special order strictly enforced between May and September required the summary execution of any dog running at large on the island without a muzzle. An Engineer Order dated 28 June 1858 authorized and established a school for the children of Pea Patch, assigning Miss Louisa Gribble as teacher. No patriarchal handout, contributions for tuition were required of the parents of participating children. Many letters from the Commandant to the Chief in Washington are filled with concern for the people in his charge; frequent in praise of their skill and dedication and ardent in petitions for increasing their wages.

Colonel Richard Delafield, superintendent of the Military Academy, convened a Special Board of Engineers to meet at West Point on 21 July 1858. The meeting date was postponed one week at the request of Major Sanders, a member of the Special Board, whose indisposition prevented attendance on the original date. On the 20th the Major again asked to be excused. His constitution weakened by diabetes, Sanders had suffered continually since his assignment as project engineer on the island. On 13 July 1858, Sanders wrote that he had "already been confined to the house for a fortnight by a carbunculous boil," which showed no signs of healing. His letters began to ramble. On 29 July 1858 Brevet-Major John Sanders died in his quarters on Pea Patch Island, of carbunculous boils terminating in erysipelas, more than ten years and five months after beginning the reconstruction of Fort Delaware. In the official dispatch Clerk Muhlenbruch wrote: "As Major Sanders attended to his public duties during the whole of his sickness the progress of the work was not in the least impeded, only today the workmen declined working, the sad event being expected since last night."

Sanders left a widow and seven children. In 1860-61, Mrs. Sanders petitioned Congress for a pension, but the War intervening, her request was not granted until 24 February 1876, when she was awarded a pension of thirty dollars per month, amended however to read "from the approval of this act," rather than the original retroactive date of 1 March 1861.

Lieutenant Craighill[9] commanded operations until the arrival of Captain John Newton[10], who assumed the superintendence of Fort Delaware in October 1858. The estimated date of readiness for guns, garrison and supplies was set at 30 June 1860. With enough money and a month's notice an emergency basis operation could be set up to quarter 1 1/2 to two regiments and mount the complete armament of 156 guns of large calibre, 91 in the bomb proof casemates and 65 firing over the top of the wall. Money was scarce, appropriations small; from here on until the end of construction there would be a zero balance on the fiscal report, which would also show sums advanced out of fortifications contingency funds.

Fine stone was sought from many sources by Chief Engineer Totten for construction of the Nations' greatest fortress. The granite blocks for the sally port were quarried in Quincy, Massachusetts.

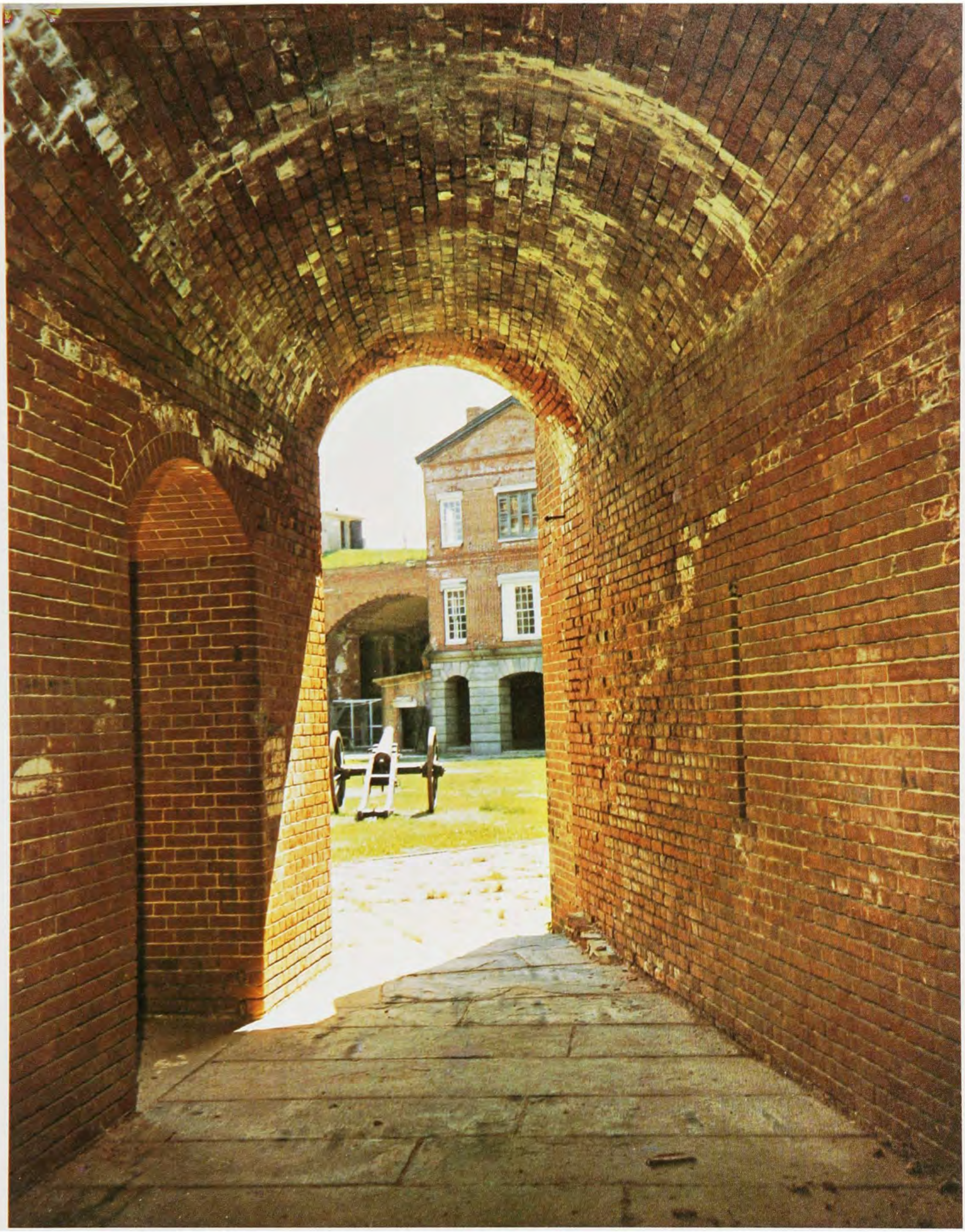
In a letter to General Totten dated Aug. 11, 1855, Major Sanders wrote: ". . . unless kitchens are furnished with ranges, officers will have to buy cook stoves which require no fireplaces; nowadays there are no cooks who can cook in open fireplaces". This officers' kitchen in restored Fort Delaware was furnished by the Fort Delaware Society.

In Fort Delaware's twelfth decade, marsh grass chokes the moat and trees flourish on the ramparts, but the masonry shows signs of only minor subsidence. The superb mitering of the stone work is observable in this view of Front 5, with the permanent bridge, drawbridge and sally port. The State of Delaware and the Fort Delaware Society have begun restoration of the fort as a military museum.

The questions of hiring an *applicateur* to direct the preparation and application of "mastic" or asphaltic tar to roof surfaces, first arose in late 1857, when Lieutenant A.A. Gillmore, Resident Engineer in New York, wrote to Major Sanders, suggesting that such a man was available for the purpose. Sanders put him off, replying that his master bricklayer could handle the work, that no tar specialist was needed. After Sanders' death, Lieutenant Gillmore wrote to Major Newton, the new project officer, again recommending that the *applicateur* be engaged. Newton relented, and agreed to hire the fellow, a Frenchman named Coeur de Vache, at sixty dollars per 26 day month, 10 hours a day.

The work progressed at a steady pace; Newton soon had to request Gillmore to send him an additional *applicateur*, one Auguste Keller, whom Coeur de Vache had recommended. But all was not well. The little Frenchman was becoming homesick, and periodically threatened to pick up and return to France. Newton curtly ". . .informed him that he had the power of transporting his person, where he might desire, subject, however, to the penalty of forfeiting, by breach of contract, all monies due him." This seemed to quieten Coeur de Vache, who remained at his work through September of 1860, excepting a temporary reassignment to work on the fortifications at Key West, Florida, from November 1859 - May 1860. At his departure, Newton recognized that, despite their differences, the temperamental Frenchman had been ". . .the best *applicateur* I have employed, since I have been in the Corps."

In the spring of 1859 all construction activities were suspended except those which directly advanced the preparations to receive



A glimpse of the parade ground, viewed from a lower tier casemate. Flagstone was shipped from quarries on the Hudson River; bricks were supplied by a dozen manufacturers in Philadelphia, Chester and Wilmington. Major Sanders paid higher than average wages to keep expert workmen on the island. In October 1857 he wrote: "I will venture the assertion that there is no other public structure in the United States where more solid and permanent work has resulted from a proportional outlay".

armament. Cost to date since March 1848 for rebuilding Fort Delaware was $950,622.73. The sum required for completion was estimated at $354,848.96 for an estimated total cost of $1,305,471.69. A bill of ordnance was forwarded with recommendations for early completion and delivery. By January, 1861 the fort was ready for guns. In Captain Newton's opinion ALL guns should be sent — "The Fort should be prepared to the full extent — because civil war will likely lead to foreign war."

A week after Sumter it seemed highly probable that Delaware would follow the example of Maryland and that both states would secede from the Union. It was feared that attempts to cripple the fort would be made from a hostile Delaware shore. Plans to raze the upper sections of barracks and officers' quarters, visible from outside the fort, were eventually abandoned. Work went forward on a temporary wooden barracks in the parade ground to accommodate 350 men and 15 officers. At this time the garrison numbered 20 men; reinforcement by regulars through the only open channels, Philadelphia and New York, was effected at the end of April. Captain Newton reported the condition of the fort on 30 June 1861 as "now in fighting order as far as partial armament extends." Forty-seven guns had been mounted: 20 flank howitzers; eight eight-inch Columbiads in the second tier; five ten-inch and 14 eight-inch Columbiads in the barbette. The permanent bridge was built and the draw worked admirably. Temporary quarters were adequate for the garrison; the bakery was completed, but shot furnaces for the 42-pounders had not been begun. Captain A.A. Gibson, commanding the fighting units, complained of the medical facilities, which still consisted of a civilian physician and a small cooperative hospital. Medical operations were put on a war footing by the Surgeon General and the last of Fort Delaware's civilian medics, Dr. George W. Webster was discharged in December, 1861.

Engineer Captain Newton's final tally sheet listed the following items as still to be done: stop leaks in the cisterns of front five; complete the drainage system of the parade ground; finish construction and fitting out of the permanent barracks and officers quarters and repoint some of the copings. Outside the fort the glacis and counterscarp were unfinished and there was need for a permanent western wharf, higher jetties and two new permanent sluices. But the events of war made a drastic revision in the fort's intended mission. When construction was resumed its purpose was to erect shelters for prisoners of war, who were brought to Pea Patch Island in thousands. The greatest fortress in the land became one of the largest and most infamous prisoner detention camps in the war between the states, "the Andersonville of the North." The tally of prisoners held on the island reached a war-time high of 12,595 in July, 1863. By war's end disease, deprivation and damp had claimed over 2,700 of them. The fortress itself stood silent. Though more armament was mounted and the alert for ironclads maintained, the guns of Fort Delaware never fired a hostile shot.

The Work of the District 1866 - 1971

STEAM AND THE NEW TECHNIQUES

By the time the Philadelphia District came into official being in 1866, two great moving forces in American life were attaining maturity of a distinctly national stamp. One was a school of engineering, forged by a varied roster of military and civil engineers through three wars and the building of a nation. The other was the precipitant development and application of the great mover: steam.

Adapted from European precedents, both sciences in their American forms quickly surpassed their continental models, through characteristically American proliferation. The remarkable number and variety of steamboats plying the waterways of the United States prior to 1820 elicited the amazed comments of visiting European engineers; M. Marestier, of the French Royal Maritime Department, found much to emulate during his survey of United States steamboats[1]. Steamboat traffic on the Delaware River had already achieved an established pattern. Experimentation with high pressures resulted in frequent boiler explosions and attendant loss of life, until the introduction of safety valves and improved methods of boiler construction. The screw propeller, eventually to replace side- and stern-wheel propulsion, already moved Ericsson Line steam packets around the District area in 1844. By mid-century steam tugs pushed and towed huge quantities of every conceivable cargo in Delaware and Chesapeake Bays and their connecting canal. Pile-driving, an infant technique in 1800, could be undertaken in the late Fifties with some assurance of predictable results, thanks to the well-documented experiments of engineers, chiefly military, employing steam-powered drop hammers. Hollow iron screw piles, much favored by engineer Major Hartman Bache, were driven by steam rigs to support typical area lighthouse structures and the famous Iron Pier at Lewes, Delaware.

In 1852, Congress authorized construction of a steam dredge, equipment and discharging scows "for the waters of Chesapeake Bay and the Atlantic Coast." Steam, harnessed to the mud-diggers, gave impetus to the growth of the new and vital dredging industry. Within four decades all the essentials of that industry would be developed, with powerful pumps and cutters, all steam-powered. The Patent Office House Document for 1855 bulged with new specifications; many for steam valves and new types of boiler construction. American inventors proliferated like mushrooms; all seemed intent on mechanizing every phase of life and on hitching the power of steam to every thing mechanical. The opening of anthracite fields, first, and later of bituminous coal mines, supplied the ingredient which vastly extended the application of steam power, accounting significantly for the phenomenal surge in industrial development. Annual coal production in the United States was seven million tons for 1850, 14 million tons

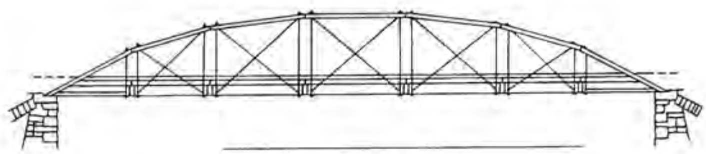
Vernier Transit, 1840

for 1860 and 240 million tons in 1900.

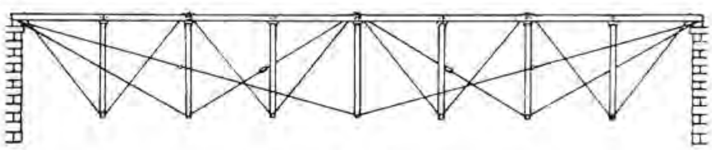
The Sixties saw the beginning of the mechanization of navies, of iron-clad vessels with armored mechanical turrets and steam propulsion. President Grant officiated at ceremonies to inaugurate the services of two great engines in the Seventies; at Friedensville Mine in 1872, the "President's Engine" with its 75-ton twin fly-wheels was the largest pumping engine of its day and a long way from the first mine-unwatering engines of Savery and Newcomen. It was outstripped by the great Corliss, largest steam engine ever built, started up by the President to open the Centennial Exhibition in Philadelphia on 10 May 1876.

"Power" was the theme of the Centennial; and the characterizing aspect of the nineteenth century's growth and development. The new power fostered and supported the geneses of new disciplines — for railroads, a specific geometry of track curves and grades and foundry techniques revolutionized by Bessemer's Cold blast and Nasmythe's geared-tilt ladle. Steel-wire rope formed the nucleus of new bridge concepts, dispensing with cumbersome, stream-cluttering structures, creating soaring spans hung lightly as giant steel cobwebs. An English genius, Maudslay, contributed a life's effort to work out all the basic forms of modern machine tools. His superb automatic-feed slide-rest mitigated the labors of machinists and initiated an era of true precision mechanics.

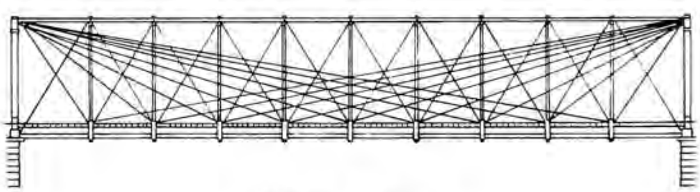
The other power, the emerging American School of Engineering, evolved like the inexorable process toward nuclear fission. The skills which were the virtual exclusive possession of military engineers at the beginning of the nation were expanded and practiced by men of skill and genius in all walks of life. The accumulated knowledge and experience of civil and military engineers were intermingled to the benefit of all phases of the nation's continuing growth: ordnance was designed by civilians (Gatling was a civilian physician), railroads were organized by military engineers (Colonel Stephen Long for the Baltimore and Ohio; General Daniel McCallum for the federalized railroads).



Whipple Bowstring



Fink Deck



Bollman Truss

Wrought iron screw pile construction was typical for lighthouses in Chesapeake and Delaware Bays. This is Windmill Point Light at the mouth of Rappahannock River.

Banked curves for railways were introduced to America by Captain Dennis Mahan, West Point Engineering instructor, whose "Mechanical Philosophy" was a a standard text up to the Civil War years. The renowned Sylvanus Thayer, Superintendent of West Point Military Academy from 1811 to 1833, instituted instructional theories and standards at that institution which would continue to enhance the civil and military engineering professions for many generations. The Military Academy, through its superbly trained graduates, contributed vastly to the establishment of a sound technical base for the engineering endeavors of a legion of pioneer American builders.

Expansion of the railroads brought a need for new bridge designs; improvements in the manufacture of iron shapes, cast and wrought, permitted realization of new concepts for the spans that would support the great weight of locomotives and loaded freight cars. The classic wooden trusses of the intuitive bridge builders were redesigned for iron by a new wave of planners who combined the methods of empirical experimentation with the theories of exact engineering[2]. The Whipple Bowstring, the Fink Deck and the Bollman suspension truss were some of the all-metal designs for timber span replacements on the pioneer railroads in the decade preceding the Civil War.

John Roebling's wire rope replaced hemp rope on the eastern canals to draw boats up the slopes of the portage railroads in the early 1840's. In 1866, Roebling was the world's foremost builder of suspension bridges; his wire rope had been spun into supporting cables for five aqueducts and three bridges of his design and he was within a year of completing a bridge across the Ohio River at Cincinnati, then the world's longest steel suspension bridge. In 1866, James Eads' steel arch bridge, which would span the Mississippi River at St. Louis, was still in the planning stage. But the five-mile tunnel under Hoosac Mountain in Massachusetts was in the twelfth of its 22 construction years; this proving ground for the technology of hard rock tunneling would require the labor of 1,000 men in three shifts around the clock until 1876 and would finally take 195 lives. Among the technological gains were the development, in 1866, of the pneumatic drill and the technique of blasting with nitroglycerine.

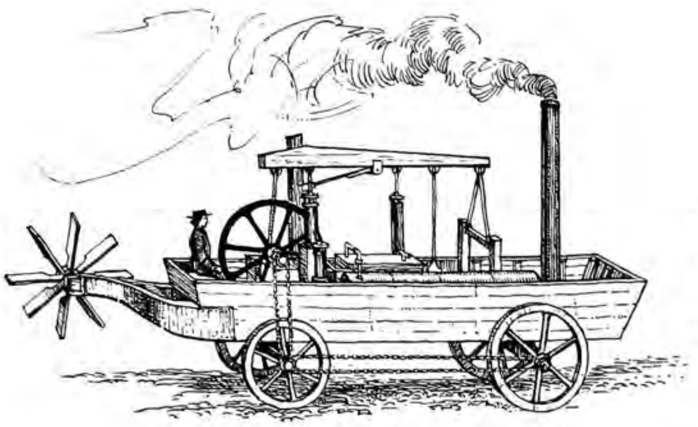
In this active, fertile environment the Philadelphia District of the United States Army Corps of Engineers was established. The new entity merely confirmed and more cogently organized the combined endeavors of civil and military engineers in the planning and management of the District area's vital public works program.

EARLY DREDGING

Masters of vessels plying the Delaware River and Bay in the 17th and 18th Centuries compiled navigation logs compounded of weather instinct, seamens' rumors and much swinging of the lead. Some reliance may have been placed on such charts as were available; Joshua Fisher's charts, variously dated, and the river and bay maps of Francis Shallus labeled the natural channels and indicated bottom contours and soundings in a broad, general manner. One of Fisher's charts, dated 1776, bore the endorsements of 44 pilots and masters of vessels as the only dependable chart available. Certainly, the shoals had a pattern of inconstancy and ship routes were alternately obliterated and restored by the endless cycle of tides and currents. Captains of ships sought safe anchorages along the estuary to wait for the tide that would bear them up to Philadelphia, navigating by the efficacy of their seamanship and faith in their leadsmen.

Noteworthy activity in the pursuit of channel dredging in the Delaware River coincided with the advent of steam-powered equipment. Muscle-powered dredging, practiced for centuries in Holland and Italy, was becoming obsolete at about the time the Delaware's deep hulls began to require the establishment and maintenance of disciplined, reliable channels. A Dutch-type mud mill was built for the Board of Port Wardens of Baltimore around 1784 and put to work deepening that harbor; the mud was raised by long-handled spoons, operated by man-powered treadmills. Delaware River mud[1] was dealt with in 1803 at New Castle Harbor when the Engineer Department installed the first ice pier there, and again within a few years, when mud nearly filled the harbor. Some dredging was done, presumably man-powered. In 1804, Oliver Evans equipped a "carriage" with a steam engine and stern paddle wheel and operated it, first on High Street, Philadelphia, then in the Schuylkill and Delaware Rivers. Its purported function was channel clearance. This "*Orukter Amphibolos*" was probably the first mechanically-powered dredge to operate in the Delaware. Evans described it as "a large flat, or scow, with a steam engine of the power of five horses on board to work machinery to raise the mud into flats."

Especially relevant to the chronicle of an industry is the related status of general technological development. Prior to the availability of mechanical power sources, the dredging of streams and harbors was laborious, slow and minimally effective. Channel clearance was largely a matter of moving the obstructing material from one place to another in the stream. Stirring and scraping devices were employed in estuaries where, hopefully, suspended particles of the shoal would find their way to deep water, transported on the ebbing tide[2]. With steam dredges it became feasible to retain and transport a greater percentage of the excavated fines, but until the hydraulic pipeline dredge came into use, deposit of dredge spoil on land sites was awkward and expensive; therefore, the mud scows were towed long distances and emptied into the bay or into "holes" in the river bottom. Solutions requiring minimum channel maintenance were projected in terms of structures which modified the channel section and induced a measure of self-maintenance through the scouring of tides and currents. A program for construction of channel training dikes was curtailed in 1885, after some effective diking



The amphibious digger, constructed by Oliver Evans for the Philadelphia Board of Health in 1804, was the first wheeled vehicle to move under its own power in America. It was also the first mechanically powered dredging apparatus to operate in the Delaware River.

had been done; maintenance planning was subsequently oriented toward dredging, since a greatly expanded capability tended to make that technique more economically favorable.

In the early years of the Nineteenth Century, when Delaware channel depths of 12 to 27 feet provided adequate draft for most of the craft then plying the river, dredging was performed primarily to clear the harbors of New Castle, Wilmington, Chester and Marcus Hook. Mud and sand were the materials requiring removal. Dredging equipment was steam-powered by 1829, possibly earlier. In that year Congress provided an appropriation for procurement of a *"dredging machine to be applied to the deepening of the Delaware River Harbors."* A similar appropriation had been granted in 1827 for a steam dredge boat to remove shoals at Ocracock Inlet, North Carolina. Specified as an experiment, this dredge was not put into operation until August 1830, due to difficulty experienced by the contractor in completing the machinery

It is clear that the Ocracock apparatus was a form of ladder dredge, which successfully performed the experiment by providing a channel through the sand bar to a depth of about 10 feet of water. The Delaware unit was operational in 1831; a hired machine worked the Delaware harbors in the summer of 1830. Although not clearly specified, this equipment probably was similar in design and function to that constructed for the Ocracock experiment. The ladder dredge, of European provenance, served the initial purposes of mechanically powered excavation, but was superseded in America by the more versatile and less costly grapple and dipper dredges. According to the Chief Engineer's report for 1831, the dredging operations were the only works of improvement undertaken that year in Delaware River Harbors. Operations continued through 1832, with Port Penn added to the harbor dredging schedule. Only Marcus Hook received the benefits of the steam dredge in 1833, when 15,369 cubic yards of earth were removed, "to form a safe and secure retreat for about 20 sail of vessels."

In 1835, Captain Richard Delafield reviewed the conditions of Delaware River Harbors since 1789 and made some cogent recommendations. He advised installation of additional free-standing piers, extending the harbors toward the greater depth of the stream to achieve increased harbor capacity. Thus, the outer portion of the harbor would maintain a stable depth through the action of the tides and currents, which would be only minimally deterred by the tapered piers. A system of sluiceways penetrating the wharves and land fast piers would effectively circulate water and thwart accumulation of mud in the inner harbors. Captain Delafield further recommended that dredging of the harbors be abandoned as "it is not deemed advantageous towards effecting the desired object, or, when accomplished, answering a permanent good."

An attempt was made to improve Delaware navigation in 1836 by authorizing dredging in Wilmington Harbor. A steam dredge removed 5,000 cubic yards of material from the bed of Christina River and placed it on dikes at the river margin. Concurrently, $15,000 was appropriated for improving the harbor at Philadelphia by removal of Mifflin Bar. On receipt of the assignment, Captain Delafield noted that no survey had been made, or plan suggested. He conducted a survey of the bar and an investigation of its history and deter-

Major General Richard Delafield

—National Archives

mined that it could be traversed in 16 to 21 feet of water, depending on the tide, and that it presented no obstacle to the largest class of merchantman. River pilots stated that depths over the bar were greater than they had ever before known them and that the whole mass of the bar had shifted 300 yards northward in the past two years. Summing up his "*memoir*," Captain Delafield pointed out the risk, by removal of Mifflin Bar, of creating mud flats to replace a navigable water course, and stressed the futility of attempting removal of a constantly shifting mass of material; "I cannot too strongly recommend that, in this instance, nature be left to work for herself, unaided by art."

Forty-four years elapsed before Mifflin Bar was attacked by the dredges. Richard Delafield's firm and appropriate decisions would earn for him the highest rank and rewards achievable in the Engineer Department of the Army. Steam dredge boats owned by the Government operated sporadically in the waters of the Delaware River and its tributaries in the 1840-50 period; inactivity made their maintenance an expensive burden; locally based units of dredging equipment were sold to commercial salvage companies. Meanwhile, Government dredge boats were employed on the Great Lakes and in estuaries of the Middle Atlantic Coast, where mud and sand shoals impeded the navigation of even very shallow draft vessels. The "*Lavaca,*" built at Louisville, Kentucky in 1845 by order of Colonel Stephen Long of the Topographical Engineers, was the prototype of the period's capability in steam-powered dredging. Equipped with two dredge ladders and four mud scows, she could remove 150 cubic yards of mud or sand per hour to a depth of 10 feet and propel herself at eight miles per hour. Congress authorized construction of a similar unit in 1847, another in 1852.

The Delaware River, swift and wide, continued to provide a natural channel adequate to the needs of navigation. The Engineer Department concentrated on military matters; in 1849 its total complement of officers numbered 49, of whom 30 were concerned with construction and repair of fortifications, nine were at the Military Academy at West Point and two in the Engineer Department Office in Washington. Eight officers were on survey missions across the country or on detached duty with other military departments. It was in the context of national defense that a system for improving navigation was recommended in 1853. Major Delafield, superintending projects for Atlantic Coast defenses, proposed a combination of dredging with ladder dredges and diking the stream banks, the dredged spoil to be dumped behind the stone-filled timber dikes. The system contained the basic formula for channel dredging which continued in practice long

Major General Andrew A. Humphreys
—National Archives

after ladder dredges disappeared from the Delaware estuary.

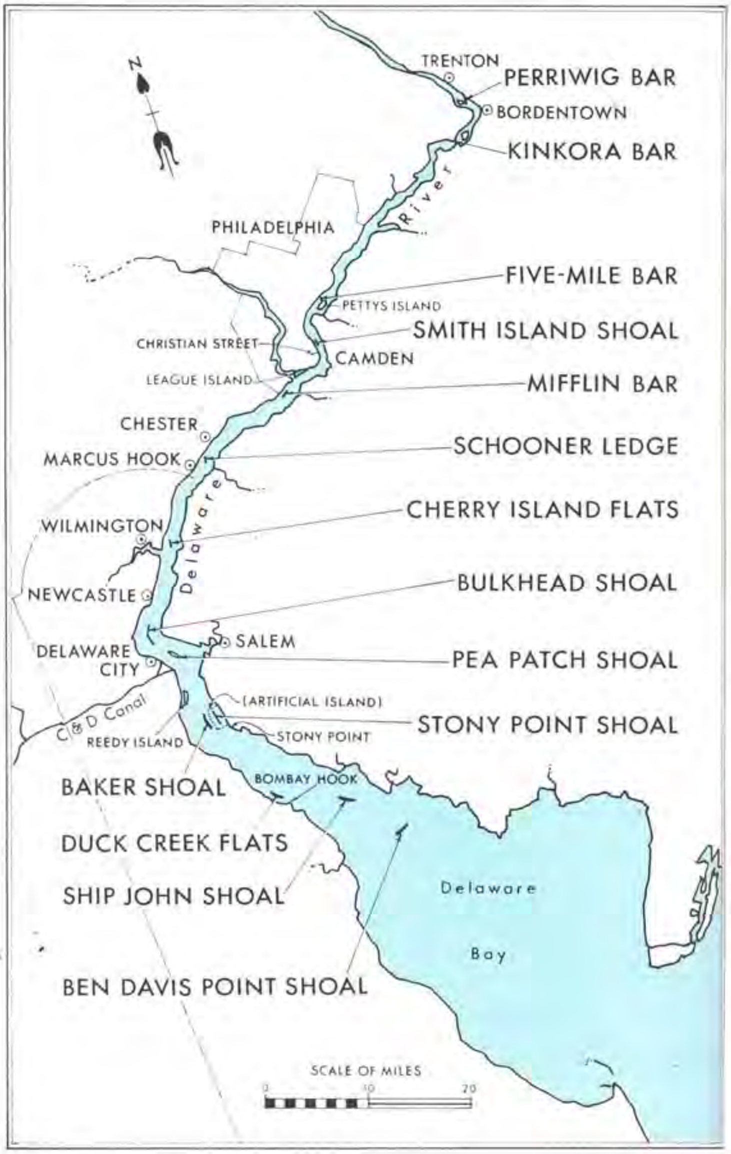
Aids to navigation in the District area in the decade preceding the Civil War were those afforded by the ice harbors and the Breakwater Harbor in Delaware Bay. The post war decade witnessed a phenomenal expansion of trade and industry and a prodigious increase in maritime taffic for Philadelphia, second largest port in the nation. International shipping lanes traversed the waters of Delaware River and Bay and harbor planners envisioned an established ship channel of fixed dimensions with permanent maintenance facilities. The 1866 reorganization of the Corps of Engineers, structured on watershed systems and oriented toward water resources planning, definitely abetted the prospects of Delaware channel improvement.

In 1878, deep water vessels had a draft of 20 to 24 feet, loaded. There were places where ships could ground in the Delaware channel without benefit of a full tide. One such hazard was at Schooner Ledge, 18 miles below Philadelphia between Chester and Marcus Hook. Schooner Ledge was a rock reef extending from the Pennsylvania shore like a submerged dam or bulkhead of irregular height, which, according to Captain Ludlow, "could be regarded as the most dangerous if not the most serious obstruction in the river."

Rock excavation of Schooner Ledge began in 1879 in the costliest single project yet undertaken for the improvement of Delaware River navigation. Since 1836, when navigation improvement was begun, channel clearance had been achieved only by dredging, using the various techniques which the currently prevailing technologies afforded. The first rock removal was at Schooner Ledge, for which drilling was begun in October, 1879. The initial project required the cut across the ledge to bottom at 24 feet, mean low water. The drill platform, of heavy yellow pine timbers, stood above high tide on four yellow pine spuds; two Burleigh drills, track-mounted, were moved across the platform by a rack-and-pinion device. The rig drilled three-inch diameter holes for the blasting charges; material was removed by dipper dredge.

Colonel Macomb, under whose orders the District operated between 1877 and 1882, wrote deploringly in 1880 of dredging contractors who dumped dredged material back into the river. A considerable amount of dredging was done throughout the tidal section of the Delaware, from Bordentown, N.J., where the entrance of the Delaware and Raritan Canal had been obstructed by a sand bar, to Duck Creek, Delaware, where the creek's entrance across the flats was dredged to a depth of eight feet. In between, much larger works were in progress: Cherry Island Flats, opposite the mouth of Christina River, were bisected by a channel from which 1.5 million cubic yards were dredged; in the broad curve of the river below New Castle, Delaware, a 24-foot channel was started through Bulkhead Shoal on a mile-long axis. Dredging continued at Pettys Island and Mifflin Bar and the problem of spoil disposal began to loom as a serious predicament. For several years the government land at Fort Mifflin and League Island had served as repositories for channel dredgings. As these would soon be filled, Colonel Macomb and Captain Ludlow cast about for new dumping sites.

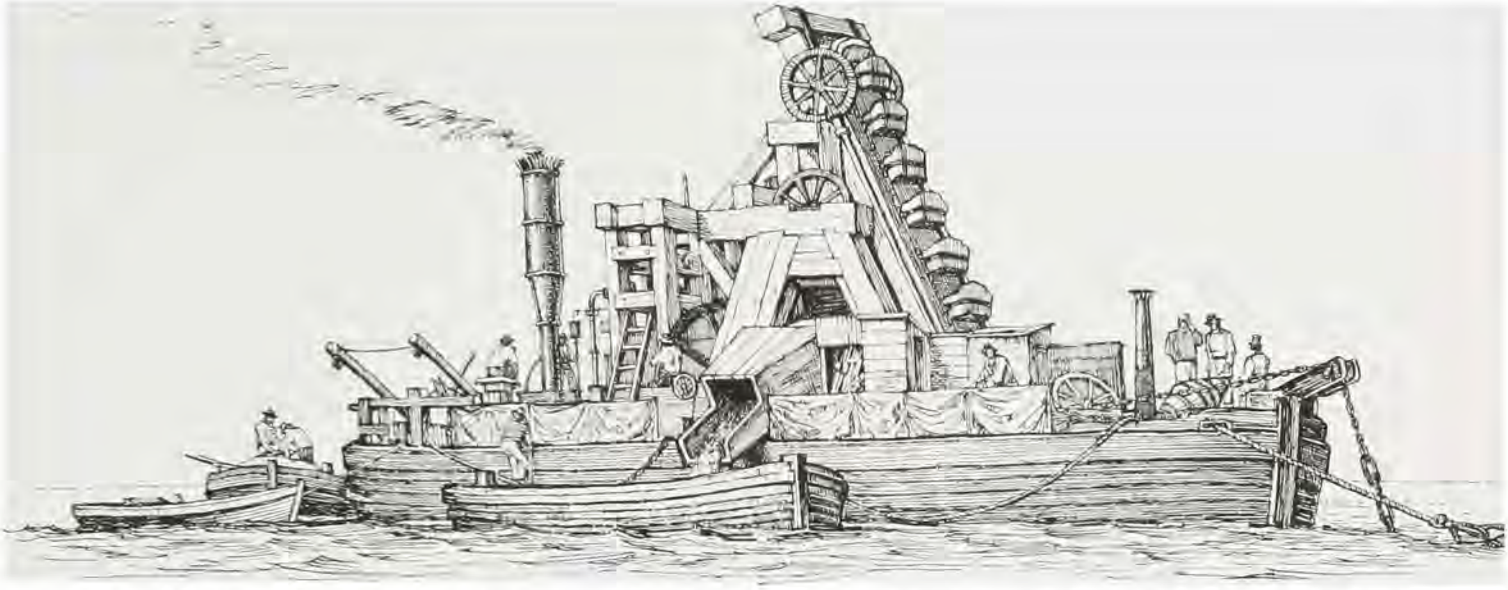
Long stretches of the Delaware River maintained a natural low water depth of about 27 feet. These navigable reaches were interrupted by more or less perilous obstacles where shoaling occurred in repetitive, natural patterns. The bars, shoals and flats named and located here were regularly cited for dredging appropriations during the years when a 27-foot depth of channel was considered an ultimate goal. Baker and Stony Point Shoals were bulkheaded to create a disposal area (Artificial Island) when excavation was begun for the 30-foot channel in 1900.



An experiment seeking an alternative to overboard disposal was proposed by Colonel Macomb and conducted at Fort Mifflin in 1879. Dredged spoil was deposited in rehandling basins dug adjacent to a land-based, diked inclosure; the material was then redredged into dump cars, moved on tracks along the top of the dikes and dumped on the inclosed lands. Colonel Macomb headed a special board appointed by General Humphreys in July 1879 to report on the future prosecution of Delaware channel improvement.[3]

The Board found the dumping of dredged materials within the tidal limits of the river to be deleterious to navigation and against the spirit of existing State laws, as the "fluid and yielding material" tended to be redistributed and returned to the channel. Most significant was the Board's statement that "the present and probably ultimate greatest available depth that can be maintained for the navigation of the Delaware River is about 27 or 28 feet at mean low water. For long stretches of many miles of main channel the existing and possible depths do not exceed these, while the actual draught required for the commerce of the river is not in excess of 25 feet." The Board recommended *"that dredged material be deposited ashore behind dikes or bulkheads or upon land beyond the reach of the tides, where requisite authority is obtained or where the privilege may be purchased at a small and reasonable price per acre."*

The Board's sincere and laudable concern brought about no immediate revision of policy in the prosecution of Delaware River dredging. Available land sites were difficult to find and riparian owners demurred at the obligation to finance the erection of dikes and bulkheads. There was a marked decline in the number of proprietors who regarded the dumping of dredged spoil on their lands as beneficial, still less as an enhancement of real estate values for which they should incur expense. Potential disposal areas beyond a stipulated maximum of 25 miles from the excavation site were considered impractical because of haulage costs; 25 miles was also regarded as the maximum range for convenient utilization of the tide in towing mud scows. The concept of an ultimate channel depth of 27 to 28 feet, based on the mean depth of the natural channel, presumed limited use of the estuary in terms of ships sizes; it also implied a predictable average volume maintenance dredging requirement.



The mud dredger of the 1830's was best exemplified by the steam-driven endless chain bucket or ladder dredge. This type retained the favor of the Europeans, but was replaced in American waters by grapple and dipper dredges.

Concepts were drastically revised by 1885, when legislation was enacted to authorize the permanent improvement of Delaware River and Bay. Since then, a succession of projects has progressively increased the depth of the navigation channel, keeping pace with the requirements of commercial traffic. (Ultimate channel depth limits were again discussed in the early 1970's, as new, gigantic hulls entered the maritime service; alternatives to traditional river traffic were studied, in the form of deepwater terminals, pipelines and shallow draft shuttle craft.)

By 1890, the scarcity of disposal areas was acute. Major Raymond, then starting a 10-year tour of duty as Philadelphia District Engineer, took vigorous charge of navigation improvement with its vexatious spoil disposal problems. A solution of sorts was achieved by making spoil disposal a responsibility of the dredging contractors. Surveys were made in quest of "secondary channels of relatively small importance and other suitable places in the bed of the river" in which spoil could be dumped. A tremendous volume of material had to be excavated from the Philadelphia Harbor area; government lands at Fort Mifflin and League Island were convenient and capable of receiving about half of the dredge material, but in 1895 the Navy Department blocked a proposed extension of authority to continue the depositing of spoil at the League Island Navy Yard site. In the six years following Major Raymond's assignment to the District, approximately 10.7 million cubic yards of dredged material were dumped on the river at nine different locations.

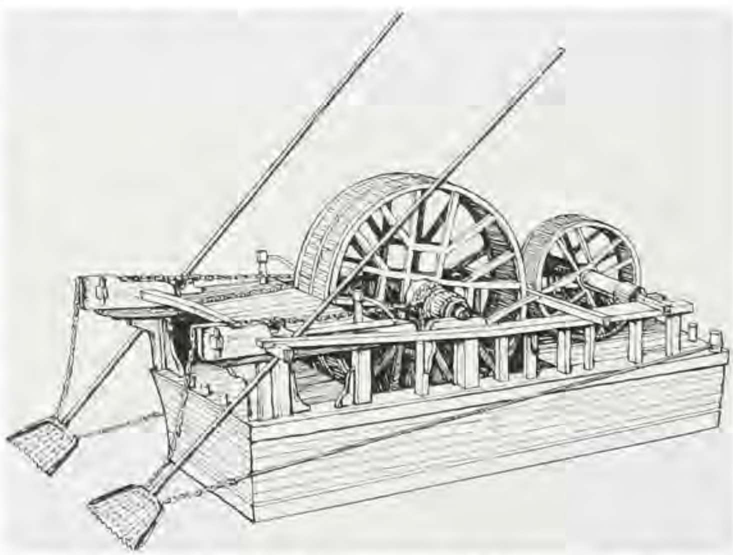
The River and Harbor Act of 3 June 1896 authorized a survey for the creation of a 30-foot channel from Philadelphia to Delaware Bay. The survey covered 56 miles of proposed channel between Christian Street, Philadelphia and a point just below Bombay Hook. Estimated cost of the project was $5,810,000. Prices were based on dredging by dipper and grapple dredges — hydraulic dredging was thought to be limited and uncertain. The amount of material to be removed by dredging was estimated at 34,953,000 cubic yards plus excavation of 24,000 cubic yards of rock. Six locations were earmarked under the heading "Places of Deposit," with the capability of receiving at least four-fifths of all material excavated. Three were on government-owned land adjacent to Forts Delaware, Mott and Dupont; a fourth was to be located along Wilmington's Delaware River shore just above the Christina River. Specific authority was provided for the creation of a large disposal area below Reedy Island on the eastern side of the river. At the site, Baker Shoal and Stony Point Shoal were to be inclosed by bulkheads to form the principal deposit basin in the Lower Delaware, known since as Artificial Island. A sixth location cited by the Survey Board was in Delaware Bay — "a deep hole below Ben Davis Point Shoal."

Initial appropriations for the 30-foot channel were designated for removal of the shoal below Reedy Island, "now the most troublesome obstruction to the navigation of the river," and for construction of bulkheading for the proposed artificial island disposal area. This work was begun with pile-driving for the bulkhead on 4 April 1900.

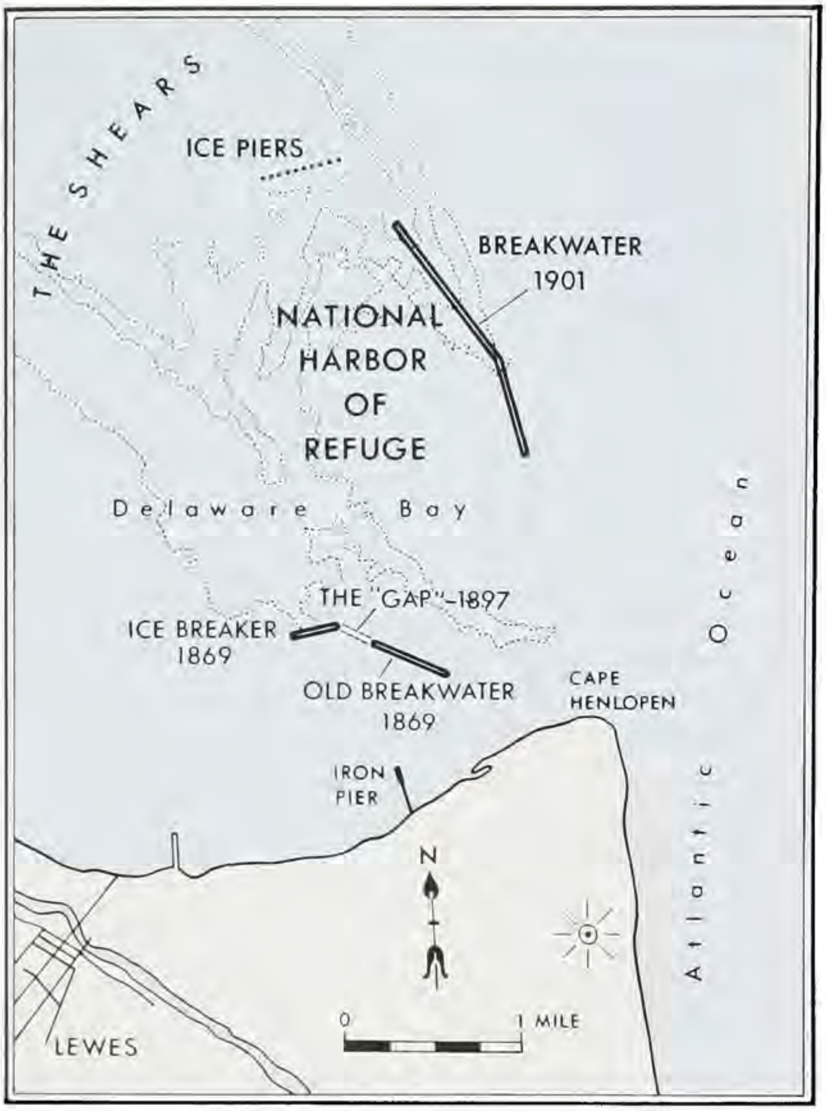
A great many dredging operations were active in the District as continuing projects around the turn of the century. The improvement of Wilmington and Philadelphia harbors went forward. Navigation channels were provided for a number of the Delaware's tributary streams, while improvement surveys were underway for others. Maintenance operations on the river did not consist solely of dredging the channel; removal of wrecks kept salvage firms occupied in all seasons. The wreckage of sunken derelict vessels imperiled navigation, both as hazardous obstacles to shipping, and as possible nuclei for the build-up of obstructive shoals. Before 1881, dredgemen under contract for removal of wrecks were required to surrender salvaged cargoes to the Engineer Department for disposal at auction. The revised policy, allowing contractors to retain salvage, resulted in keener competition, lower bid prices and more thorough clean-up of wreckage.

The craft of dredging was maturing rapidly; hydraulic systems, with improved cutters and pumping plants, were increasingly used to supplement or supplant the old reliable dipper and grab dredges. The U.S. Government built its first hopper dredge in 1890; three more before 1900. Fourteen hopper dredges were completed or under construction by the government in the intensive construction period between 1901 and 1904.

Dredging was no longer a primitive craft, nor yet an exact science; but it had become an established, key function in the growth and development of the maritime community. Community expansion and the availability of more refined tools had led to the realization that dredging was essential to the economic health of the region.



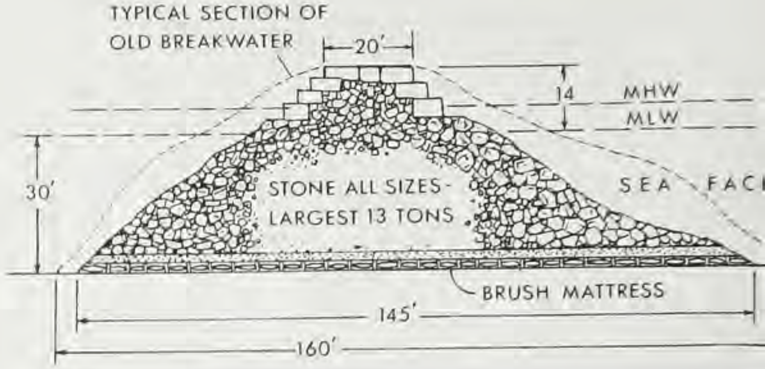
This type of mud mill or spoon dredge was used to deepen Baltimore Harbor. The two treadmills were rotated by manpower.



HAVEN WITHIN THE CAPES

In the dozen years immediately following 1869, District activities in lower Delaware Bay consisted primarily of removing wrecks and building the famous Iron Pier at Lewes, Delaware. Proposals were regularly forwarded in engineer reports for the improvement of Breakwater Harbor by closing the open space between breakwater and ice breaker, commonly referred to as the "gap." In 1876, Western Union Telegraph Company occupied the old lighthouse on the breakwater by permission of the War Department, and subsequently the Philadelphia Maritime Exchange established a reporting station there. This facility provided advance notice of ship arrivals to Philadelphia's merchant and port interests and advised life-saving stations of shipwrecks in the bay area. Ten vessels laden with coal foundered in and near Breakwater Harbor in the gale of October 4, 1877, when 225 vessels sought shelter there; as they broke up on the Delaware shoals, resourceful citizens of Lewes and Pilot Town helped themselves to some cheap winter fuel.

The year 1882 saw completion of the Iron Pier and the adoption and funding of a project to build the long-sought linking structure for the old breakwater. Work began immediately on a plan which called for a random stone foundation and concrete superstructure, and went forward irregularly funded by sporadic appropriations until its completion in June, 1898. The original plan specified construction of a timber bridge to carry a double track railroad across the interval. Concrete was to be poured from rail cars into boxes formed from the bays of the bridge, inclosed by detachable aprons. The plan was modified in 1891, deleting the



The "Gap" Closure
Proposals to build a linking structure between the old breakwater and icebreaker were offered frequently during a 45-year period following Major Richard Delafield's suggestion in 1836. Design plans varied; even after appropriations were made in 1882 three design concepts were alternately adopte As finally completed in 1897, the new structure differs from the old by its brush mattress foundation, its slimmer volume and its disciplined superstructure of dimension stone monoliths.

requirement for bridge and concrete. Stone was used throughout: random stone for the substructure was bottom dumped from barges; the balance of the stone was placed by barge-mounted derricks. The final result was a continuous wall 1,350 feet long connecting breakwater and ice breaker; from low water to the top-about 14 feet — heavy stones were laid in position, the wall tapering to a top width of 20 feet. The actual cost of the gap closure was $529,888.44; estimated cost of the project was $675,000.

The concept of a Harbor of Refuge, vintage 1829, did not fit the requirements of the booming nineties. Although still valuable as a haven for small craft, especially since completion of the linking structure, Breakwater Harbor provided little sanctuary for the increasing numbers of longer, deeper hulls which came through the Delaware Capes. Even before its completion, stone was being dropped for a new, larger breakwater located 6,500 feet farther north, nearer the ship channel. The annals of the old breakwater contain the records of noteworthy storms and wrecks of this period. The Morro Castle was driven onto the solid mass of the breakwater in November, 1888 and the Norwegian bark Patriot suffered a similar fate in May, 1889. In both wrecks the crews were rescued by personnel of the breakwater lighthouse and signal station. The storm of 7-11 September 1889 drove 32 vessels ashore below the breakwater; all but seven were eventually salvaged.

The new breakwater was authorized as "The National Harbor of Refuge, Delaware Bay, Delaware" by the River and Harbor Act of 3 June, 1896. It was to be constructed on the line of least depth along the eastern branch of a shoal known as the "shears". Its cost was not to exceed $4,665,000. The project included provisions for a row of ice piers across the upper end of the harbor. Work on the breakwater commenced 4 May, 1897. A project plan for ten ice piers was adopted on 23 April, 1900 and their construction was begun in fiscal 1901. Hexagonal in plan, the piers were placed at 200-foot intervals on a line extending westward from a point 2,400 feet above the upper end of the breakwater.

Harbor of Refuge breakwater was completed on 11 December, 1901; its total length at low water line was 8, 040 feet; the length at top 7,950 feet; the cost $2,090,765.82.

View southward of National Harbor of Refuge with its dog-legged breakwater at left and row of ice piers in the foreground. Distantly, to the right, Cape Henlopen and the old breakwater seem striving to meet.

The sectional configuration of the new structure, similar to the "gap" structure of the old Delaware Breakwater, was in fact developed using the same methods employed on that project. The great reduction in volume from the typical mass of the old breakwaters was principally due to the availability of more efficient facilities for handling materials.[1]

The District's Colonel Raymond summed up the new methods in the Annual Report of 1899. Placement of very large stones (largest, 13 tons) by steam derrick permitted rather precise construction of the superstructure, with a steeper slope to seaward than had previously been employed. The height of the wall was limited to dissipate the force of waves breaking over the crest, so that the full impact would not be absorbed by the structure. The step arrangement of the superstructure served to break up the wave, reducing the intensity of its return action and consequent scouring of the substructure. The angle of the sea slope at the old breakwater was assumed to represent a slope of stability and was adopted for the new substructure. Bottom-dumping barges dropped stone for the substructure, raising it temporarily five to six feet higher than its final level on the seaward half, thereby providing the stone vessels with a shelter from wave action. By weighting the mass early, the settling and slope stabilization of the sea face continued while construction of the harbor side proceeded.

Designs for other random stone breakwaters (Sandy Bay, Massachusetts; San Pedro, California) were prepared in 1890, using criteria of the Delaware Bay Harbor of Refuge project. Characteristic of the advantages of random stone breakwaters over other types was the ease and simplicity of construction and repair, which seemed to outweigh their peculiar disadvantage: the need for a massive foundation to resist the action of the sea.

The old light shared the west end of Delaware Breakwater with Philadelphia Maritime Exchange's signal station. Eight years after this 1890 view, the 1350-foot gap structure was completed between here and the ice breaker.

Navigation Above Tide Water

Navigation of the Delaware River above tide water was practiced in pre-Columbian times by native tribes, inhabitants of the region, but there is no evidence that the Indian navigators attempted works intended to modify or exploit the stream's pristine flow characteristics; however, works of this order were undertaken soon after the arrival of commerce-oriented European settlers. Necessarily, regulatory legislation enacted by states whose common boundaries the river defined soon followed.

A Pennsylvania law enacted March 9, 1771 declared:

> "*When the improvement of the navigation of rivers is of great benefit to commerce, and whereas many persons have subscribed large sums of money for this purpose; . . . the Delaware and Lehigh Rivers shall be common highways for the purpose of Navigation.*"

With this act, twenty-six commissioners were appointed to receive subscriptions and to improve the navigation of the Delaware.[1]

The State of New Jersey legalized common use of the Delaware by an enactment of May 27, 1783:

> "*. . . . The River Delaware, from the northwest corner of New Jersey to the place upon the said River where the circular boundary of Delaware toucheth upon the same, is, and shall continue to be and remain, a common highway, free and open for the use of both New Jersey and Pennsylvania.*"

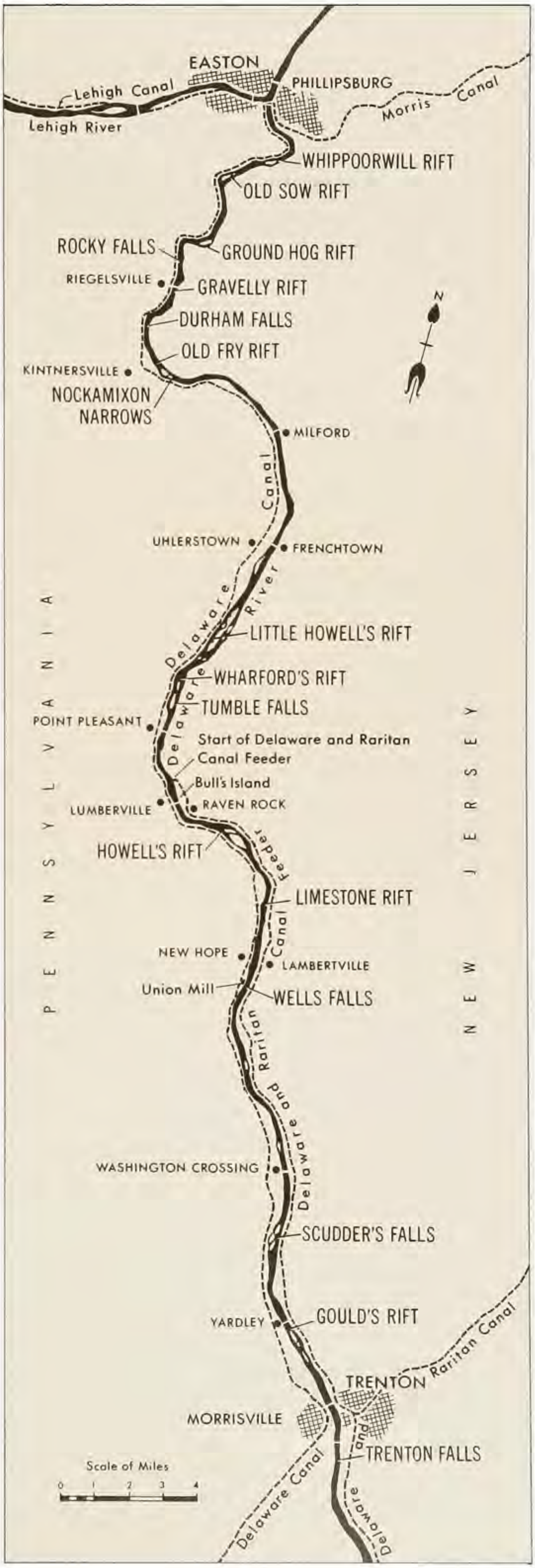
Specific laws came along to meet changing demands upon the river's resources. Lumbering was first and of great importance to the improvement of the channel. The transit of log rafts through numerous falls and rifts was fraught with danger. Twenty-four of the more terrifying obstacles between Easton and Trenton were listed in a Philadelphia publication of 1830 as requiring improvement. For many years prior to this, raftsmen had taken their chances.

"In the Delaware River[2] there are no precipitous falls" stated a navigation survey of 1827; small consolation for boatmen who daily coped with hazards as legendary as Foul Rift, 12 miles above Easton; Wells Falls, a 4,780-foot obstacle course starting a mile below New Hope; or the famed Scudder's Falls, where wing dams were first built in 1819 by State of Pennsylvania Commissioners. The treacherous Trenton Falls, with a fall of nine feet eight inches over a length of 3,500 feet, ended the downstream course of water hazards at tidewater.

Log rafting on the Delaware achieved its greatest intensity between 1835 and 1850. The forests along the banks receded year by year as lumbermen worked virgin stands of pine and oak; then hemlock, ash and maple. Eventually, the scarcity of timberlands with reasonable access to the river made log rafting unprofitable. Admittedly on the decline, the production of sawed lumber was still considerable in 1873, as reports on 38 mills situated at 23 locations between Easton and Morrisville[3] indicate. These mills, many powered by water from the river, produced 113,700,000 board feet of lumber from logs rafted down the Delaware that year.

Rafting both preceded and outlasted the arks and Durham boats which served as alternative modes of upriver navigation. The Durham boat, developed initially to transport

From the Forks at Easton to the fall line at Trenton, 31 rapids were identified by Engineer Merriman and tabulated in his report of 1873. These natural obstacles, commonly known as rifts or falls, were negotiated routinely by ark crews, log raftsmen and Durham boatmen, who were the virtual sole navigators of the upper Delaware.



the products of the young iron work industry, made its appearance about 1750. This craft is known to have worked the river as far up as the Lackawaxen, 75 miles above Easton and to have served the bog iron furnaces to the south by way of the little rivers of New Jersey. "Arks", rectangular pine boxes 50 to 80 feet long, 16 feet wide with a two-foot draft, came into use with the working of the anthracite mines of northeastern Pennsylvania, beginning about 1810. A portion of this coal traffic should be listed under the heading lumbering, as the arks were strictly one-way craft disassembled at destination and sold as lumber. After the Delaware Division Canal was opened in 1832, arks ceased to descend the Delaware River. Even then, it was becoming difficult to obtain lumber for their construction.

The upriver channel was evidently a wayward, vaguely definable thing. For the most part, raftsmen and boatmen navigated by instinct, legend and a few inconstant landmarks down a course which some called "the natural channel". Rudimentary works of improvement contrived, at relatively meager expense, to maintain the natural channel in such condition as to allow downward passage of rafts, arks and Durham boats at no risk greater than the navigators' lives and cargoes. Upward passage was occasional, strenuous and only for a boat in ballast — a rugged boat like the Durham — round-bottomed and with a virtual zero draft.

The channel was trained by means of wing dams, chute walls and some rock blasting; among many picturesquely named rocks, "Blowed Rock," "Entering Rock" and

"Foam Rock" share the record for frequency. Ten thousand dollars were appropriated in 1817 by the Pennsylvania Legislature for improvement of the river from Trenton to Foul Rift twelve miles above Easton. Most of the money was spent for rock blasting and wing dams at Rocky Falls, seven miles below Easton; at Tumble Falls, above Point Pleasant and halfway between Easton and Trenton; and at Wells Falls, a mile downstream from the New-Hope Lambertville Bridge. All of these works were destroyed and rebuilt several times; many remnants of them are still standing. The principal vested commercial interests along the river, early and late, were the canal companies. Lehigh Navigation Company, running Durham boats and arks down the Lehigh River from White Haven to the Delaware at Easton, was responsible for building and maintaining many of the works which aided navigation. The Delaware and Raritan Canal Company and their lessee, the Pennsylvania Railroad Company, also expended considerable sums on improvements. The New Jersey legislature, in March, 1820 specifically interdicted erection of any structure or device which would create, draw or use water power from the Delaware River. Any proposed construction was to be viewed by three "skillful and respectable freeholders" in each state (New Jersey and Pennsylvania), who would report to the courts by which they had been appointed. The courts could grant permission to build where the commissions found the project offered no menace to navigation. Prior to this, mills along the banks had freely drawn power from the stream; though users rather than consumers of water, they would subsequently operate only by sanction of the courts.

The canals were another matter. Their feeders withdrew water in significant quantities and returned it to the river in such places and amounts as to potentially effect a depletion of levels in the ranges of navigation. There followed, in 1825, 1826, 1828, 1832 and 1833 legislation by both states defining the privileges of water use accorded to the two canal companies, the Lehigh and the Raritan. The feeder for the Delaware and Raritan Canal was built in 1832-34; enabling legislation is found in a Pennsylvania Act dated April 6, 1825 which authorized:

> *"The Delaware and Raritan Canal Company to supply the said Canal with water from the (Delaware) River, provided no injury is done to either ascending or descending navigation, but reserves the right to withdraw this privilege if, in consequence, the water of the River is lowered one inch,[4] and also provides that this privilege shall cease whenever the State of New Jersey shall refuse to grant a similar right to Pennsylvania to take the same amount of water."*

The feeder started at Bull's Island near a landmark known as Raven Rock, 22 miles above Trenton. It was 60 feet wide, 6 feet deep and navigable. The supply of water continued to be ample until the late 1860's, without the need of impounding structures. Then, during drought seasons temporary timber dams were placed across the river at Bull's Island to raise the water level several feet. Permission to erect permanent structures was granted the Delaware and Raritan Canal Company by New Jersey in 1868 and by Pennsylvania in 1872. These structures con-

The Durham Boat. Workhorse of the Delaware, this sturdy vessel was built in 1750 for the Durham Iron Works in Bucks County, near Riegelsville to transport ore and pig iron through white water to market in Philadelphia. More than 2,000 rivermen ran 300 Durham Boats from Easton to Philadelphia, carrying iron, grain, whiskey and produce downstream, and manufactured goods upstream.
Forty to sixty feet long, with an eight foot beam, and a three foot hold, the Durham drew five inches when empty, and thirty inches with a 15 ton load. Downstream, captain and crew used a thirty foot sweep and setting poles to guide the vessel. Upstream, the load was cut to two or three tons and the boat was poled along the bottom of the riverbed. Perhaps its greatest fame is linked to that Christmas night in 1776 when Washington ferried a long-harried army across the Delaware, to take the offensive at Trenton.

— Washington Crossing Park Commission

sisted of wing dams and a chute and were constructed at a cost of approximately $30,000.

The Delaware Division Canal was supplied at its summit by waters of the Lehigh River. In this as in other respects it shared common cause with the Lehigh Navigation Company and the paternal ministrations of Josiah White. As Canal Commissioner for Pennsylvania, White took whatever action he deemed essential to make the Delaware Division a viable link in the anthracite navigation system, of which his own Lehigh Canal was a vital component. Between 1829 and 1846 at least four acts of the Pennsylvania Legislature required commissioners to examine the navigation and water power problems of the Wells Falls area. Wing dams and mills had been there ever since 1770. At Union Mill, about a mile below New Hope, water was admitted from the river to the lower sections of the Delaware Division Canal — just completed in 1830. Here was installed the power and liftwheel arrangement which functioned as a mid-point feeder.

The expense of periodic alteration and annual maintenance of the Wells Falls Dam and feeder was borne by the canal companies, whose interests joined at this point on the river. Here a rope ferry connected the Raritan feeder with the Delaware Canal, both of which had outlet locks to the river 1000 feet upstream from the dam.

Another of Lehigh Navigation Company's projects was the wing dam at Phillipsburg Rift, across the river from Easton, constructed for raft navigation, probably prior to 1820. This structure maintained sufficient depth off the channel to facilitate the crossing by rope ferry of barges transferring between the Lehigh and Delaware Canals and the Morris Canal. A project was afoot in 1827 to construct a slackwater navigation in the Delaware River from Philadelphia to Easton to Carpenter Point at a cost not to exceed $12,000 per mile; sufficient depth of channel was to be provided for passage of steamboats. The Pennsylvania Legislature authorized a survey but the project was abandoned with the digging of the Delaware Canal, started in 1827. A small steamboat did ply the river between Lambertville and Easton in the Summer of 1851; the "Major William Barnet", drawing 18 inches loaded, took eight hours for the 36-mile trip. Lambertville was then the end of line of the Belvidere Delaware Railroad. After completion of the railroad in 1857, navigation of the upper Delaware was left to the raftsmen. Only occasionally, in winter with the canal closed, a coal boat made the run on a rare freshet.

Records of appropriations for the benefit of the river by the State of New Jersey appear non-existent prior to 1870. Raftsmen raised $1,100 by subscription in 1861, which paid for rock blasting and a wing dam at Tumble Falls. Pennsylvania provided $10,000 in 1866 for more improvements at Tumble, at Wharford's Reef above Tumble and at Wells Falls below Lambertville.

The first Federal examination of the Delaware River above Trenton resulted in a survey report datelined Philadelphia, January 2, 1873, titled "Survey of the Delaware River between Trenton, New Jersey and Easton, Pennsylvania" and submitted by Col. J. D. Kurtz, Philadelphia Engineer Office, for the annual report of the Chief of Engineers, FY

In 1830 power and lift wheels were installed at Union Mill to take water from the river and feed it into the Delaware Canal. Wells Falls was at this point, one mile below New Hope.

1873. The report was substantially a record of the river's condition above tidewater with recommendations for improvements, based on a cruise made by M. Merriman[5] and a crew of five in August and September, 1872. Mr. Merriman's detailed examination and analysis estimated an average annual loss to raftsmen of $17,300. His proposals for elimination of navigational hazards by specific improvements at seven major and five minor sites included, "at Ground Hog--,--that the Pennsylvania Channel be dredged or scooped with ox-team, using ordinary road scrapers" and requested a total expenditure of $23,110.54. Cost of the survey was $2,738.24. A careful search of Rivers and Harbors records has yielded no evidence of action taken on Merriman's proposals. Log-rafting on the Delaware River decreased as railroads extended their lines throughout the region and timberlands were turned to other uses by an increasing population.

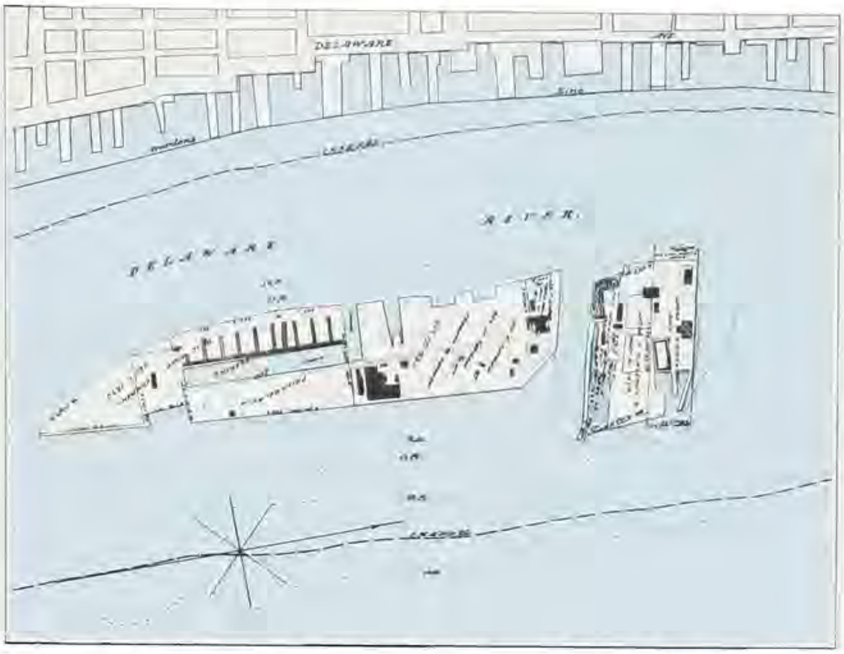
A preliminary examination of Delaware River between Trenton and Port Jervis was authorized by the River and Harbor Act of 1882. The ensuing report found the cost of improvements to be unjustified as benefits would accrue solely to a declining lumber industry. A study authorized in 1915 was concerned with the reach between Trenton and Easton. It concluded unfavorably because of the unwarranted cost; a commercially profitable channel would require canalization of the river at a cost of over $7,500,000. The Trenton to Easton reach came again under examination subsequent to the R & H act of September 22, 1922. Again, foreseeable benefits seemed insignificant compared to the probable expense. Going beyond the defined scope of the report, the Philadelphia District Engineer cited an additional 1,400,000 annual tons which might be hauled by extending navigation improvements a few miles above Easton on both the Delaware and Lehigh Rivers, but added: "under no conditions should the upper Delaware improvement be provided prior to the New Jersey Ship Canal" ("The Missing Link", page 87). In all of the above studies hydroelectric power was dismissed as a negligible consideration.

Head of Tide to the Sea

A Board of Engineers specially convened in 1885, recommended a plan for permanent improvement of Delaware River and Bay including the preparation of a permanent ship channel from Philadelphia to deep water in Delaware Bay. This channel was to have a minimum width of 600 feet and a depth of 26 feet at mean low water. Prior river improvements were made sporadically under appropriations for specific localities and consisted almost exclusively of dredging. The new plan proposed to obtain a channel by regulating tidal flow with dikes, dredging where necessary, and including provisions for annual maintenance. Estimated cost for the ship channel was $2,425,000; annual maintenance costs were estimated at one percent of the original cost for dikes and ten percent of the original cost for dredging. From Trenton, natural head of navigation, to the bay the river's course twisted and wound past more than a dozen islands; the channel, 17 to 24 feet deep in its natural state, was impeded by numerous bars, shoals and ledges. The sections offering the most difficulty for projecting and maintaining a proper channel were at and below Bombay Hook at the river's mouth.[6]

> *"In these sections, especially in the lower one, the conditions are most favorable for shoaling. The river is very wide and greatly exposed to the severe actions of storms. The channel occupies a very small part of the width of the bed. During the period of the flood, water from the marine wave pours into the channel, bringing with it material eroded from the shores and bottom of the bay. At the turning of the tide cross currents scour the broad expanse of the river's bed in every direction, and here material brought down in suspension by the outflowing waters of the ebb is most likely to be depositied — the shoals extending throughout the lower section of the river constitute the bar at its mouth, and whether a Channel . . . . can be maintained through this bar at reasonable expense can only be determined by actual trial."*[7]

The permanent improvement project of 1885 called for considerable diking and a creditable amount was completed, with good results, in the ensuing 12 years. Dikes were built at Bulkhead Bar, Mifflin Bar and Five-Mile Bar. Much more extensive diking was planned for training the channel above the river's mouth, an area severely affected by the "marine wave," with an extremely soft bottom. Cost estimates of 1885 indicated an economic advantage to building dikes there in preference to a continuous program of dredging. In ten years the balance shifted, due principally to the availability of better and less costly dredging equipment. In 1896, the



This real estate chart of about 1890 shows Windmill Island (left) and Smith Island in mid-channel before Philadelphia's busy waterfront. After considerable controversy, these sentimental landmarks were removed in 1893.

dike between Reedy Island and Liston Point was well underway with 6,300 running feet completed and additional 10,500 feet under contract. Originally, the structure was to extend uninterrupted for a length of 26,600 feet. The work was halted by an injunction brought about by citizens of Delaware who claimed that a continuous dike would cut off navigation of Appoquinimink River and Blackbird Creek and affect sanitary conditions between dike and shore. As subsequently completed, the dike provided openings which permitted tidal flow and transit of shipping.

Expenditure of federal funds for improvement of the river from 1836 to 1897 totaled $2,463,909.77. Of this sum, $119,479.21 was expended on the section from Trenton to Philadelphia. As of June 30, 1897 the channel was of "navigable width" and seven to eight and one-half feet deep above Philadelphia; from Five-Mile Bar through Bulkhead Bar to deep water the width was 600 feet, the depth varying from 23 to 26 feet.

Within the next year the channel had attained a minimum width of 1000 feet and a 26-foot depth in the Philadelphia Harbor area, and from Philadelphia to Reedy Island had generally reached the minimum controlling dimensions of 600 feet wide by 26 feet deep.

In 1898, after much debate, an old landmark was removed from the Philadelphia waterfront to facilitate the movement of shipping. Windmill and Smith's Islands appear on very early maps as a shoal; accumulated sediment arrested by self-seeded willows and marsh grass finally reared a mass above the water line. The island became a familiar, sentimental feature of the Philadelphia scene through paintings and engravings of the eighteenth and early nineteenth centuries. Around 1840 a channel was cut through it to provide direct transit of ferry boats plying between Camden and Philadelphia. The two resulting islands became popular resort areas; Smith's especially was a rendezvous for bathers and gourmets. A survey to determine advisability of removing the islands was authorized by Congress in 1882; an appropriation of $5,000 was approved in 1888 to fund an examination by a board of three engineers as to the effect of the islands upon the flow of commerce.

The resulting polemic between politicians, sentimentalists and shipping interests was won by the latter. A harbor contract calling for the removal of Windmill and Smith's Islands and a portion of Petty's Island (over 20 million cubic yards of material) was awarded to the American Dredging Company in May 1893.

As Major Raymond made his annual report to the Chief of Engineers in 1898 a new channel depth of 30 feet was being studied. This project, according to Major Raymond, "contemplates an improvement much greater than has ever been attemped in any tidal river of a similar character." The Major suggested conservatively that the project might be undertaken with a reasonable probability of success.

THE UNITED STATES BUYS A CANAL

With the growth of industry and world trade, and the increasing size and speed of vessels, the shipping interests of Baltimore realized ever more urgently the need for a nore direct ship route to the sea. Other interests were involved but pressure was exerted mainly from the Chesapeake side of the Delmarva Peninsula. In 1871 the National Commercial Convention in session in Baltimore resolved:

> *"That Congress be memorialized to direct a survey to be made between the Chesapeake and Delaware Bays for proposed improvement, and, if found to be practicable, desirable, and valuable to the great interest of the country, that the said ship canal be constructed."*

In March 1872 action was taken in the House of Representatives to obtain feasibility reports and that same year the Maryland and Delaware Ship Canal Co. was incorporated. During the next six years a number of reports were prepared by such eminent engineers as Benjamin H. Latrobe and W. Cullen Brown.

Finally, directions for the surveys of a ship canal route were contained in the River and Harbor Bill for 1878 and surveys were undertaken by the Engineer Office in Baltimore under the direction of Maj. Wm. P. Craighill. The report of Mr. N. H. Hutton, Assistant Engineer, dated Sept. 20, 1879 was the first to bring in an unbiased, comprehensive appraisal of all the routes then under popular consideration. Moreover it weighed factors which would be requisite for consideration of a National Defense Route, an aspect of the project which seemed less than vital to the commercial interests. The *debouche* of a ship canal into Lower Delaware Bay presented problems of fortification both difficult and expensive:

> *"The shore from Cape Henlopen to Liston's Point presents an almost unbroken marsh, several miles in width, much of it overflowed at high water, and none of it more than four feet above low water,"*

complicating the prospects for establishing adequate foundations for mechanical structures.

The sum of $10,000, "or so much thereof as may be necessary"[1] was appropriated in 1882 to complete surveys. By the following year, this work was substantially finished. The River and Harbor Act of August 1894 authorized the President of the United States to appoint a board of officers and civilians to examine and determine the most feasible route for construction of a canal between the Chesapeake and Delaware Bays "which shall give the greatest facility to commerce and will be best adapted for National Defense." This appraisal was to be based on surveys previously made under the direction of the War Department, the results of which were contained in annual reports of the Chief of Engineers for the years 1879, 1880, 1882, and 1883.

Board members were: Brig. Gen. Thomas Lincoln Casey, Chief of Engineers, Chairman; E.P. Alexander of South Carolina; Mendes Cohen of Maryland; Capt. George Dewey, U.S. Navy; Col. William P. Craighill, Corps of Engineers and Capt. John G. D. Knight, Corps of Engineers, Secretary.

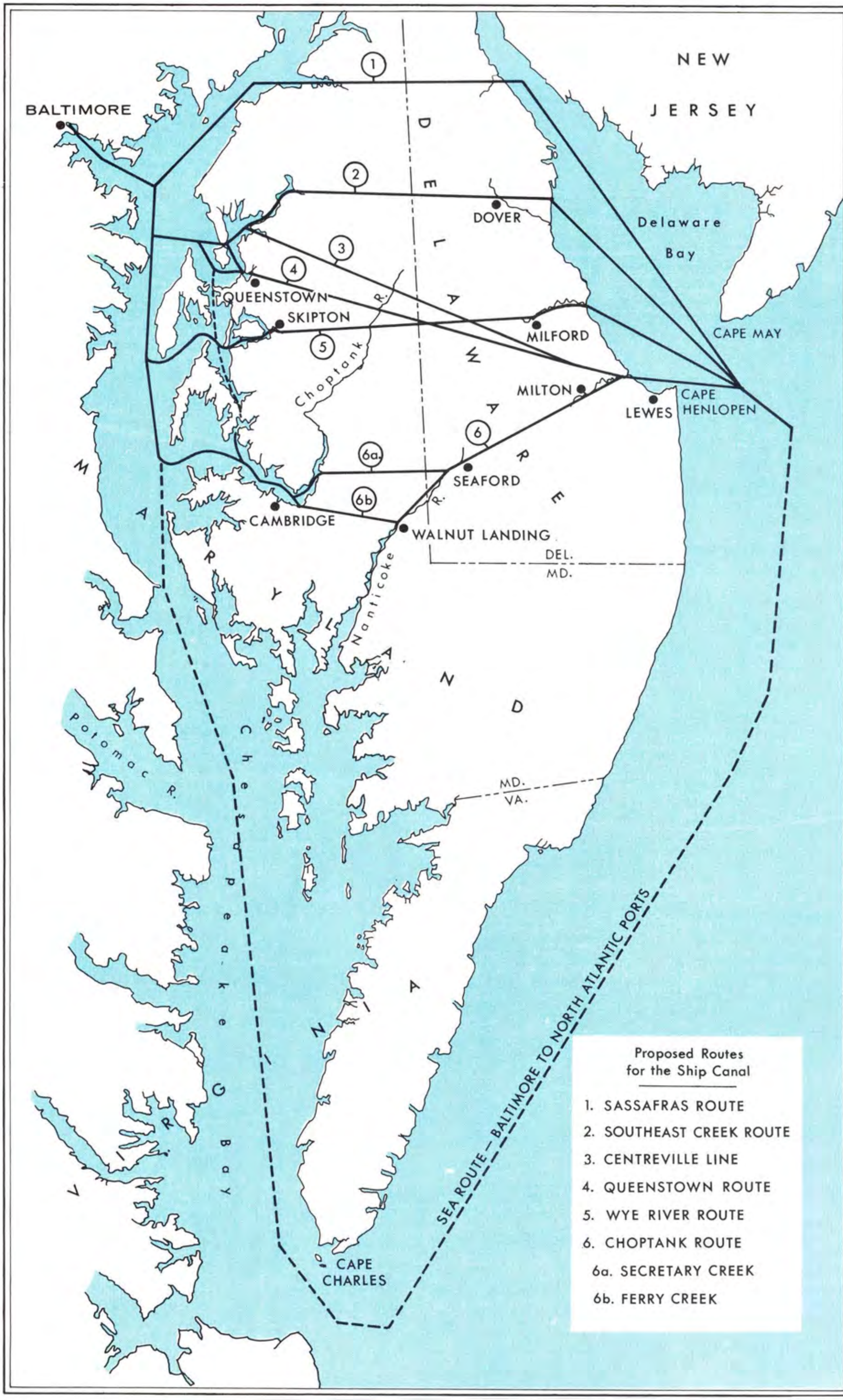
The surveys under appraisal were detailed, *The merchants of Baltimore requested the Congress in 1871 to direct studies for a ship channel across the Delmarva Peninsula. Ensuing in depth surveys of six routes and the existing shallow Chesapeake and Delaware Canal found only the latter eligible for development by the National Government. By 1894, studies were considering the proposed channel as a link in an inland coastal waterway, generally beneficial to East Coast shippers, but of little specific interest to the Port of Baltimore.*

comprehensive studies covering seven possible routes. Of these, the most northerly was the Back Creek route, substantially the route of the existing Chesapeake and Delaware Canal. The Sassafras Route proposed to cross the peninsula ten miles farther south and was sponsored by the Baltimore-based Maryland and Delaware Ship Canal Co. Farther south ran the proposed Southeast Creek, Centreville Line, Queenstown, Wye River and Choptank Routes.

The original studies proposed the use of tide locks at either terminus of the ship canal. For the purpose of computing savings in time, miles and cost, a point at sea was arbitrarily established twelve miles beyond the Delaware breakwater. In 1883 highway traffic was viewed in terms of horse-drawn vehicles; the load factors for bridges were calculated accordingly. The 1894 board found some of the old criteria obsolete and many of the cost estimates unrealistic, due in part to technological advances made in the elapsed decade. Reaction to the proposed ship canal was widely expressed throughout the two-bay area.

Lengthy studies of tide patterns and icing characteristics in the bays eventually led to the opinion that entrance locks would be unnecessary. Variables in planned channel dimensions ranged from 21 to 27 feet for depth, from 40 to 100 feet for bottom width. These dimensions were deemed adequate to accomodate the largest vessels then afloat. A general polarizing of preference for the more northerly routes began to emerge. The long lines of the southern routes would require huge sums for construction and maintenance. The slow speeds of canal navigation (4 MPH) over the long routes (Queenstown, 54 miles) offset the benefits of directness and saved mileage. Most of the objections were cogently stated in a report by the Committee on River and Harbor Approaches of the Baltimore Board of Trade, presented and read at a special meeting on 22 June 1894. The committee found that "such a ship canal will be of no practical use or benefit to the foreign commerce of this port". They cited increased dangers of navigation, groundings, collisions, etc. which were more frequent in narrow and shallow waters, hazards of canal transit at night, and probable increase of insurance costs. Almost as a footnote, the report endorsed construction of a canal "*deeper and wider than the one which now connects the Delaware and Chesapeake Bays,....capable of passing barges and light weight steamers.... provided it is constructed by the United States Government...and made absolutely free.*"

Consideration of the second part of the dual-purpose concept, adaptation for the national defense, also urged renewed assessment of the northern routes: the old Chespeake and Delaware Lock Canal (Back Creek route) and the Maryland and Delaware Ship Canal Company's proposed Sassafras route. A presumed military function of the proposed ship canal was to provide an escape route for a fleet bottled up in Delaware Bay. It was suggested, too, that submarines would have greater tactical maneuverability if given access to the top of both bays. In those pre-aircraft days, when tactical concepts were based almost entirely on horizontal mobility, the static armored fortress still had great defensive potential. Two such installations already



NEW JERSEY
BALTIMORE
DELAWARE
DOVER
Delaware Bay
QUEENSTOWN
SKIPTON
MILFORD
CAPE MAY
MILTON
LEWES
CAPE HENLOPEN
Choptank R.
SEAFORD
CAMBRIDGE
WALNUT LANDING
DEL.
MD.
Nanticoke R.
MARYLAND
Potomac R.
Chesapeake Bay
MD.
VA.
VIRGINIA
CAPE CHARLES
SEA ROUTE — BALTIMORE TO NORTH ATLANTIC PORTS
1
2
3
4
5
6
6a.
6b
Proposed Routes for the Ship Canal
1. SASSAFRAS ROUTE
2. SOUTHEAST CREEK ROUTE
3. CENTREVILLE LINE
4. QUEENSTOWN ROUTE
5. WYE RIVER ROUTE
6. CHOPTANK ROUTE
6a. SECRETARY CREEK
6b. FERRY CREEK

existed at the northern end of the bay: Fort Delaware on Pea Patch Island opposite Delaware City and Fort DuPont, on the west bank of the Delaware River just south of Delaware City. From the batteries of these two forts a crossfire could be trained on any hostile vessel which might approach the eastern terminus of the canal.

The enthusiasm of the Baltimoreans in 1871, enough to generate a decade of federal activity in behalf of the much-desired ship canal, had degenerated into indifference and outright opposition. The view that the canal would not be used by ocean-going ships was aired repeatedly in 1882-83 by the mercantile and shipping interests of Baltimore and must have contributed to the eventual discarding of all but the two northern routes. The opinion in other areas including the Government, was that a toll-free ship canal across the peninsula would unquestionably be of great convenience to foreign shipping as well as to coastwise trade, and that objections notwithstanding, once the channel was cut the ships would always take the shortest course. This theory was subsequently vindicated by annual tonnage records.

The special board of 1894 concluded in favor of the Back Creek route as the most feasible for national defense and of greatest facility to commerce. Factors favoring it over all others were:

1. Minimum total length (about 14 miles); minimum restricted canal way.
2. Least number of bridges required.
3. Already existing military defenses.
4. Opportunity to reimburse owners and stockholders.
5. Property in which the government already had equity.
6. Least expensive to acquire, reconstruct and maintain.

A new board was appointed by the President in June 1906 to examine and appraise the value of the existing Chesapeake and Delaware Canal and to examine and investigate the feasibility of the Sassafras route. This panel, referred to as the "Agnus Commission," was chaired by then-retired General Felix Agnus of Baltimore. General Agnus was among the first and most articulate of the ship canal's proponents. On the board with him were Major C. A. F. Flagler, Corps of Engineers and F. T. Chambers, Civil Engineer, U. S. Navy.

Within six months the Agnus Commission had gathered the data for its report, containing re-evaluations of precedent reports, evaluations of new hearings and a detailed appraisal of the works and franchises of the Chesapeake and Delaware Canal Company's holdings. Of singular interest was Capt. Philip Reybold's rather impassioned deposition, given before the commission at Wilmington, setting forth the military advantages to be realized by developing the existing route. The Sassafras route was examined with equal thoroughness but was judged, finally, to lack first choice advantages. The commission recommended purchase of the old canal at a price not to exceed $2,514,289.70. The Canal Company's total valuation was $5,348,071.00. Capital stock of the C&D Canal owned by the state of Maryland in the amount of $81,250 was offered to the project "if the United States Government will purchase said canal and construct over the route of the same a free and open waterway, having a depth and capacity sufficient to accomodate the largest vessel afloat at mean low water."[2]

Efforts to get the canal company into a negotiating position continued to be ineffective. Stockholders, in 1906, numbered 340, bondholders 531 and the states of Maryland, Delaware and Pennsylvania owned large blocks of stock, which they carried on their books as nonproductive assets. A dividend on the stock had not been paid since 1877. Company officials expressed willingness to sell the property but found it impossible to get a consensus of the stockholders.

A broader concept of the benefits of a ship canal connecting Delaware and Chesapeake Bays came to maturity in the next two years. The original impetus provided by the mercantile and shipping interests of Baltimore was directed toward one specific solution: A protected route, direct as possible, for ocean-going ships between Baltimore port and the sea. There is little doubt that those interests would have been happily served by a free and open waterway developed and maintained by the Federal Government over a route of their choosing. Such unilateral benefits were never regarded by the study commissions as adequate to justify a federal project and erosion of Baltimore's support increased as the broader concept evolved. The River and Harbor Act of March 3, 1909 touched off the final phase of the ship canal search. That act directed surveys for a waterway, inland where practicable, from Boston, Massachusetts to Beaufort Inlet, North Carolina" . . . . *as may be found sufficient for commercial, naval or military purposes . . . . . and a report upon the desirability of utilizing as a part of such waterway any existing public or private canal, or any part thereof . . .* " As a link in a network of protected intracoastal navigation channels, the old C&D Canal was ideally situated. A special board of Corps of Engineers officers[3] found this to be so and on Dec. 13, 1911 the Board of Engineers for Rivers and Harbors (senior member, Col. Wm. T. Rossell, Corps of Engineers) concurred, recommending immediate purchase of the canal, by condemnation if necessary.

Final reports, dealing with specific changes to be made in transforming the Old Lock Canal to its new function, were made by the special board, the Board for Rivers and Harbors, and lastly, in August 1913, by Brig. Gen. W. H. Bixby, Chief of Engineers. A memorandum for the Chief of Staff, War Department under the subject "Military Advantages of the Chesapeake and Delaware Canal" presented a 7-paragraph summation of the military significance attributed to that waterway in 1914. This document was signed by Brig. Gen. M. M. Macomb, Chief of the War College and bore the concurrence of Brig. Gen. Tasker H. Bliss, Acting Chief of Staff and Lindley M. Garrison, Secretary of War.

In December 1918, 33 days after the signing of the Armistice which ended World War I, Newton D. Baker, Secretary of War dispatched a message to the 65th Congress, recommending the purchase and improvement of the Chesapeake and Delaware Canal as part of the Inland Waterway. A bill was passed, funds appropriated and the purchase transacted.[4] Thus, 48 years after the kick-off resolution in Baltimore, the ship canal was authorized and the task of its construction and maintenance was assumed, and not since relinquished, by the Corps of Engineers.

THE INLAND WATERWAY

The historic Gallatin Report on Roads, Canals, Harbors and Rivers, presented to Congress on April 4, 1808, defined a concept of internal improvement which, in its broad terms has remained up to modern times as a virtual statement of national policy. But President Jefferson's Secretary of the Treasury was ahead of his time in American government. The Congress of his day was not ready to spend 20 million dollars of the peoples' money on a ten year program of road and canal building. It devolved upon private enterprise and local government to actualize the concepts engendered in Mr. Gallatin's proposals.

The first part of the three part program recommended in the Secretary's report proposed the creation of an Inland Waterway from Massachusetts to North Carolina, using existing bays and rivers linked by a system of canals. Practical benefits would obviously accrue to the national defense beyond the provision of a protected trade route for coast-wise shipping. The report's specific recommendations included federal financial support for the Chesapeake and Delaware Canal, a privately promoted enterprise incorporated in 1799, which had made three unsuccessful attempts to begin construction. This important link did eventually obtain substantial government assistance in 1822 and was finished in 1829.

The Delaware and Raritan Canal

This other "logical" segment of a national water route partially within the purview of the District was not opened for navigation until 1834, after undergoing financial difficulties typical of the period. The Delaware and Raritan Canal, connecting the Delaware River with Raritan Bay and the Port of New York, materialized as a consequence of commercial logic rather than as a part of an Inland Waterway plan. Coal from Pennsylvania mines, carried by the Schuylkill Navigation[1] to the Delaware River at Philadelphia, had to be reloaded into seaworthy vessels for the long trip to New York via Cape May and the Ocean. By canal, the 43 miles of the inside route between Bordentown and New Brunswick could be traveled by open barges which had been loaded at the mines, saving almost 200 miles and the need to transfer cargoes. Ill-starred from the beginning, the D & R had to compete with railroads from the day it was chartered. On that day, Feb 4, 1830, the State of New Jersey granted a charter also to the Camden and Amboy Railroad, which built its line parallel to the canal route. A peculiar arrangement was negotiated by which the two companies shared fiscal matters but retained separate corporate identities. The State of New Jersey, in a questionable bargain with the two companies, granted them a virtual monopoly for transportation between Philadelphia and New York in exchange for the payment of lucrative transit duties.

The physically best-endowed of American canals for many of its earlier years, the Delaware and Raritan might have become hugely profitable, but for its unfortunate involvement in Railroad and State transportation deals. Chief engineer for its construction was Canvass White, then considered the country's foremost engineer. Backed by ample funds and a store of experience gained from his work on the Erie and other projects, White built an almost trouble-free waterway. With only 14 locks, an ample water supply and the largest channel section except that of the Cheasapeake and Delaware, the Delaware and Raritan was the key link for freight traffic to New York Harbor from Chesapeake Bay, the Susquehanna hinterland and the Pennsylvania coal fields. Exclusively a freight carrier, its commerce was preponderantly "through" hauls of coal cargoes. The channel was enlarged in 1846 to meet competition of the Railroad and the canal attained its peak in 1859 when it carried 1,699,101 tons, of which 1,372,109 were anthracite coal.

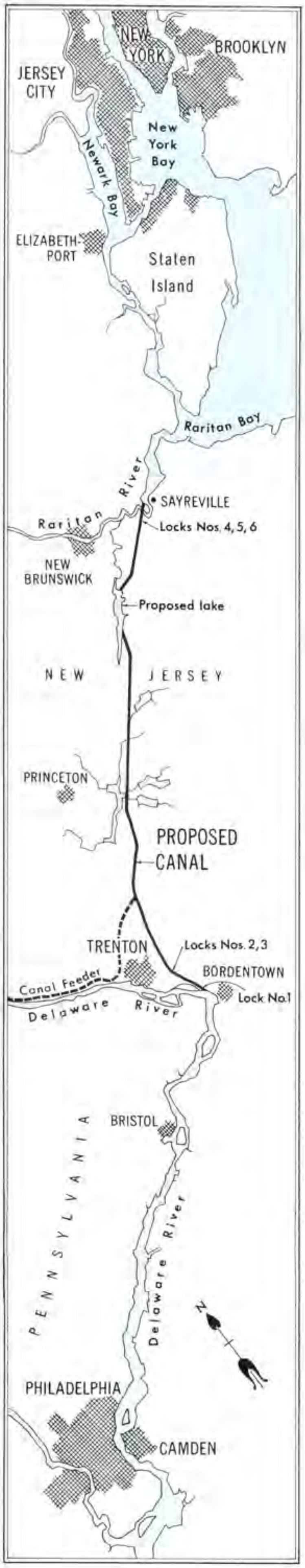
Having built its business on a specialized commodity, the D & R was dependent on the flow of coal barges from the Pennsylvania mines, especially via the Schuylkill Navigation. So the fortunes of the Schuylkill Navigation and the D & R were inextricably entwined. Those fortunes began to deteriorate with the 1850 Schuylkill floods which wrecked 23 dams, and continued to slump as the Reading Railroad took over more of the coal transport business. The year 1869 was catastrophic. A miner's strike halted coal shipments and a severe drought reduced flows to levels too low for navigation. In September rain fell in exorbitant amounts, producing the greatest flood the Schuylkill Valley had known and nearly wiping out the Navigation Company's works. A year later the Schuylkill Navigation came under the control of the Reading Railroad.

Across the Delaware things fared little better. In 1871, the Pennsylvania Railroad leased the Camden and Amboy Railroad and with it took over the Delaware and Raritan Canal. In rivalry with the Reading, the Pennsylvania Railroad prohibited use of the D & R for transport of coal from the Schuylkill mines, in one stroke curtailing the canal's business by a million tons annually. Both Companies allowed their water routes to decline, diverting the freight business to their rail lines. The Schuylkill suffered disastrously; unable to recover, it had by 1905 ceased carrying all freight traffic.

Though neglected, the Delaware and Raritan survived and remained a fine canal. Never seriously impaired by floods or droughts, its setbacks stemmed principally from the fancies and foibles of its controllers, rather than from a faulty physical plant. It carried 1,200,000 tons in 1889 and was still doing business, though at a loss, when in 1895 a prominent group of Philadelphians started a movement to promote construction of a deep draft canal between the Delaware River and the Atlantic Ocean.

New Jersey Ship Canal ("The Missing Link")

The Canal Commission of Philadelphia was created by ordinance of Select and Common Councils of the City of Philadelphia under date of July 2, 1894. The Commission, originally chaired by Mayor Edwin S. Stuart,[2] listed among its members some of the most prestigious names[3] in Philadelphia public life. N. H. Hutton, Engineer of the Harbor Board of Baltimore, was appointed Consulting Engineer and Professor L. M. Haupt was engaged as the Engineer in Charge of Surveys. The sum of $10,000 was appropriated for preliminary surveys and studies. The petition requesting the first public hearing had cited Baltimore's efforts to secure a ship channel to the sea and the urgent necessity of increasing the transportation facilities of Philadelphia port and city. Concurrently, a board was



Proposed Trans-Jersey Ship Canal—1896.

In 1894, A survey party of 17 Corps of Engineers personnel ran lines for canal and feeder—59 miles in 51 days.

On the map, the route appeared to its proponents as logical and necessary as that of the Chesapeake and Delaware Canal, which was then receiving favorable consideration for development by the National Government.

Its undenied merits were offset by obstacles of logistics and ecology and by opponents in the power struggle which was shaping the transportation patterns of the period.

appointed by the President of the United States to determine the most feasible route for a deep draft Chesapeake and Delaware Canal.

In a combined report submitted to Philadelphia City Councils on June 4, 1895 Hutton and Haupt set forth an overall configuration for a one-level lock canal with facilities for transiting all classes of vessels including warships. The route under consideration stipulated improvement of the Delaware River Channel from Philadelphia to Bordentown, where the canal proper would start. From there the canal would proceed nearly due northeast across New Jersey to the Raritan River in the vicinity of Sayreville. River to river, the canal was to be 31.4 miles long. The plan generally ignored the old Delaware and Raritan route, which was 11 1/2 miles longer and meandered considerably. Three locks at each end would provide a total mean lift of 56 feet. Alternative prism designs were offered; one for a depth of 20 feet, bottom width 96 feet and a surface width of 150 feet; the other for a 28-foot depth and widths of 100 feet at bottom and 184 feet at the surface. Proposed toll rates were: 20 cents per ton for the 20-foot channel; 30 cents per ton for the 28-foot channel. Estimated construction costs for the two plans, respectively: \$14,264,600 and \$23,894,700. Hutton's report gave figures for mileage saved by the inside route: Philadelphia to Battery, N.Y., 182 miles; time saved by average steamer, one way: 12.4 hours. Water supply was to be obtained entirely from the Delaware River by "construction of a suitable dam and feeder." On the project map this appears to be

Chesapeake and Delaware Canal conversion to sea-level waterway, 1924. Hydraulic pipeline dredge is excavating in the Deep Cut east of Summit Bridge.

located on the course of the old D & R feeder, which ran from Raven Rock to Trenton, a distance of 22 miles. The old feeder, built 1832-34, was 60 feet wide, 6 feet deep and navigable through the first quarter of the twentieth century. The report notes that the survey party, staffed by 17 Corps of Engineers personnel, "prosecuted the work rapidly, over 59 miles having been run in 51 working days."

The traditional opponent of canals — the Railroad—fought any attempt to realize a trans-Jersey link for the Intracoastal Waterway. Among other obstacles cost was always paramount. Maintenance of the huge water supply, estimated by Prof. Haupt to be 7,677,366,000 cubic feet per annum for passage of 10 million tons of traffic, posed logistical problems which prompted many persons to start thinking in terms of a sea-level canal. Meanwhile, the Special Board headed by Chief of Engineers General Casey, was preparing a report on the proposed Chesapeake and Delaware Ship Canal and would, in a few months, recommend purchase of the old C & D Lock Canal and its conversion to a toll-free sea level waterway.

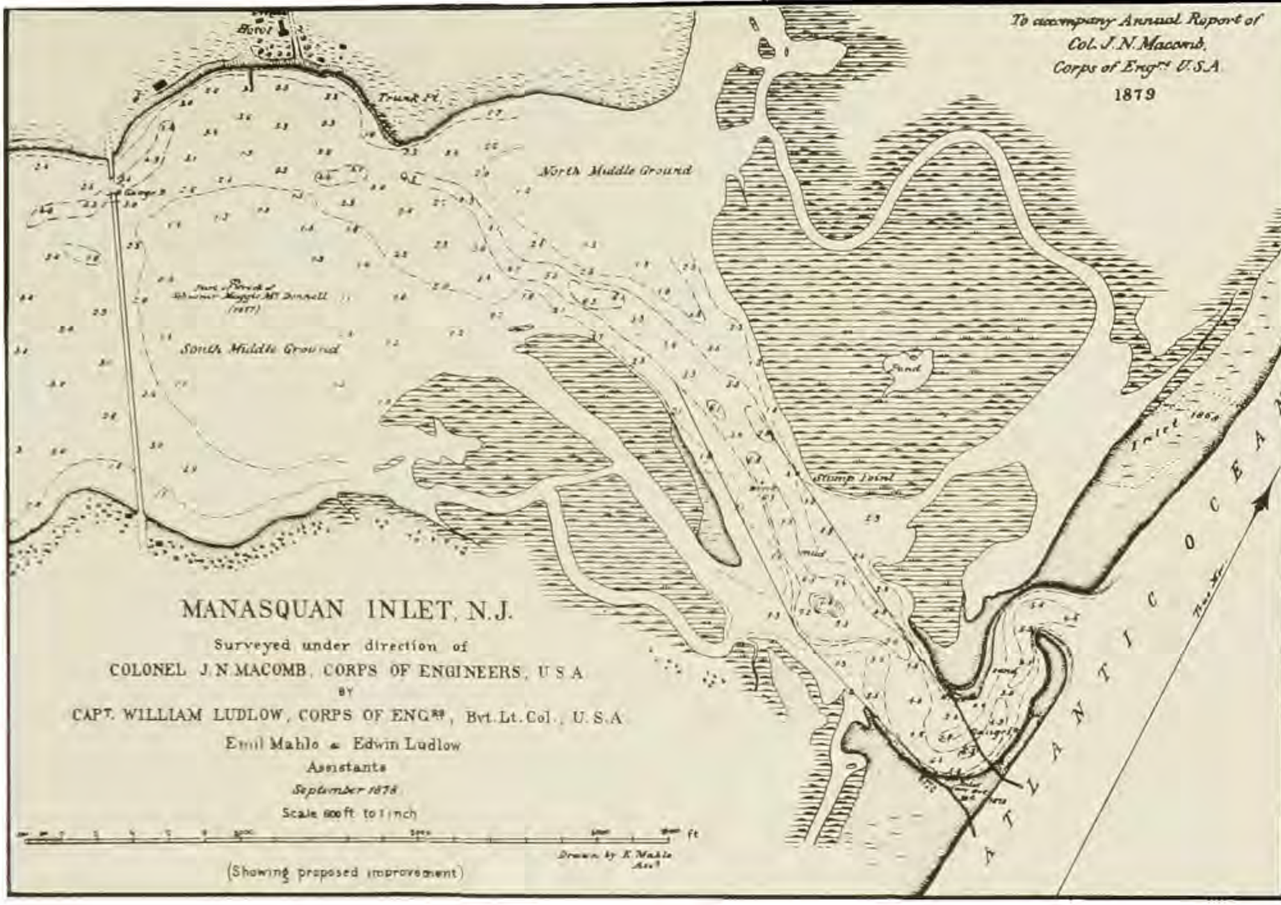
A new group, the Atlantic Deeper Waterways Association, founded in 1907, took up the cudgels for the Trans-Jersey Ship Channel, which they dubbed "The Missing Link". At their Baltimore convention of 1908 resolutions were drawn emphasizing the needs of commerce, risks to human life accompanying the outside route and benefits to the Nation in case of war. It was also resolved "*That the canals should be digged in any case by the Federal Government - - - because the Government alone has authority over navigable waters - - - because all the canals should be free* ---" The Philadelphia Record, a leading daily newspaper, deplored the railroads' destructive waterways practice of acquisition and compulsory disuse[4]. "*. . . It has been deemed good policy on the part of the Railway Companies as far as possible to do away with the rivalry of water carrying. To this end vast sums of money have been spent* *in acquiring control of canals and water lines . . .The adoption of such a destructive policy was perhaps natural enough at the beginning, but it was and is a stupendous blunder . . . . To create a new facility for traffic is to create new traffic. To destroy an existing facility brings no answering advantage."*

Advocates of the "Missing Link" propounded no new arguments in the 30 years subsequent to the founding of the Atlantic Deeper Waterways Association. But the old issues were kept alive and before the attention of Congress. In a report of 1912, cost of the project was estimated at 20 to 45 million dollars. In 1937 estimated costs were 65 to 85 millions.[5] By 1942 the quoted figure was 187 million dollars[6], based on studies for a revised channel concept. This plan proposed a summit level at an elevation of 10 feet above mean low water, requiring a deeper excavation and consequent penetration of the area's waterbearing sands. Objections were raised by New Jersey water supply authorities, who thought that salt intrustion from the Sayreville entrance would ruin ground water supplies and contaminate the Delaware River. A review report directed in June 1934 by the House River and Harbor committee defined the problems and sought solutions relevant to the proposed project. These studies, undertaken by the New York District, Corps of Engineers were incomplete due to lack of funds. Recommendations included construction of a dam on the West Branch of the Delaware River at Cannonsville, New York from which substantial releases would furnish ample flows and generating power to pump Delaware River water into the Bordentown locks; reservoirs fed by the Raritan drainage area would augment the supply and furnish a sufficient current volume to operate the locks and carry out a system of flushings which would obviate salinity intrusion. A large scale model of the proposed canal and locks was set up at the Corps' Waterways Experiment Station at Vicksburg, Mississippi. The empirical conclusions of a large number of scale lockages predicated the above recommendations.

The "Missing Link" is still a subject of sporadic interest and missionary enthusiasm. Its value as a strategic military tool declines as modern weaponry advances beyond traditional restraints of time and space. During World War II there was some thought to justify the project by using the valuation of boats and cargo lost to enemy submarine action between Norfolk and New York harbor. If a report was made it must have been confidential and possibly less than persuasive. The argument for safe passage of ships also loses emphasis as technology continues to contribute to safer navigation. An editorial campaign was undertaken several years ago to stimulate interest in restoration of the old Delaware and Raritan Canal as a route to serve the East Coast's growing numbers of pleasure craft.

New Jersey Intracoastal Waterway

That segment of the Inland Waterway[7] which comes under the District's supervision begins, at its northern end, where the route enters Manasquan Inlet from the Atlantic Ocean, at the mouth of the Manasquan River. The channel penetrates the lower basin of the Manasquan for two and one half miles, then



turns southeastward and passes through the two-mile long Point Pleasant Canal to join with Barnegat Bay at Bay Head.

Plans for a canal to connect the waters of the Manasquan River and Barnegat Bay were projected around 1839. A state charter was obtained, Commissioners appointed and funds raised by public subscription. The survey, run across the littoral marsh, revealed a four foot differential in water levels of the terminals, predicating the need for a canal with two locks. An assessment of costs and potential assets persuaded the commissioners that the project was financially unfeasible and should be abandoned.

Forty years later a survey and examination of Manasquan River was reported to the Chief of Engineers by Captain William Ludlow of the Philadelphia Engineer Office. The 1879 chart accompanied the report, which included a project plan and cost estimates for improving the river, opening an inlet and constructing protective jetties. The natural inlet was an intractable, S-shaped gut, scoured out of the sand beach, separated from the ocean by a sand bar 80 to 100 feet wide. The constantly shifting sands made the channel unpredictable, navigation hazardous. Occasionally, with westerly winds prevailing, the bar was flooded to sufficient depth to permit the entrance of shallow draft vessels. At times the upper section of the gut became congested, causing stagnation of the river, consequent fish kill and noxious living conditions for the local inhabitants.

Captain Ludlow's plan called for dredging a channel through the bar perpendicular to the coastline and constructing jetties to extend offshore, wing fashion, about 100 feet. Creosoted timber piles were to be driven by water jet, the structure to be sand-filled and capped with stone. Survey lines run for the report failed to corroborate an appreciable disparity of levels between mean high water of the bay and mean low water of the river, which had been reported in 1839. Captain Ludlow dismissed the relevance of a canal, in any event a canal with locks, but emphasized the expediency of the inlet project as providing a needed harbor of refuge for vessels navigating the "long reach of unbroken shore of New Jersey."

In the second session of 1879, Congress appropriated $12,000 for commencement of

Capt. William Ludlow

the Manasquan River improvement. In the next two years additional sums were appropriated for a total of $39,000. In 1883 work was suspended. Gaps in the records allow some conjecture as to the actual extent of operations, since the project cost was estimated at $52,120. Certainly, an inlet was dug and lined with timber piling; dredging in Manasquan River, as originally proposed, was probably curtailed and snagging operations may have gone by the board as often happened with the early river projects.

Sand, swept northward with the littoral drift, rounded the south jetty and obstructed the inlet, which was frequently closed in the early 1900's. A project of 1933 provided new jetties of dumped stone; inshore bulkheads of steel sheet pile were installed in 1937. Rehabilitation of the bulkheads in substantial amounts was carried out in 1939 and 1955; minor patching was done in 1952, 1957 and 1961. Progressive deterioration of the steel piling, due to galvanic action and the corrosive effects of salt water and air, occasioned an examination in 1962; subsequent study offered alternate plans for rehabilitating the bulkheads by installation of steel sheet pilings, jetty-type stone structures or pretensioned prestressed concrete sheet piles.

The last method was adopted (the first of its kind in the District) and installed in 1964-65. The 1 1/2 to 7 1/4 ton slabs were placed behind the existing piles and tied in with existing tie rods. Every detail was studied for optimum results with maximum economy. Extensive core sampling was ruled out by the stringency of the budget. Historically, the materials most resistant to penetration were sand and soft clay. Piles for the north bulkhead were jetted into place without undue difficulty, but the south bulkhead required deeper penetration, and here tough resisting clay was encountered. The blunt pile tips were not designed for percussion driving; water jets were ineffective in penetrating the stiff bottom material. Iron wedge shoes for the pile tips were considered, but not adopted for cost reasons. The south bulkhead piles were finally lowered into place by hammer blows — about 400 to the inch.

The District maintains channel depths of 14 feet between the Manasquan jetties and 12 feet to the R. R. Bridge over Manasquan River. Point Pleasant Canal, formerly Bayhead-Manasquan Canal, was developed by the State of New Jersey; it was completed in 1926 over the route originally surveyed in 1839 and resurveyed in 1879. Previously, between 1908 and 1916, the State had excavated over three million cubic yards of material from the bays and thorofares from Bay Head to Cape May Harbor, to provide a protected waterway six feet deep, 100 feet wide and 100 miles long. The final link in the New Jersey Intracoastal Waterway was created as a wartime emergency measure in 1942. The three-mile Cape May Canal, between Cape May Harbor and Delaware Bay, was dredged at federal cost, about 95 percent of which was defrayed by Navy Department funds.

Federal control of the Waterway was urged by the State of New Jersey and by other public interests in the latter years of World War II. A study by the Corps of Engineers in 1938-39, recommending Federal Jurisdiction was the basis for a 1945 Congressional Act approving the transfer. Final conveyance to the United States was made in 1954.

The channel is maintained at a six-foot depth for most of its length and follows a fairly tranquil course, except for a few open reaches exposed to sea conditions. The route passes under or through 26 bridges, of which four are fixed, six swing and 16 bascule. Operation of the movable spans is governed by Federal regulations. The District's maintenance operations account for the removal of approximately 194,200 cubic yards of material annually from the navigation channel.

The waterway serves hundreds of thousands of persons annually for pleasure boating, sport and commercial fishing. Continuing studies are exploring the expediency of increasing its depth and improving the channel alinement. Broad Thorofare, below Margate City, was improved in 1963 by the excavation of 150,000 cubic yards of material, providing a safer transit by bypassing Great Egg Harbor Inlet. Rehabilitation of bulkheads for the two-mile length of Point Pleasant Canal was begun in 1971; canalside walkways, access stairs and landscaping are in planning for this sector. A proposed project for Northern New Jersey would extend the inland channel above Manasquan by digging a 20-mile canal between the Manasquan and Shrewsbury rivers. Reported to Congress in 1918, the project has not yet merited economic justification.

Parallel jetties guard the entrance to Cape May Canal at its western terminus in Delaware Bay; they were constructed in 1943 under the same authorization that funded the canal. In 1964, the south jetty was relocated 175 feet southward by the Delaware River and Bay Authority, to facilitate operation of its Cape May-Lewes ferry system. Under Department of the Army permit and at its own expense, the Authority further improved its bay crossing by channel dredging, construction of a stone breakwater at Lewes, Delaware, and construction of ferry terminals at Lewes and within the Cape May Canal entrance.

Leaving Cape May Canal, the Delaware Bay crossing is the next link in the Inland Waterway: about 17 miles to Roosevelt Inlet and access to the Lewes and Rehoboth Canal or nearly 59 miles to the Reedy Point entrance

Old railroad drawbridge across Manasquan River.

The saving basin on the north side of Chesapeake City Lock was modified to facilitate admittance into the canal of working craft too large to enter through the locks. In this view, adapted from an old photograph, a dipper dredge has entered the basin through the gated coffer dam at left. On the right, a large pipeline dredge is berthed under the north wall of the lock.

of the Chesapeake and Delaware Canal. The District's maintenance responsibilities extend westward from Reedy point about 25 miles to the C & D Canal approach channel in Chesapeake Bay and Elk River.

A New Freeway

The purchase of the Chesapeake and Delaware Canal by the United States Government was transacted on August 13, 1919. Its conversion to a sea level canal began with dry excavation by steam shovel on June 27, 1921. The reconstruction project was under direction of the Corps of Engineers with the District Engineer, Wilmington, Delaware in charge. The authorization provided for a channel depth of 12 feet and a bottom width of 90 feet. The route was to essentially follow that of the existing canal except at the eastern terminus. There a new entrance would be made at Reedy Point, two miles south of the old entrance at Delaware City.

This deepening and widening operation was candidly conceived as a first step, the rather limited dimensions still not fulfilling the requirements of a ship channel. Specified for barge traffic, its plans anticipated further enlargement should such a course appear justified by a substantial increase in traffic. Piers for the five new vertical lift bridges were built deep enough to allow for a possible future channel depth of 35 feet. The bridges when open had a vertical clearance of 140 feet above low water and a clear span of 175 feet between fenders, except the Chesapeake City bridge, which had a horizontal clearance of 240 feet.

It was stipulated that work should proceed without interruption of water traffic, which amounted to an estimated 30 to 50 vessels daily. This implied continued use of the locks and liftwheel pumping plant and imposed some restrictions on movement of the dredges, which were too large for the locks. Highway and railroad traffic using the bridges across the canal was to be interrupted as infrequently as possible. The problem of moving large dredges into the canal was solved by ingenious conversion of the saving basin at Chesapeake City to the function of a lock. Cofferdams of steel sheet piling were constructed on two sides of the basin. One of these was removed to admit the dredge at low tide. This cofferdam was then replaced, the basin flooded to canal level and the dredge floated through the opening made by removal of the second cofferdam. Six large dredges were moved in and out through this auxiliary lock. The working plant consisted of seven large hydraulic dredges, two scoop dredges, one steam shovel and two dragline banking machines.

As with the original canal, major problems were again encountered in excavating the Deep Cut. Here, the largest amount of material to be removed was concentrated, and bank slides made considerable excess dredging necessary. The summit Divide, through which the deepest excavation was made, averaged an elevation of 80 to 85 feet above sea level. Lifts of 80 to 95 feet were involved in removal of dredge material to disposal areas outside the channel cutting.

The locks at St. Georges and Chesapeake City were finally removed and the new channel was formally opened on May 14, 1927. The new entrance from the Delaware River at Reedy Point was protected by two

rubble-mound type jetties, each extending offshore 1,350 feet. The jetties were completed in 1929, at a cost of approximately $350,000.

The estimated cost of converting the canal to a 12 foot depth was $13,000,000; the actual cost $10,060,000. The total amount of material excavated was 16 million cubic yards. During its last year of operation as a lock canal a total of 608,466 tons were carried. Annual tonnage figures for the next six years were:

1928 —	700,413
1929 —	709,095
1930 —	867,715
1931 —	990,940
1932 —	1,017,332
1933 —	1,191,242

Free of tolls and locks, the canal had become an attractive route for more freight lines, increasing its annual tonnage by nearly 100 percent in a half-dozen years. The upward trend indicated a growing demand for access to the route and attested to the need for a deeper, wider channel to accommodate ship transit. In 1933, the Board of Engineers for Rivers and Harbors recommended that the channel be modified to a depth of 25 feet and a width of 250 feet. It was further recommended that a 400 foot wide channel be dredged from the mouth of Back Creek down Elk River and Chesapeake Bay to deep water near Pooles Island, an additional 26 miles.

Way for the Ships

In 1933 the Country was still reeling from the effects of the '29 market crash. The economy was in dire straits; many thousands could not find work and were on relief rolls. Initial funding for the new enlargement project was made under the Emergency Relief Appropriation Act in the amount of $5,107,000. The purpose of the Act being to provide jobs for persons on relief, it was rigidly stipulated that 90 percent of all workers should be hired

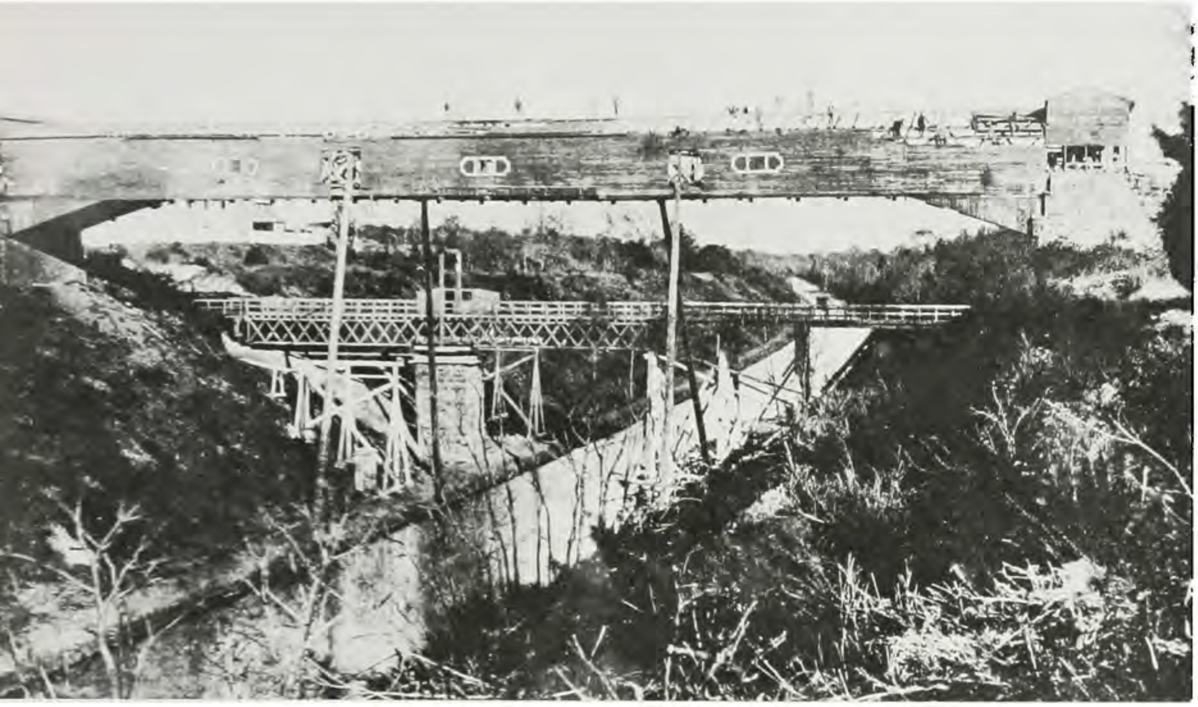
Workmen employed under the Emergency Relief Appropriation Act moved earth with hand tools on the embankments of the Chesapeake and Delaware Canal.

from relief rolls. The project was adopted in 1935 as recommended in the 1933 report, except that a revised depth of 27 feet was authorized. The work was under the direction of the District Engineer, Philadelphia District, except the 26 miles of channel from Elk River to deep water, which came under the jurisdiction of the Baltimore Engineer District.

Approximately 35 million cubic yards of material were excavated to produce the new channel, most of it pumped out by hydraulic dredges at the rate of one million cubic yards per month. A vast and varied array of equipment was engaged in the reconstruction project, headed by the powerful pipeline dredges: Baltimore, General, Orion, and Ventnor, of which the Baltimore was the largest and most modern. In addition there were steam shovels, draglines, elevating graders, diesel tractors, caterpillar wagons, euclid carry-alls, dump trucks and Le Tourneau scrapers. The removal of 4 million cubic yards of material by dry excavation was accomplished in the Deep Cut. Bank slides were minimized by this procedure, the overburden being removed down to the plane of 15 feet above mean low water before dredging was started.

However, the slopes through the Summit Divide continued to prove unstable. The decision was reached to seek methods for preventing the recurrent slides. Studies were initiated at the Foundation Investigation Section at Ithaca, N.Y.[8] and a laboratory was set up on the Engineer Reservation at Wilmington, Delaware to study bank soils. The results of these observations showed the need for flatter slopes than 1 on 2, more on the order of 1 on 5[9]. Relieving berms (ledges) were advised together with a drainage system to carry off ground water. A bank stabilization program was approved in April 1939. From 1940 to 1948 six and one half miles of embankment were graded and equipped with drainage facilities. The work required excavation of 4 million cubic yards of earth, installation of 10 miles of drainage pipe and placement of 56,000 tons of riprap at a cost of $2,250,000.

The full channel prism was excavated at the bridges, requiring new shoreward spans and abutments. The existing bridge piers were



The original Summit Bridge was built in 1826 before the channel cutting was made. It spanned the canal across the "Deep Cut," 247 feet between abutments, 90 feet above the canal bottom.
In this 1872 photograph the first Summit Bridge is being dismantled and its replacement is nearing completion just beyond.

Summit Bridge No. 2 was this pivoting span, located a short distance eastward of the old covered bridge site. Also known as Buck Bridge, the structure was in service 55 years before giving way to the canal enlargement project of 1921-1927.

reinforced by driving steel pipe batter piles vertically around them. The piles were then filled with concrete and topped with concrete collars. A model study was made to seek remedies for the rapid shoaling which was occurring between the jetties at Reedy Point. The Waterways Experiment Station report concluded that shoaling could be reduced by extending the north jetty. This was accomplished in 1942, when the north jetty was extended 800 feet.

Dredging the 26-mile approach channel in Elk River and Chesapeake Bay started on July 21, 1936. The work was directed by the District Engineer, Baltimore District using the Corps of Engineers' Hopper Dredges Nave-

The third bridge at Summit, Delaware was a vertical lift iron bridge with a horizontal clearance of 190 feet between piers and 140-feet vertical clearance at mean low water, span up. Its design was similar to that of four other lift bridges, constructed when the Chesapeake and Delaware Canal was converted to a sea level waterway.

The high level Summit Bridge was opened to traffic in 1960. That year it received the "most beautiful bridge" award from the American Institute of Steel Construction. This fourth Summit Bridge spans the canal near the "Deep Cut" site of the original bridge, but the cut seems shallow with its terraced embankments and new width of 450 feet at the water line.

sink, Absecon, Atlantic and Delaware in the work. When dredging stopped on May 11, 1938 a channel 400 feet wide and 27 feet deep had been dug from the mouth of Back Creek in Elk River to a point in deep water southeast of Pooles Island in Chesapeake Bay. More than 24,315,920 cubic yards of material were removed, and deposited in specially-diked disposal areas contiguous to Pearce Creek. This 997 acre site at the mouth of Elk River had previously been purchased by the U. S. Government for the purpose. Tonnage figures soared from 1,061,207 tons in 1935 to 10,827,000 tons in 1942, from the middle of the 27-foot conversion period through the "Arsenal of Democracy" years into the first full year of United States engagement in World War II. That war-inflated figure remained the all-time peak for 22 years. It was topped in 1964 by the impressive total of 11,167,500 tons.

The 27-foot channel at last provided a ship-way across the Delmarva Peninsula, but not the final ship-way. Ocean-going vessels picked up pilots at canal's entrances, glided around the curves and edged cautiously between the piers of the steel bridges, not always successfully. There were scrapings, groundings and collisions. On Jan. 10, 1939 at about 8:30 A.M. the S.S. Waukegan, westbound from Reedy Point, refused to answer the helm, sheered north and struck St. Georges bridge, completely demolishing that structure and killing the bridgetender and his assistant.

On a day of good weather, July 28, 1942, at 11:38 A.M. the 540-foot Motorship Franz Klasen with three towing vessels in attendance, approached Chesapeake City bridge from the eastward side. With a strong current running against her starboard bow, the vessel failed to make the proper maneuver in what

A merchant ship, bound for Philadelphia through the canal, passes under Chesapeake City bridge.

The S.S. Waukegan aground and jammed in the wreckage of St. Georges Bridge.

was then the middle of a 3,700-foot radius bend. Her sheer to port brought her against the south pier of the bridge and the impact crashed the lift span down across her bow. The bridge towers with their counterweights and the approach spans collapsed into the canal. No lives were lost.

Interruption of highway traffic was remedied at both sites by the installation of a ferry service, which operated while the bridges were being replaced. The new St. Georges bridge, a single span tied arch structure carrying a four-lane highway was opened to traffic on 31 Jan. 1942. Chesapeake City's new high level bridge of similar construction was built between 1946 and 1949. Longer hulls with deeper drafts and broader beams sought access to this convenient short cut on the seaboard trade route. As before, the arguments for change were supported by the most persuasive proof of the canal's usefulness: an increase in the number of transits and the amount of tonnage hauled. Serious consideration had to be given the depositions of pilots, crews and government personnel, taken in the increasingly frequent instances of ships' impacting with each other and with canal structures.

Resident Engineers' accident reports redundantly recommended a wider channel, elimination of curves and replacement of the narrow lift bridges with high level fixed spans. Responding to these needs, the studies in progress faced the inevitable dilemma: whether to make another interim change to satisfy current needs or to project a final ideal situation that would still be consistent with economic reality. Vessels transiting the canal

Franz Klasen with wrecked Chesapeake City Bridge.

Between late July and October of 1942 only pedestrian traffic crossed the canal at Chesapeake City. Vehicles had to detour about ten miles, using Summit bridge. Of the several launches used initially for ferrying, one was named "Oakes" in recognition of the bridge tender, William F. Oakes, who was killed three years earlier in the collision which destroyed St. Georges bridge. The traffic situation was relieved when the Corps of Engineers installed ferry slips and put the 40-vehicle ferry boat "Gotham" on a 24-hour toll free schedule. This service was discontinued on September 21, 1949, after completion of the new high-level bridge.

The population of Chesapeake City, Maryland numbered 2,301 in the 1940 census, about evenly divided between north and south. Destruction of the bridge caused considerable disruption of community life. The fire house was on the north side of the canal; schools were on the south side. Interim ferry service for pedestrians was provided immediately by the Government in the form of various Corps-owned launches. A leased motor cruiser, the "Victory," began service on September 15, 1942 and ferried approximately 1,850 persons daily during her 39-day lease. Here, school children are boarding at the north side.

Nearing completion in this 1968 view is the cut-off channel with new railroad lift bridge. This improvement eliminates the navigational hazards of Lorewood curve and the narrow span at left.

averaged a beam width of 62 feet, with a maximum permissable width of 72 feet and length of 540 feet respectively. An ultimate prism formula was determined after studying Panama Canal figures for passing distances and ascertaining the fact that most passages on the C & D were partially loaded vessels taking on or discharging cargo between the ports of Baltimore, Philadelphia and New York. It was additionally determined that:

> *"the width of canal that would be required to keep the forces of interaction between large vessels, and between vessels and the banks down to negligible magnitude would be so great as to be impossible of economic justification."*

This seemed to suggest that limiting criteria were needed to regulate admissible hull sizes and the movement of traffic. Such considerations were inherent in the establishment of ultimate channel dimensions and fixed bridge clearances.

The Final Touches

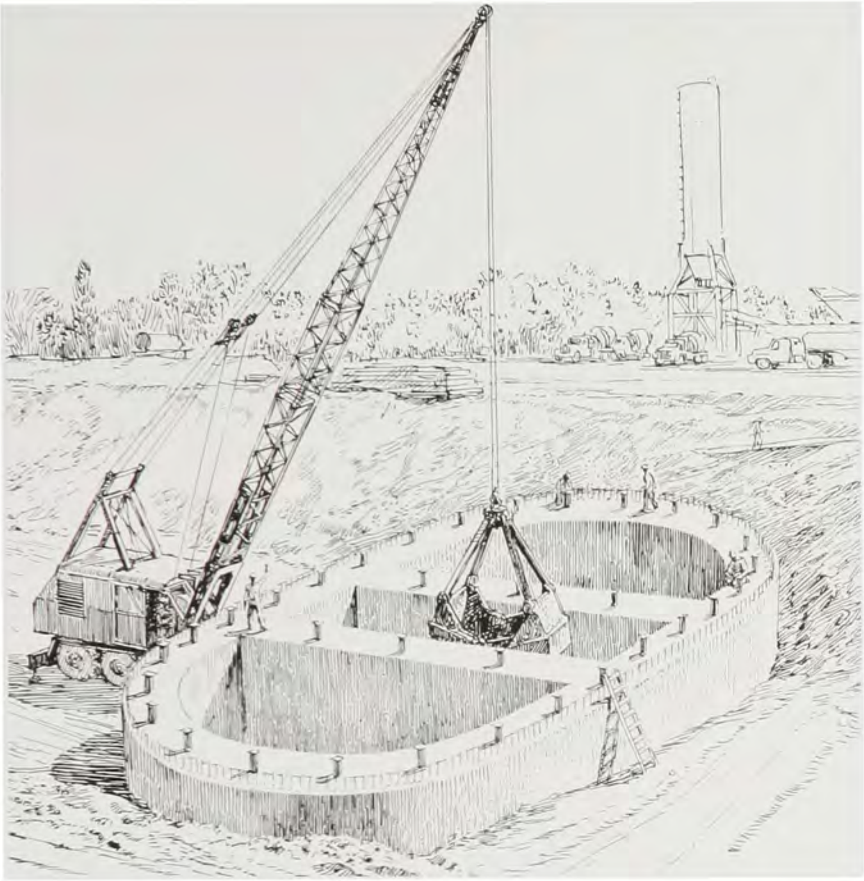
Major studies were completed in 1954, with the Congress authorizing further improvements to the canal in that year. First of the improvements was a four-lane high-level highway bridge at Summit, Delaware to replace the 32-year old iron lift bridge. This new Summit Bridge, begun in 1958 and opened to traffic in 1960 is the fourth to be constructed at the high point of the Deep Cut divide. Before the lift bridge there had been a pivot swing bridge, built in 1867 to replace a high-level wooden covered span. High priority was given to easing the severest curves, especially those at the railroad bridge and at Chesapeake City. No bend was to have a curvature radius of less than 7,000 feet. The new channel was to be 35 feet deep at mean low tide with a bottom width of 450 feet. The hazardous Lorewood curve at the railroad bridge was by-passed by a straight cut-off channel 1,400 feet to the south. A new vertical lift bridge with a span of 500 feet

Construction of piers for Reedy Point high level bridge.

would carry the Penn Central tracks across the straightened channel.

With the construction of a high-level highway bridge at Reedy Point, all of the old lift bridges except the railroad bridge have been replaced with fixed spans. Reedy Point Bridge was officially opened on 23 November, 1968 after three years of construction. A total length of nearly two miles was required to achieve the necessary vertical clearance and maintain a tolerable three percent road grade. Piles were driven for 31 piers on the north approach and 33 piers on the south, across the tidal plain. Caissons for the two main piers were lowered through sand, clay, and gravel to a depth of 80 feet below ground surface. The 600-foot through-truss cantilever span carries a four-lane highway across the canal with a vertical clearance of 135 feet above mean high water.

The improvement plan provides for stabilization of the banks by grading, seeding and drainage. A stone revetment was installed on the banks between high and low extremes of tide level and lighting was provided along both banks for the entire length of the canal proper. As of Spring 1970, dredging was continuing to complete the channel to a new controlling depth of 35 feet. Contracts were being negotiated for removal of the old lift bridges at Reedy Point and Lorewood Curve which, though replaced, were still traffic hazards. Contracts were then in preparation for removal of the south jetty at Reedy Point and construction of a new jetty farther south. Other phases of the Plan of Improvement provided for the planting of a variety of trees and shrubs, and for the installation of recreation areas at Reedy Point and Welch Point, with facilities for swimming, boating, fishing, and picnicking.



Sinking a caisson for Reedy Point Bridge

Material was elevated by clamshell through the dredge wells and hauled away in dump trucks. A batch plant, installed at the work site, was capable of producing sufficient good mix for the maximum pour to be made in an eight-hour day. Maximum pour was the caisson cap.

Old and new bridges at Reedy Point. The vertical lift span, in up position, seems to fill in the incomplete center span of its unfinished high level replacement beyond.

THE EARLY YEARS

It is an irony of war that the comparative health of any military structure is often directly proportional to the ferocity of the struggle it is engaged in. Over four years of internecine conflict had raised the authorized strength of both Engineer corps from an 1861 high of 79 officers and 100 enlisted men, to 109 officers and 752 men by 1866. In that year the Philadelphia District (among others) was established as part of an organizational infrastructure necessary to expand and expedite the Corps' civil mission in the vacuum of activity created by the end of the war. We date the District from that year. Yet the Corps had been active in the area for over a century, its officers assigned directly from Washington or from West Point, and before that from whatever headquarters a Revolutionary army in flight could manage to establish.

On 31 July 1800, speaking prophetically of the Corps' expanding civil mission, Secretary of War James McHenry wrote that:

> *We must not conclude from these brief observations, that the service of the engineer is limited to construction, connecting, consolidating, and keeping in repair fortifications. This is but a single branch of their profession, though, indeed a most important one. Their utility extends to almost every department of war, and every description of general officers, besides embracing whatever respects public buildings, roads, bridges, canals, and all such works of a civil nature.*

But implicit in that statement is the recognition that the Corps' mission is first and foremost a military one — to practice the ancient martial art of defensive and offensive fortification, whereby the soldier's mechanical ingenuity is made to serve his tactical and strategic need. The designs and devices of engineers are firmly rooted in the cause of

James McHenry, 1753-1816. Born in Ireland; died at Baltimore, Md. American statesman and surgeon; joined the American Army in 1776 as Assistant Surgeon; secretary to Washington 1778-1780; Maryland Senator 1781-1786; member of Congress from Maryland 1783-1786, and of the Constitutional Convention in 1787; U.S. Secretary of War 1796-1801.

After a drawing by Charles B. J. F. de St. Memin, 1770-1852, property of the late J. F. McHenry.

—Library of Congress

An East prospect of the city of Philadelphia taken by George Heap from the Jersey shore, under the direction of Nicholas Scull, surveyor-general of the province of Pennsylvania. Engraved and published according to an act of Parliament by T. Jeffreys, near Charing Cross, 1768. —*National Archives*

military economy, both of money and of man power.

Recognizing that, Secretary McHenry reasoned that:

> *A slight attention to circumstances and the actual position of our country, must lead to the conviction that a well connected series of fortifications is an object of the highest importance to the United States, not only as these will be conducive to the general security, but as a means of lessening the necessity, and consequently the expense, of a large military establishment.*[1]

This chapter will follow the Corps' developing military mission in the Philadelphia area, from its early Revolutionary beginnings through the establishment of the District in 1866, to its enormous contribution in the fields of military construction and supply during World War II and the Korean Conflict. As Military Construction is the senior Corps mission, and as Supply's original provenance lies in the Quartermaster Corps, we will first examine that older branch's activities in the Philadelphia area, turning to Military Supply as its mission evolves.

THE *CHEVAUX-DE-FRISE* AND THE CABBAGE GARDEN

On 10 May 1775, with the cold war muddle of Massachusetts politics a month ablaze into revolution, the Continental Congress in session at Philadelphia appointed Richard Gridley (already besieging British forces in Boston) as the Grand Army's first chief engineer, at $60 per month. At 64, Gridley was one of the few officers available to the American cause with any real engineering experience. His record in siege tactics was impressive though acquired at the siege of Louisburg, thirty years before. While able, he was old, and his sympathies and competency were apparently questioned, though probably without foundation (he had Tory friends).

Nevertheless, On 5 August 1776 Congress appointed Lieutenant Colonel Rufus Putnam full Colonel and Chief Engineer, either supplanting or effectively diminishing Colonel Gridley's preeminent position.[2]

On the 17th of June, Washington had written to the Pennsylvania Committee of Safety concerning the building of a redoubt at Billingsport:

> *I have but one on whose judgment I should wish to depend in laying out any work of the least consequence. Congress will know my wants in this instance and several of my late letters to them have pressed the appointment of gentlemen qualified for the business.*

Finally, on 2 December, Congress legitimized the effort by authorizing Washington to raise "*a Corps of Engineers, and to establish their pay.*" This was easier said then done.

General Charles Lee had bitterly com-

Rufus Putnam, 1738-1824. Second Chief Engineer of the Revolutionary Army. Leaving that service, he fought at Saratoga and Stony Point. From 1796-1803 he was Surveyor-General of the United States.

—National Archives

Charles Lee, Esqr., 1731-82. Major General of the Continental Army in America. Mezzotint published 1775. C. Shephard. Despite his propensity to deride the military capacities of others, Lee was himself a military disaster: he was captured; secretly went over to the enemy; was exchanged; bungled his new command at Monmouth in 1778; and was finally court martialled, condemned and dismissed from the Army by Congress in 1780.

—Library of Congress

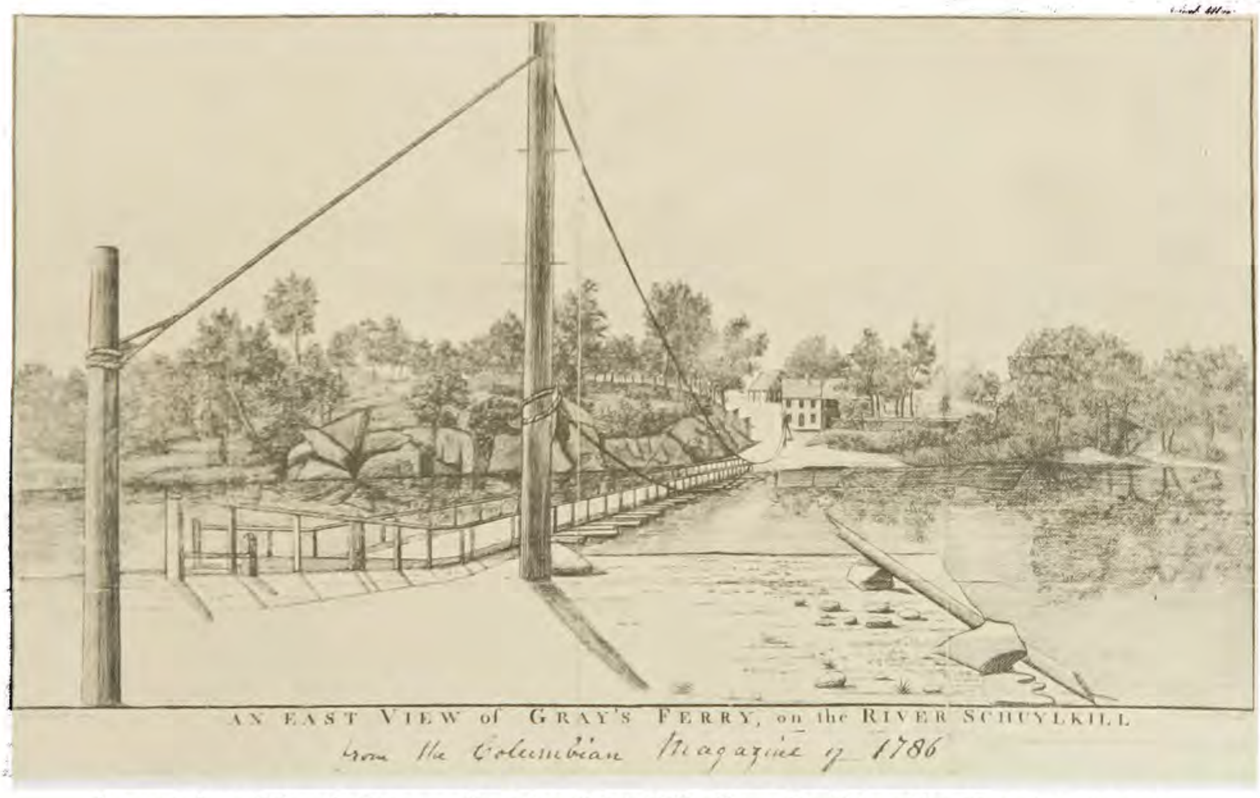
plained of the incompetence of American engineers, remarking that *"we had not an officer who knew the difference between a chevaux-de-frise and a cabbage garden."*[3] France, through the intercession of Franklin and Silas Deane, supplied the need, sending four French engineers led by the Chevalier Louis le Bégue de Presle du Portail. The Chevalier arrived on 17 June 1777 and was confirmed as Chief of the new Corps of Engineers on 11 July 1777 after a wait occasioned by the brief but fascinating ascendency of M. Philippe du Coudray who, arriving previously, had been accepted as the official French emissary and was already serving as Washington's chief engineer. An embarrassing pass, fortuitously resolved when du Coudray drowned while crossing the Schuylkill. It happened at Gray's Ferry where, against the advice of Yorkshire Ferryman George Gray, the rash Frenchman insisted on keeping a seat in the saddle while the boat was crossing the stream. Near the opposite bank, the frightened horse jumped over the gunwhale, drowning M. du Coudray and his ambitions.[4]

Taking command, du Portail mapped and laid out Washington's winter camp at Valley Forge, a job so skillfully done *"that Lord Howe refrained from attacking even when he knew the desperate condition of the troops behind them."*[5] Under his engineer's eye rose the Star and Stirling Redoubts and Forts Huntingdon and Washington, with their flanking line of breastworks.[6] Here du Portail established a practical Engineer School for the Corps, as the general orders of 9 June 1778 attest.

Sir William Howe, 1729-1814, Commander in Chief of the British Army in the American Revolution. Occupied Philadelphia in September 1777, but allowed the Americans to remain unmolested at Valley Forge. Was succeeded by Sir Henry Clinton in May 1778. From an English print, 1777.

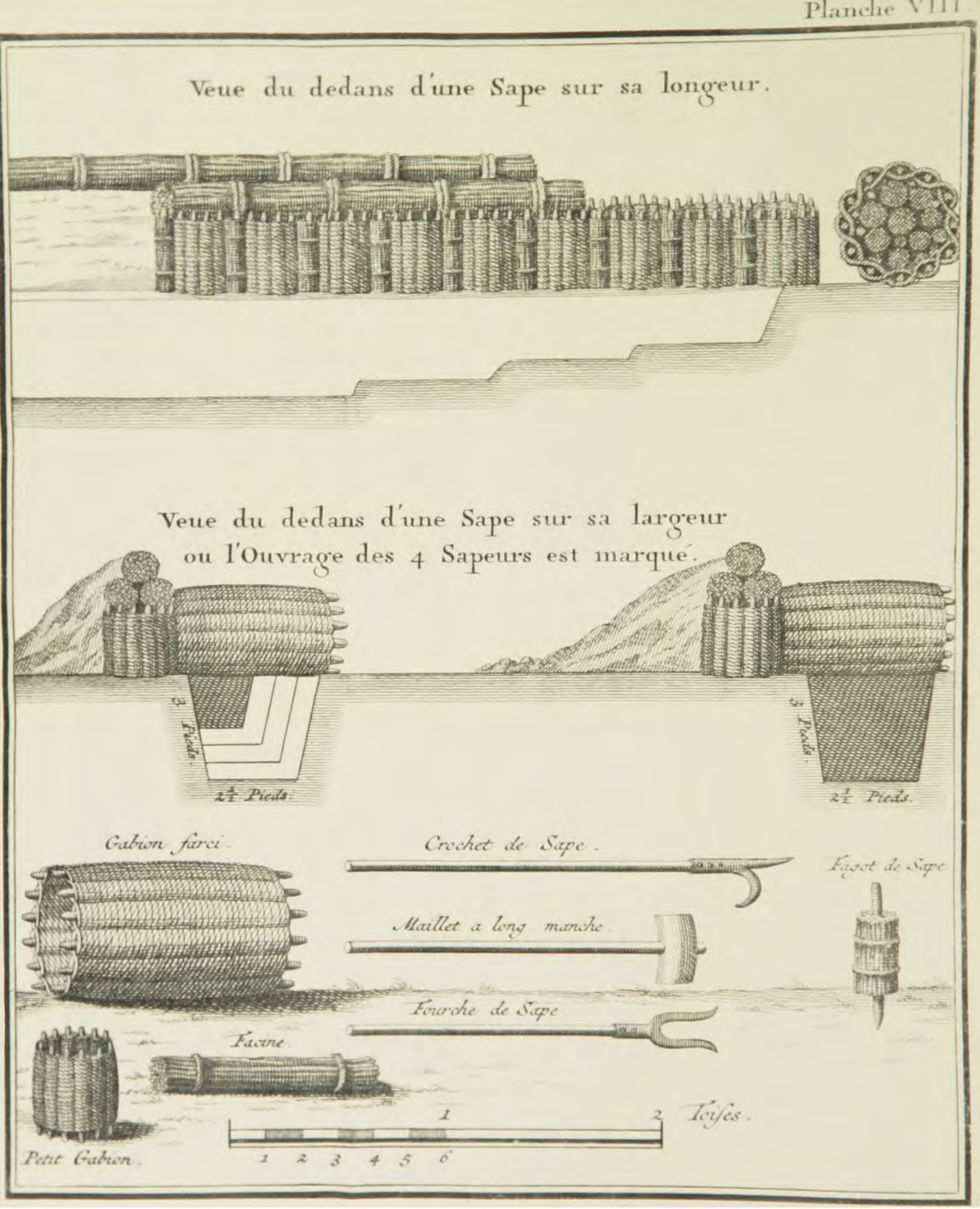
—Library of Congress

—Historical Society of Pennsylvania



An east view of Gray's Ferry on the River Schuylkill. From the Columbian Magazine of 1786.

—Free Library of Philadelphia



View of a sap along its length, with a cross-section of the interior showing the work of the four sappers, and assorted items of engineer equipment. The gabions were woven baskets filled with earth or sand and assembled to form temporary fortifications. From Vauban's "Memoir pour servir d'instruction dans la conduite des sieges et dans la defense des places." Leiden, 1790.

—University of Pennsylvania

Thomas Mifflin, 1744-1800. Engraved by E. Welmore from a painting by G. Stuart. American General and political leader in the Revolution. Quartermaster-General of the Revolutionary Army at different periods during the Revolution, Mifflin resigned under the pressure of an investigation. Member of the Continental Congress 1774; Pennsylvania State Assembly 1778-79; member of Congress 1782-84; Delegate to the Federal Constitutional Convention 1787; First Governor of Pennsylvania 1790-1799.

—Library of Congress

Orders, General Headquarters, Valley Forge:

> *Three captains and nine lieutenants are wanted to officer the company of sappers. As the Corps will be a school of engineering, it opens a prospect to such gentlemen as enter it, and will pursue the necessary studies with diligence, of becoming engineers and rising to the important employments attached to that profession, such as the direction of fortified places, etc. The qualifications required of the candidates are that they be natives, and have a knowledge of the mathematics and drawing, or, at least, be disposed to apply themselves to those studies. They will give in their names at headquarters.[7]*

While Von Steuben drilled his troops in field exercise, du Portail taught fortification. From Valley Forge to Morristown, New Jersey, (site of Washington's winter quarters in 1779-1780) the engineer officers and their enlisted troops, the sappers and miners, built.

The years before Valley Forge had confronted both Washington and Congress with the unpleasant probability of a British assault on a virtually undefended Philadelphia. The river approaches were guarded by an earthen and timber fort on Mud Island, later Fort Island (the present Fort Mifflin, named after Governor Thomas Mifflin) and by Fort Mercer, opposite on the Jersey shore at Red Bank. Fort Mifflin had been begun in 1773, under the direction of John Montrésor, a captain of the Royal Engineers who was to direct the eventual British assault on the

Colonel John Montrésor. British Chief Engineer in America during the Revolution.

—Free Library of Philadelphia

Thomas Antoine Mauduit du Plessis, 1753-1791. Distinguished French soldier in the Revolutionary Army. He served as a Lt. Colonel and was noted for his bravery in engagements at Brandywine, Germantown and Monmouth.

—Historical Society of Pennsylvania

position. These defenses were augmented by five tiers of *Chevaux-de-frise*, (barbed wire or spikes attached to a wooden frame) sunk across the river at Fort Mercer, Hog Island, and Billingsport. With the exception of the Billingsport defenses, the cost of the work had been borne by the State of Pennsylvania, with Robert Smith, of the Carpenter's Company directing the construction of the *chevaux-de-frise*. In the month preceding the British assault on Philadelphia in September 1777, there was vigorous debate between Washington, his officers and the city fathers—stretching through the end of August—as to which line of defense ought to be strengthened. The British landward investment of the city on 26 September, made the argument academic, and the river forts themselves fell in November of that year, despite the efforts of du Portail's engineer officers Gaston Fleury and Mauduit du Plessis.[8] In June of 1778 the British abandoned Philadelphia. By October, Washington's correspondence reveals that he *"had sent General Portail to form a plan of fortification for the Delaware."*

This was however interrupted as the war shifted north and southward from the Delaware Valley.

Washington's engineer officers seem to have been particularly active in the bridging and fording of rivers, particularly the Schuylkill. In December 1776, Washington had ordered the river bridged at High Street Ferry. General Israel Putnam supervised its construction—a crude ponton structure, resting partly on rafts and partly on scows—and designed as a westward avenue of escape. When Washington was forced to abandon the city in 1777, the bridge was broken up and the scows hidden

REVOLUTIONARY
DELAWARE RIVER STOCKADES

LAST REMAINS OF THE REVOLUTIONARY DELAWARE RIVER STOCKADES, ESTIMATED AGE 300, IN THE RIVER 170.

CHEVAUX-DE-FRISE, FRENCH WORD, MEANING STOCKADE. AS PER DATE OF JULY 3, 1775 A COUNCIL OF SAFETY OF PFNNSYLVANIA WAS ORGANIZED IN PHILADELPHIA, OF WHICH BENJAMIN FRANKLIN WAS UNANIMOUSLY CHOSEN ITS FIRST PRESIDENT.

ON JULY 15, 1775 A COMMITTEE WAS APPOINTED TO VISIT THE PRINCIPAL INHABITANTS OF OLD GLOUCESTER COUNTY TO SOLICIT THEIR ASSISTANCE, AND AS A RESULT THEREFROM 296 PINE LOGS TO BE USED IN THE MAKING OF THE CHEVAUX - DE - FRISE WERE GENEROUSLY DONATED BY THE FOLLOWING MEN WHO LIVED NEAR THE DELAWARE RIVER FRONT, NAMELY, BENJAMIN WHITEALL, JOHN WOOD, NATHAN KINSEY, RICHARD JOHNS, DAVID PAUL, JOSEPH LOW, JAMES BROWN, JOSEPH WARD, JOSHUA HOPPER, ISAAC HOPPER, LEVI HOPPER, JAMES WOOD, JOSEPH TATEM, AND CHARLES WEST.

THE FIRST STRING OF CHEVAUX - DE - FRISE WAS SUNK AT FORT MIFFLIN.

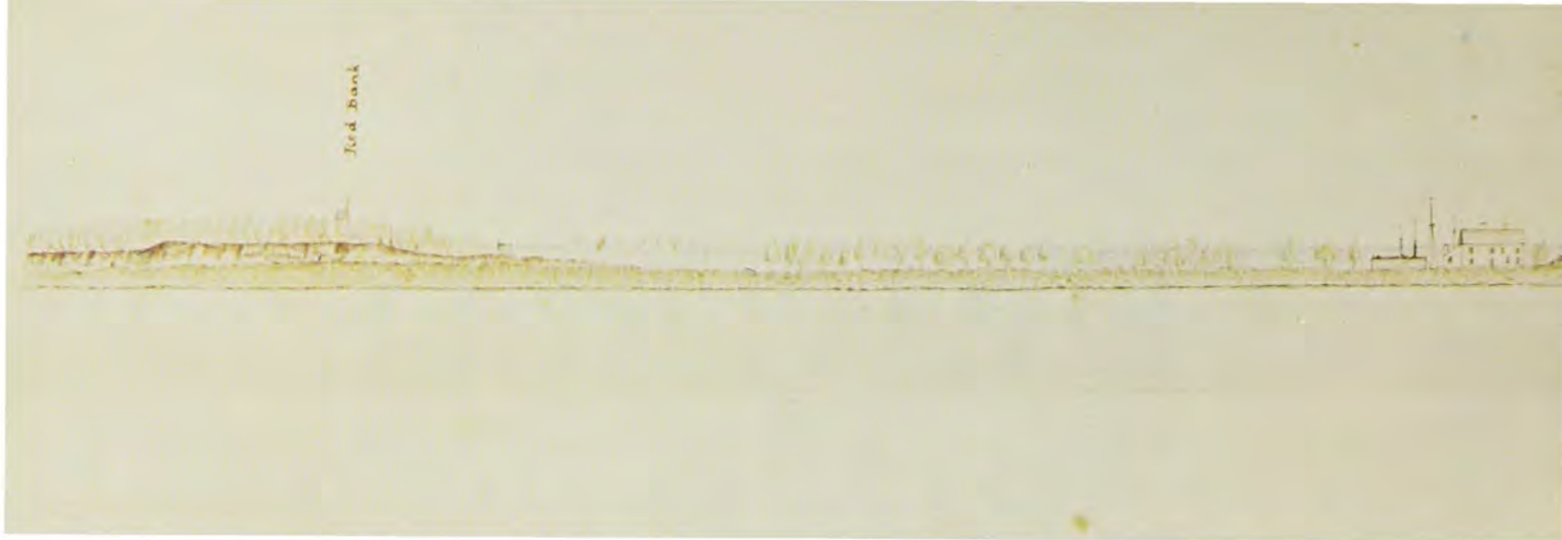
THESE FRAMES WERE BUILT FROM LOGS AS MUCH AS SIXTY-FIVE FEET LONG AND TWENTY INCHES SQUARE WITH TWO TO FOUR HEAVY TIMBERS EXTENDING THEREFROM AT AN ANGLE OF ABOUT 45 DEGREES WITH HEAVY IRON SNAGGED POINTS MADE BY BLACKSMITHS AND LINED WITH THIRTY THOUSAND FEET OF 2-INCH PLANK FLOATED OUT IN THE RIVER AT FORT MERCER AND FORT BILLINGSPORT AND SUNK WITH STONE AND HELD IN PLACE WITH ANCHORS AT A DEPTH OF ABOUT FOUR FEET BELOW LOW WATER MARK.

THESE TIMBERS, ANCHORS AND POINTS HERE ON EXHIBIT ARE THE LAST REMAINS TAKEN OUT OF THE DELAWARE NEAR FORT MIFFLIN IN 1936. THEY WERE INTHE RIVER 170 YEARS, ESTIMATED AGE 300.

PRESENT DAY ARMY ENGINEERS ADMIT WITH ALL THEIR EQUIPMENT OF MODERN MACHINERY IT WOULD BE A MOST FORMIDABLE TASK.

THESE TIMBERS WERE PLACED ON EXHIBIT SEPTEMBER 25, 1946 BY THE COMMITTEE, NAMELY, HUGH L. MEHORTER, ALVIN S. CRISPIN, STANLEY MARTIN AND ROBERT LEE.

JAMES M. TURNER
FREEHOLDER



View of Mud Island before its reduction 16 November 1777, under the direction of John Montrésor, Esq., Chief Engineer in America,

Proposed entrenchments for the Defense of Philadelphia, from the Delaware to the Schuylkill River, near Vine Street. This 1777 schema was never realized, as the British took the city in late September.

—Atwater Kent Museum, Philadelphia

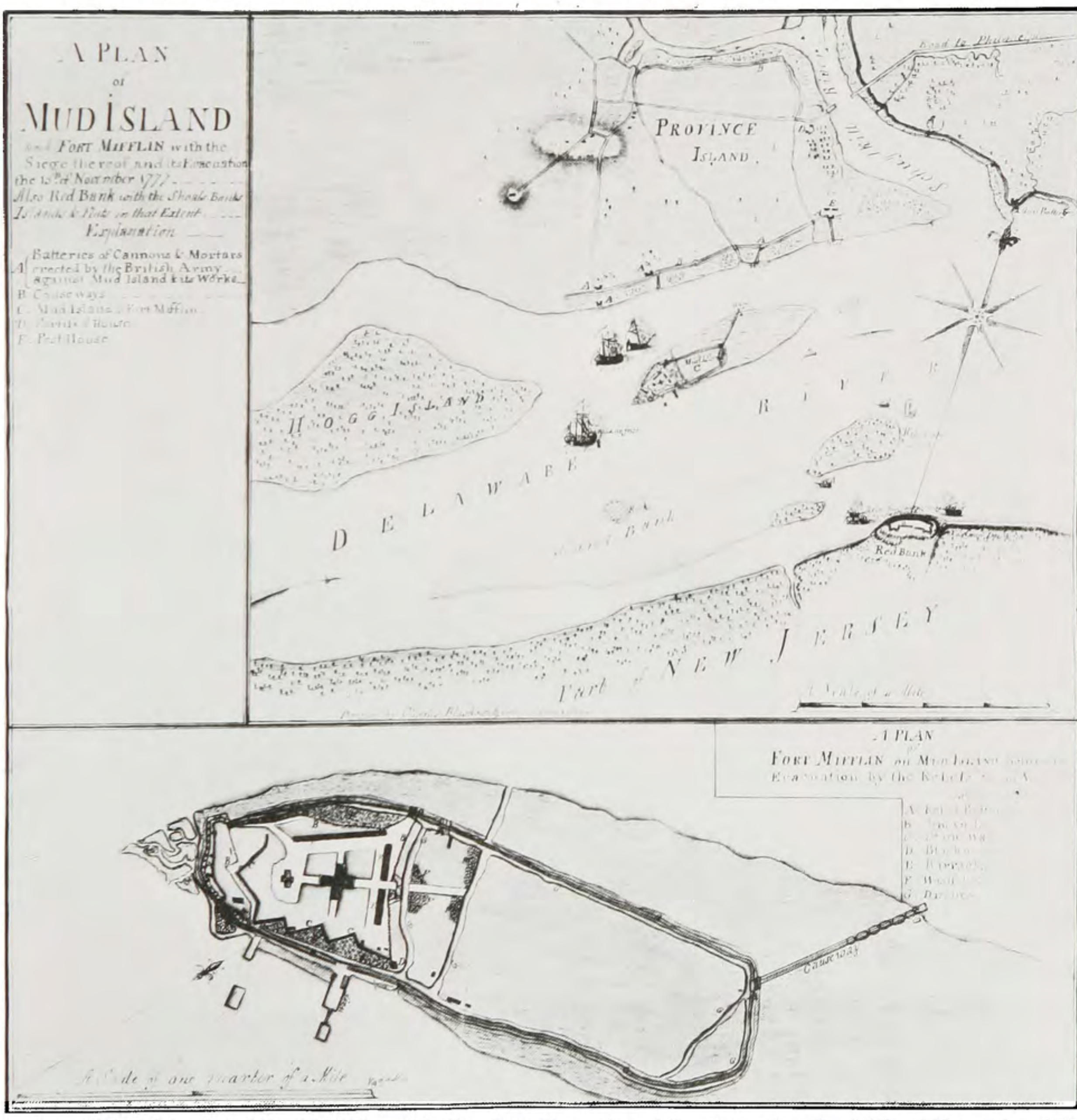
along the river, where they were found by occupying British forces and the bridge reconstructed.

In December 1777, du Portail threw a shaky bridge of wagons topped with fence rails over the Schuylkill at Swedes Ford (below Valley Forge), to aid the American retreat to Valley Forge; there in early 1778, General Sullivan and his New Hampshire Militia again crossed the river with a log bridge, each pier of which was decorated by the General with a memorial to a Revolutionary leader, with Washington at the center. Though sturdily built, it could not hold against the fast Schuylkill current, and within a few months, the ice swept it away.[9]

Major General John Sullivan.

—National Archives

taken from the dyke in front of the six gun battery on Carpenter's Island. Watercolor by Pierre Nicole, 1777. —*Library of Congress*



A plan of Mud Island and Fort Mifflin, with the siege thereof, and its evacuation the 15th of November 1777.
—*Yale University*

President-elect Washington crosses Floating Bridge (Gray's Ferry) on Inaugural journey to Philadelphia, 20 April 1789.
—Free Library of Philadelphia

In November 1783, at war's end, the Corps of Engineers was disbanded, not to be reestablished until 1789 and the inauguration of the new constitution. In that year, a plan submitted to the President by the Secretary of War, Henry Knox, for the reorganization of the nation's military forces recommended, as part of the military establishment of the United States, a *"small corps of well-disciplined and well-informed artillerists and engineers."*

Under pressure of deteriorating relations between this country and the principal European powers, Congress, on 20 March 1794, authorized the President to fortify certain harbors along the coast, and the next day appropriated funds for the undertaking. As there were no engineers in the Army to carry out these works, the President directed the temporary appointment of a number of engineers to design and superintend construction, dividing the coast up into districts, and appointing one or more engineers for each.

The officers appointed were foreign-born, including a number who had also served in the Corps of Engineers during the Revolution.

Those appointed included:
- Stephen Rochefontaine, (New England)
- Charles Vincent, (New York)
- John Jacob Ulrich Rivardi, (Baltimore-Norfolk)
- John Vermonet, (Annapolis-Alexandria)
- Nicholas Francis Martinon, (South Carolina)
- Paul Hyacinte Perrault, (South Carolina—Georgia)
- Peter Charles L'Enfant, (Philadelphia—Wilmington)

Henry Knox, 1750-1806. American General in the Revolutionary War. Knox served as Secretary of War under the Articles of Confederation, 1785-89, and as Washington's first Secretary of War under the Constitution 1789-94. By James B. Sword, after an original by Charles Wilson Peale.

—Historical Society of Pennsylvania

Pierre Charles L'Enfant, 1754-1825. French Army Engineer and Architect and Officer in the American Revolutionary Army. L'Enfant designed the new Federal City of Washington in 1791. In 1794 he was given the mission of fortifying the Delaware River Ports.

—National Archives

In the 1780's, the City Councils of Philadelphia contributed to the maintenance of Fort Mifflin and other area defenses, as can be attested by this voucher, signed by Benjamin Franklin on 13 June 1787, authorizing the City Treasurer to advance £12,2s. to Lewis Rice as partial payment for work done to "the Banks of Mud Island."

—Atwater Kent Museum, Philadelphia

For £12..10..0 In Council
Philadelphia June 13th 1787
Sir
Pay to Lewis Rice or order the sum of twelve pounds ten shillings, in part of the sum to be advanced to him for repairing the Banks of Mud island, according to Contract.

B. Franklin

To David Rittenhouse Esqr
Treasurer

All were appointed between 25 March and 12 May 1794.[10] L'Enfant, one of the French engineer officers who had served under du Portail, had chosen to settle here after the war. In 1789 he had been made Engineer of the United States. In 1791 Washington invited him to design the new capital city, a project he worked on through early 1792, when conflict with the Commission of Buildings and Grounds and intense political pressure forced the President to remove him.

Thus, in 1794 he returned to Philadelphia to rebuild the old defenses at Fort Mifflin and to explore the defensive possibilities of the lower Delaware, with a view toward protecting Wilmington's approaches. Secretary of War Knox authorized L'Enfant to rebuild the fort again as an earthwork—"*the parapets of the work to be erected are in general to be of earth, or where that cannot be obtained of an adhesive quality, the parapets may be faced with timber and filled in with earth.*" For this, Congress appropriated $11,913.82, which sum L'Enfant was cautioned not to exceed.

L'Enfant replied that the proposed works at Mud Island were insufficient for a proper defense of the city. Moreover, "*its situation is altogether so ill judged as to be enfiladed from every point from whence an attack is the most likely.*" L'Enfant proceeded with the work, but by September had exhausted his alloted monies, and had resorted to soliciting six thousand dollars in funds from the Pennsylvania Legislature, which in the following year ceded the property to the United States. He managed to explore the defensive possibilities of the lower reaches of the Delaware, specifically at Pea Patch Island, where Fort Delaware was eventually to rise. He noted the advantageous situation of the island, the spelling of which he phoneticized as *Pip Ash*—

> *Upon the Pip Ash Island, it cannot be questioned but that pass may be well armed, and that proper works erected there would protect the whole river bank.*
>
> *The perfect security which the protection of that pass would ensure to the whole river, and to the several harbor towns on its shore, being an object fully to compensate the expense of erecting proper works on it, although the means at present inadequate, as they are, to the accomplishment of those temporary works, determined upon, cannot indulge me in the idea that these shall be undertaken at present. I could not but wish to ascertain myself the propriety of that situation, of an importance, in my opinion, not to be lost sight of, when the means of the country will render the undertaking practicable.*[11]

By 1795 the project at Mifflin was completed, but interest soon lagged again, and the earthworks were allowed to deteriorate.

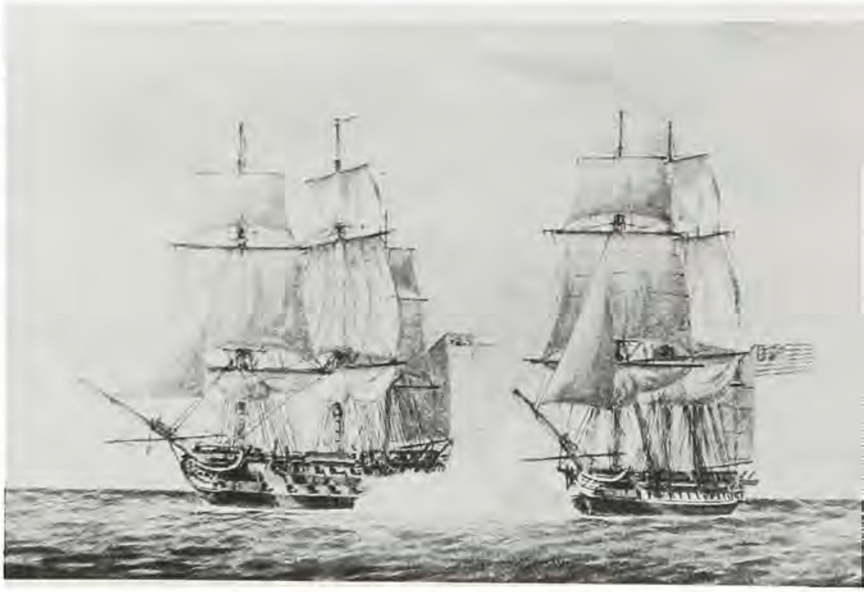
In 1798, the alarm was raised again. War with France threatened, and Congress appropriated $250,000 for a new series of permanent masonry fortifications to replace the old earthen palisades.

The new Fort Mifflin was built between 1798 and 1803, as a masonry work combining both star-fort and bastion designs, mounting twenty-nine guns and a detached eight gun water battery. In the course of construction,

Aerial view of Old Fort Mifflin, Philadelphia.

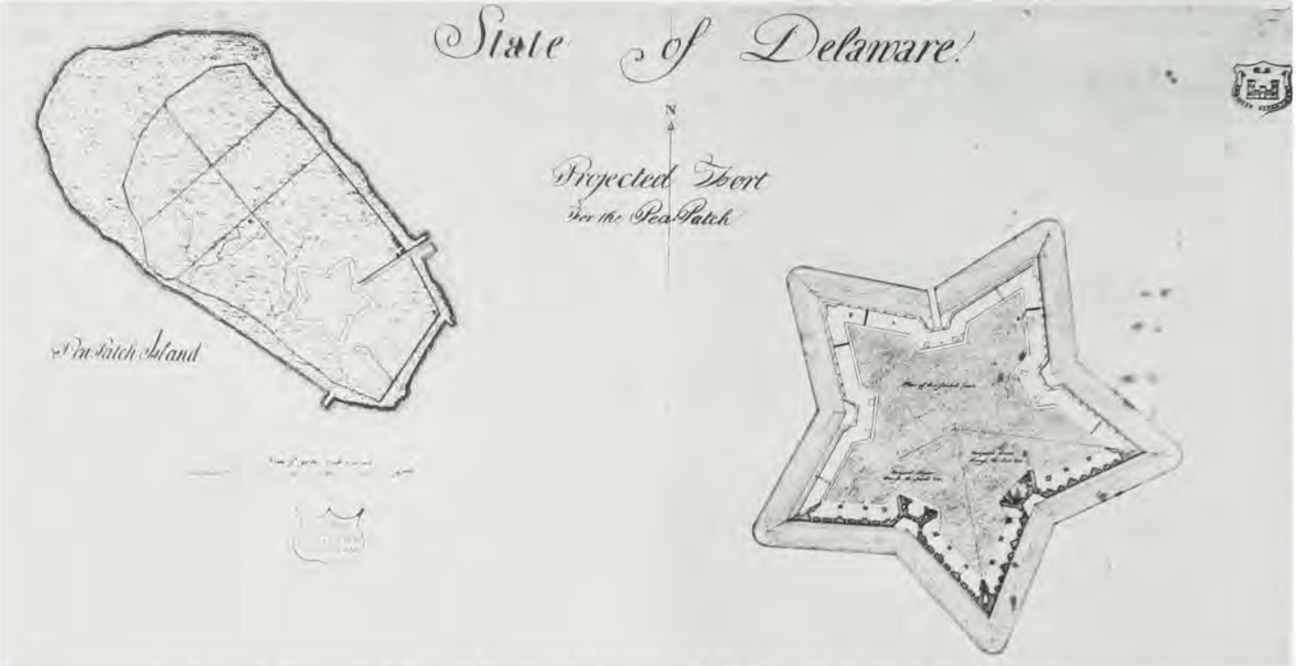
$64,361.09 were spent on the works, with the United States disbursing a total of $171,984.37 to fortify the Delaware during that time period. The work was extensively repaired in 1808-1809 and was used intermittently through the Civil War, when it became a rather infamous prison camp for Confederate soldiers, as dank if not as genocidally lethal as its successor, Fort Delaware. The 1808-1809 modifications were undertaken under the threat of a second war with Great Britain, arising out of the Chesapeake incident of 1807.[12] From November 1807 to the outbreak of the War of 1812 over three million dollars were appropriated for new construction. This construction is noteworthy as the first major project designed and implemented by engineers of American birth and education.

On 6 March 1802, Congress had authorized the formation of a permanent Corps of Engineers, with an engineer school to be established at West Point. Major Jonathan Williams, current inspector of fortifications, was appointed Chief Engineer and the academy's first superintendent. The founding of a permanent Corps was to profoundly influence military construction in the Philadelphia area, providing a continuing supply of engineer officers to direct future fortification projects—the chief proposal being the projected fort on Pea Patch Island. Congressional documents as early as 1800 suggest the desirability of such a facility and by 1819 the construction of a masonry star-fort built on pilings driven into the Delaware mud was well underway, under the direction of Major Samuel Babcock, who supervised the work from 1815 to 1824, replacing an earthwork



H.M.S. Leopard attempting to board and search U.S.S. Chesapeake, June 1807. Watercolor attributed to Warren.
On 21 June 1807, the Frigate U.S.S. Chesapeake, Captain Charles Gordon, bearing the broad pennant of Commodore James Barron, encountered H.M.S. Leopard, Captain Humphries commanding off Cape Henry. After a broadside exchange, Chesapeake hauled down her colours and submitted to the British search.

—Mariners Museum, Newport News, Virginia



Samuel Babcock's "Star Fort" on the Pea Patch, 1815-1824. —National Archives

hastily erected in 1814, to blunt an expected British drive up the Delaware. However, there was considerable subsidence and evidence of deviation from the original plans, for which Babcock was brought before a general court-martial in 1824 (May-September). Although acquitted, the court determining him guilty of errors in judgment rather than intent, a glance at the trial transcript suggests that Babcock may have been indicted to prevent the implication of higher authorities in the scandal. He consistently maintained that his deviations from original plans had not only been authorized but had actually been proposed by Lieutenant Colonel Joseph Totten, a power in the Corps and its future chief for over twenty-six years. The court ruled that most of Babcock's documentation was inadmissable and refused to comment on the allegations.[13]

In 1831 the fort burned down; reconstruction commenced in 1833 under the command of Major Richard Delafield, an undertaking rather fully covered in an earlier chapter, "Rebuilding Fort Delaware."

The Trenton Coastwise Travel Bridge over the Delaware. Erected in 1804-1806 by Theodore Burr, the Bridge provided an effective response to the British blockade of the Lower Delaware and other Atlantic Harbors during the War of 1812.

—Free Library of Philadelphia

Admiral Sir John Poo Beresford. By Sir William Beechey.

—The British Museum

THE WAR OF 1812

A declaration of war against Great Britian on 15 June 1812 caught the Philadelphia area unawares. A British Order in Council, issued on 26 December 1812, and declaring the Chesapeake and Delaware Bays to be in a state of rigorous blockade, sent a flurry of invasion fever throughout the region. In 1813, Delaware ceded the Pea Patch to the Federal Government with an injunction to begin the oft-recommended fortifications as quickly as possible. By the spring of 1813, a British squadron under the command of Sir John P. Beresford had effectively blockaded the mouth of the Delaware and was threatening to burn Lewes unless the inhabitants ransomed the town for *"twenty live bullocks with a proportionate amount of vegetables and hay."* The people refused; the bombardment commenced; guns and militia were rushed from Philadelphia and Wilmington, and batteries erected to fight off the attack.

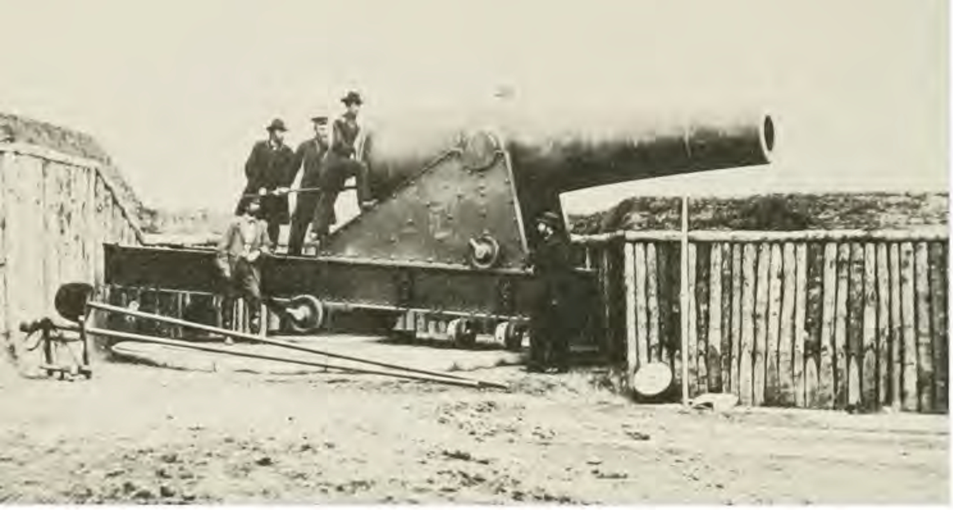
Philadelphia, meanwhile, was all but unprotected. Fort Mifflin had a garrison of fourteen invalided soldiers and the City Councils did little to correct the situation. The British squadron roamed the Delaware, looting and burning settlements and ships as far north as Reedy Island. The Upper Delaware was defended by a flotilla of ninteen gunboats, sixteen barges, and two block sloops, which did manage to frighten off the British frigate *Belvidera*, when she attempted to run through their fire.[14]

On 25 August 1814 news of the British capture and burning of Washington threw the city into a panic of activity.

Fortifications and redoubts were proposed for Gray's Ferry, the West Bank of the

Blockade of the Delaware by H.M.S. Belvidera, Admiral Sir John Beresford commanding, War of 1812.

—New York Historical Society



Fifteen-inch Rodman gun. T. J. Rodman's smoothbore cannon, with a tapering barrel designed to follow the pressure curve, was cast on a hollow core, and cooled from the inside out, greatly increasing the strength of the metal. Before the Civil War, this revolutionary weapon was the most powerful gun in the American arsenal.

—National Archives

Schuylkill, at Hamilton's Grove, the Lancaster road and at Fairmount. Between 3 September and 1 October, a citizen levy of 15,000 volunteers worked feverishly to throw up earthworks, each man giving one day's labor. Fortunately, the British were turned back at Baltimore, and Philadelphia's citizen engineers were happily deprived of an opportunity to test their defenses in battle.[15]

The years between the War of 1812 and the Civil War were marked by considerable advances in ordnance development, the old twenty-four pounder sea-coast defense guns eventually being replaced by weapons as large as the massive new fifteen-inch Rodman guns. In new brick and stone forts which arose in the period, these were mounted in casemates or armored compartments within the walls, and fired through embrasures in the masonry rather than sitting atop the walls *en barbette* as had previously been the case. This shift in the method of mounting armaments necessitated the strengthening of the defenses' stonework, to support the large masses of cannon now contemplated. The history of military construction in the Philadelphia area during that period is congruent with the reconstruction of Fort Delaware, first under Delafield and later under Sanders, and the intermittent repair work done to Fort Mifflin. The Mexican War (April 1846-September 1847), when it came, was very much a foreign affair, drawing Engineer Officers away from the Northeast (and the Philadelphia area) to combat service in the field. Fort Delaware grew slowly, dependent as it was on annual Congressional appropriations and the general neglect of military facilities normal during periods of relative peace.

Officer of Engineers, 1846.

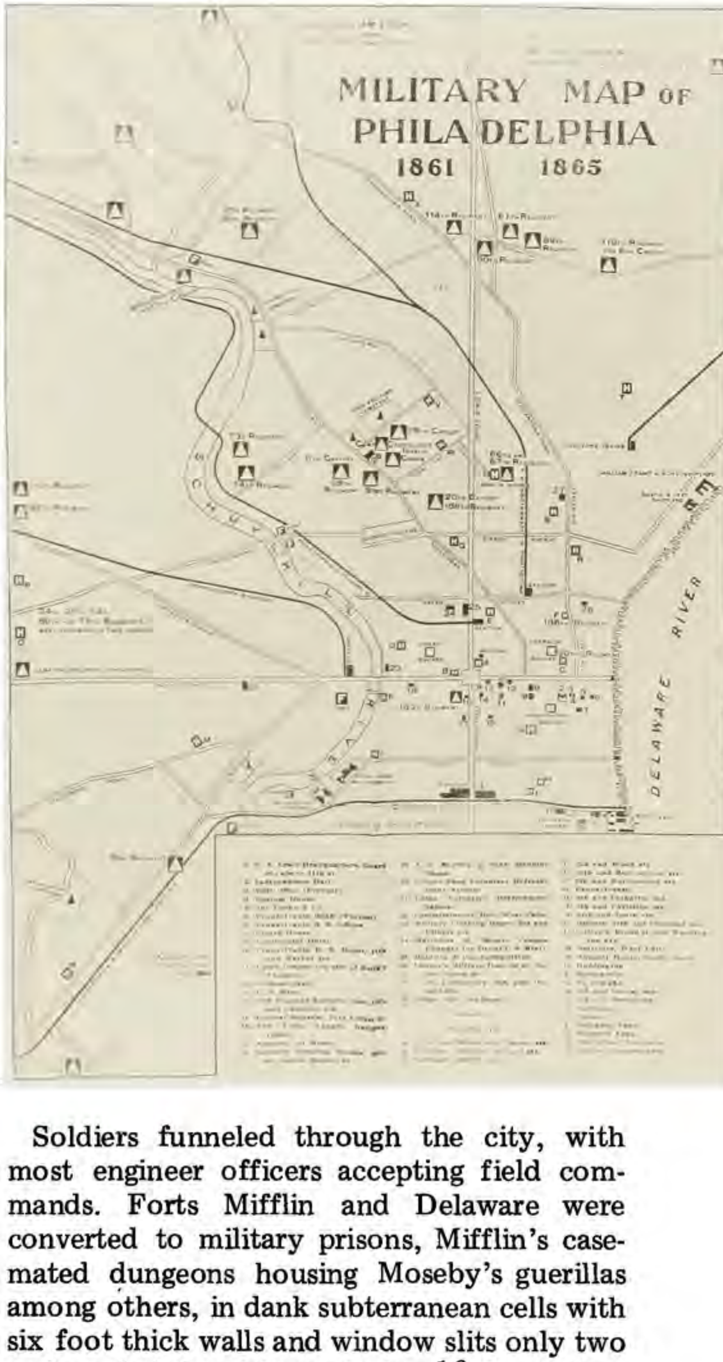
—National Archives

THE CIVIL WAR

The Civil War, with its massive lines of entrenchments, and its hundreds of Engineer troops so active on the field of battle, swirled around the Philadelphia District, but never really touched it, while Washington, a short 109 miles from the confederate capital at Richmond, was ringed by 68 forts and redoubts, and more than twenty miles of entrenchments. Although Philadelphia was continually fluttered by the daily battle reports and almost panicked by an influx of refugees from Gettysburg in 1863, there was no repetition of the 1812 entrenchment policy. To defend against a threatened advance on the city of Confederate forces, in June 1863 a Committee of Defense was authorized by City Councils to establish a number of redoubts commanding the principal approaches. Their locations were to be determined by officers of the United States Coast Survey and placed on the south side of Chestnut Street, east of the junction of Darby road; on the east side of the Schuylkill River, near the U.S. Arsenal; on the west side of the Schuylkill River, below Gray's Ferry Bridge; at the east end of Girard avenue bridge; at Hestonville, near Lancaster Avenue, and on School House Lane, near Ridge road.

The total cost of these defenses, as shown by the records of the City Controller, was $51,537.37. The largest work, located at the falls of the Schuylkill and known as "Fort Dana," was created by the gas-works force, and cost only $3,559.47.

However, no guns were ever mounted, the danger having ended with the battle of Gettysburg. Several of the redoubts remained for a number of years after the war, as reminders of the strenuous, and to some ridiculous, labors of an excited public.



Soldiers funneled through the city, with most engineer officers accepting field commands. Forts Mifflin and Delaware were converted to military prisons, Mifflin's casemated dungeons housing Moseby's guerillas among others, in dank subterranean cells with six foot thick walls and window slits only two and one-half by eighteen inches.[16] Conditions

Volunteer Refreshment Saloon, Philadelphia. This canteen welcomed the union soldiers, providing them with free hot meals. —*National Archives*

were infinitely worse at Fort Delaware, within whose precincts up to 10,000 prisoners at a time were immured. Periodic rumors that the prisoners would escape and join with northern "*copperheads*" in an attack on the city were groundless.

S. Weir Mitchell, a Union Army surgeon, attested to:

> *...a thousand ill; twelve thousand on an island which should hold four; the general level three feet below low water mark; twenty deaths a day of dysentary and the living have more life on them than in them.*[17]

Of the more than 30,000 prisoners who passed through Fort Delaware, 2,700 died while incarcerated there—an even higher rate than at the Southern nightmare prison at Andersonville.

On 2 December 1861, the Philadelphia Board of Trade warned Congress:

> *That the river and bay defenses of Philadelphia are entirely inadequate, and need to be immediately and largely increased, and that it is the duty of the United States government to superintend and effect such increase, at such points as a competent Corps of Engineers may indicate, with the least possible delay.*[18]

However, after the mounting of guns at Forts Delaware and Mifflin, no real action was taken. In the field, military engineers breached and undermined walls; pushed roads across captured terrain; and bridged rivers and forded streams, often with trains of engineer ponton boats—but all far from the Philadelphia area.

In the city, the war had made itself felt. Aroused by the 12 April 1861 firing on Fort Sumter, Philadelphia militia had rushed to a

Wagon Train Crossing Ponton Bridge. Rappahannock River, below Fredericksburg, Va. *—Library of Congress*

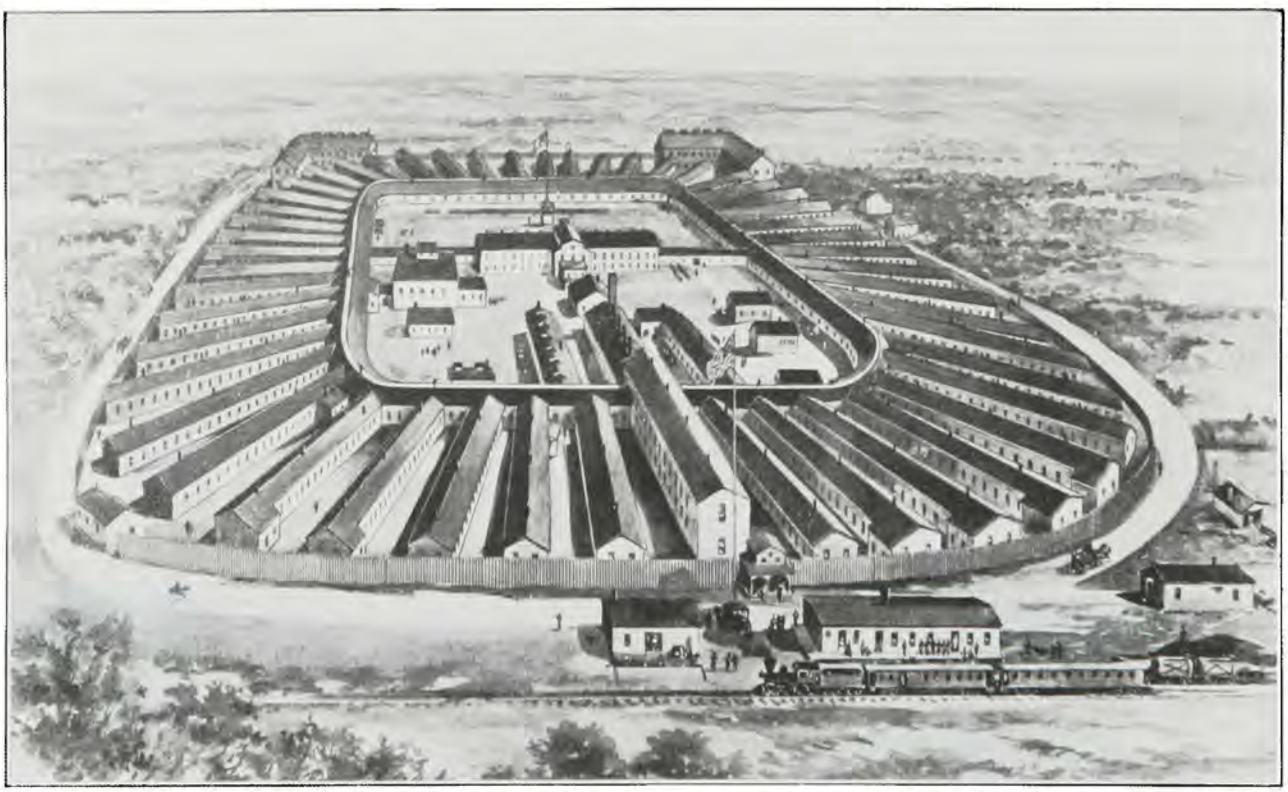
Confederate Prisoners at Fort Delaware. *—Free Library of Philadelphia*

Captain Josiah Gorgas, commandant at the Frankford Arsenal from 8 June 1860 to 3 April 1861; later Chief of Ordnance, C.S.A.

—Frankford Arsenal, Philadelphia

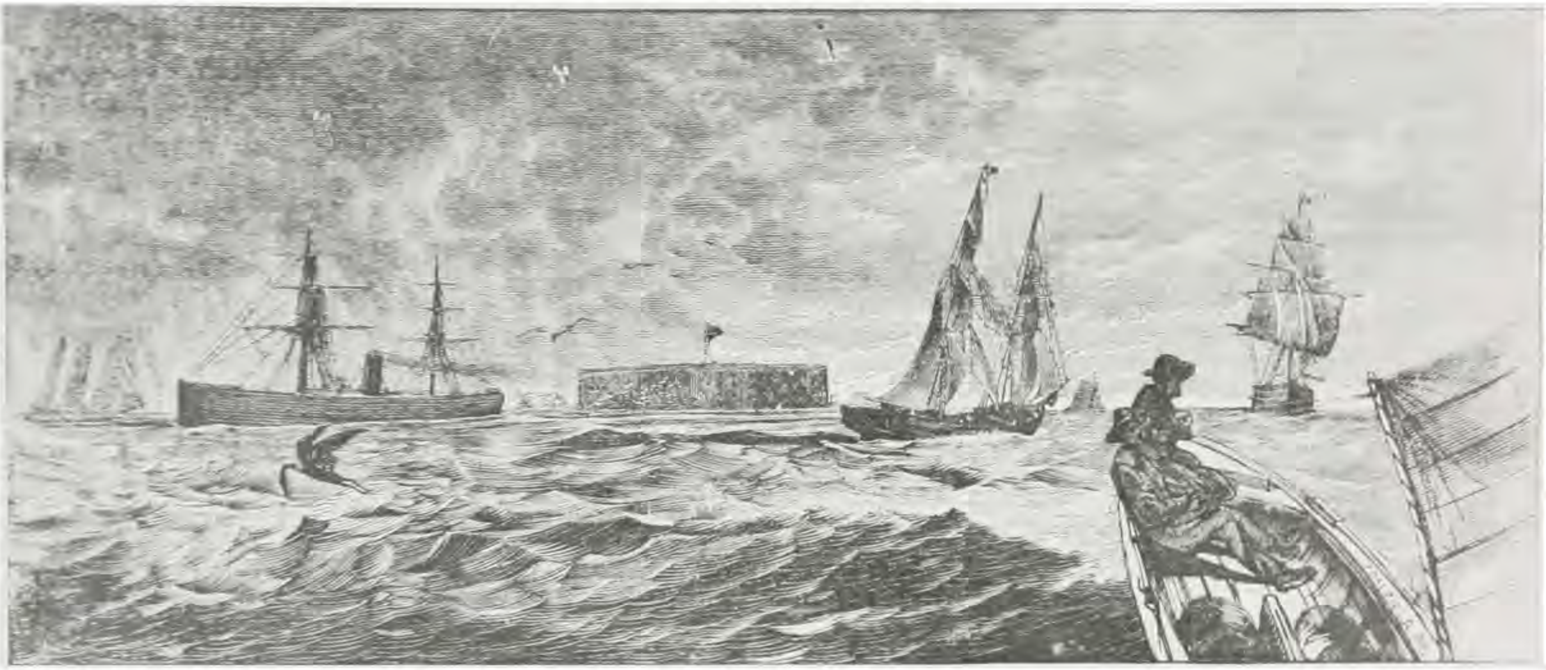
supposedly well-stocked Frankford Arsenal, only to find the cupboard bare. Captain Josiah Gorgas, the arsenal commandant and a man of strong southern sympathies, had managed to ship the greater part of the arsenal's ordnance and artillery south, including a 29 January shipment of twenty carloads of rifles to a destination considerably south of the originally logged "Washington." On 3 April, Gorgas resigned, following his secret "care packages" south, and ultimately rising to command the Confederate Ordnance Department.

In the course of the war, the city served as evacuation and hospitalization center for tens of thousands of wounded soldiers, who streamed north from Southern and Western battlefields. A vast network of military hospitals was established in the city, including the 4000-bed Mower General Hospital in Chestnut Hill, and the 4500-bed Satterlee General Hospital in West Philadelphia. There some of the 157,000 wounded cared for in Philadelphia hospitals during the war received treatment—having been evacuated by boat up the Chesapeake, by barge through the C&D Canal, thence up Delaware Bay and the Delaware and Schuylkill Rivers to Gray's



Mower General Hospital. The second major military hospital in the Philadelphia area during the Civil War. This 4,000 bed facility was located in Chestnut Hill, on the northwestern outskirts of the city.

—Free Library of Philadelphia

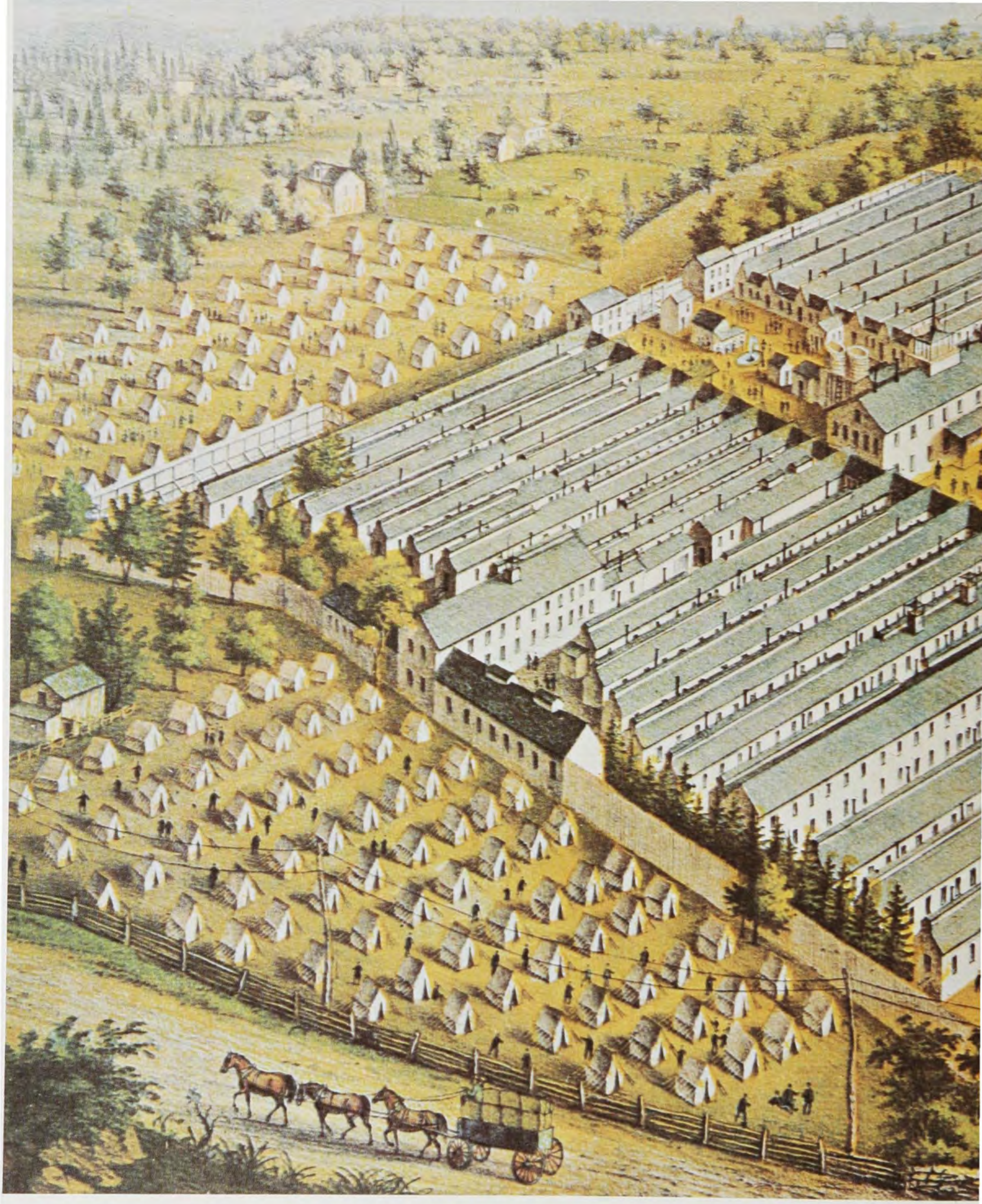


Delaware River and Fort Delaware, 1872. Van Ingen Snyder, Philadelphia. —Free Library of Philadelphia

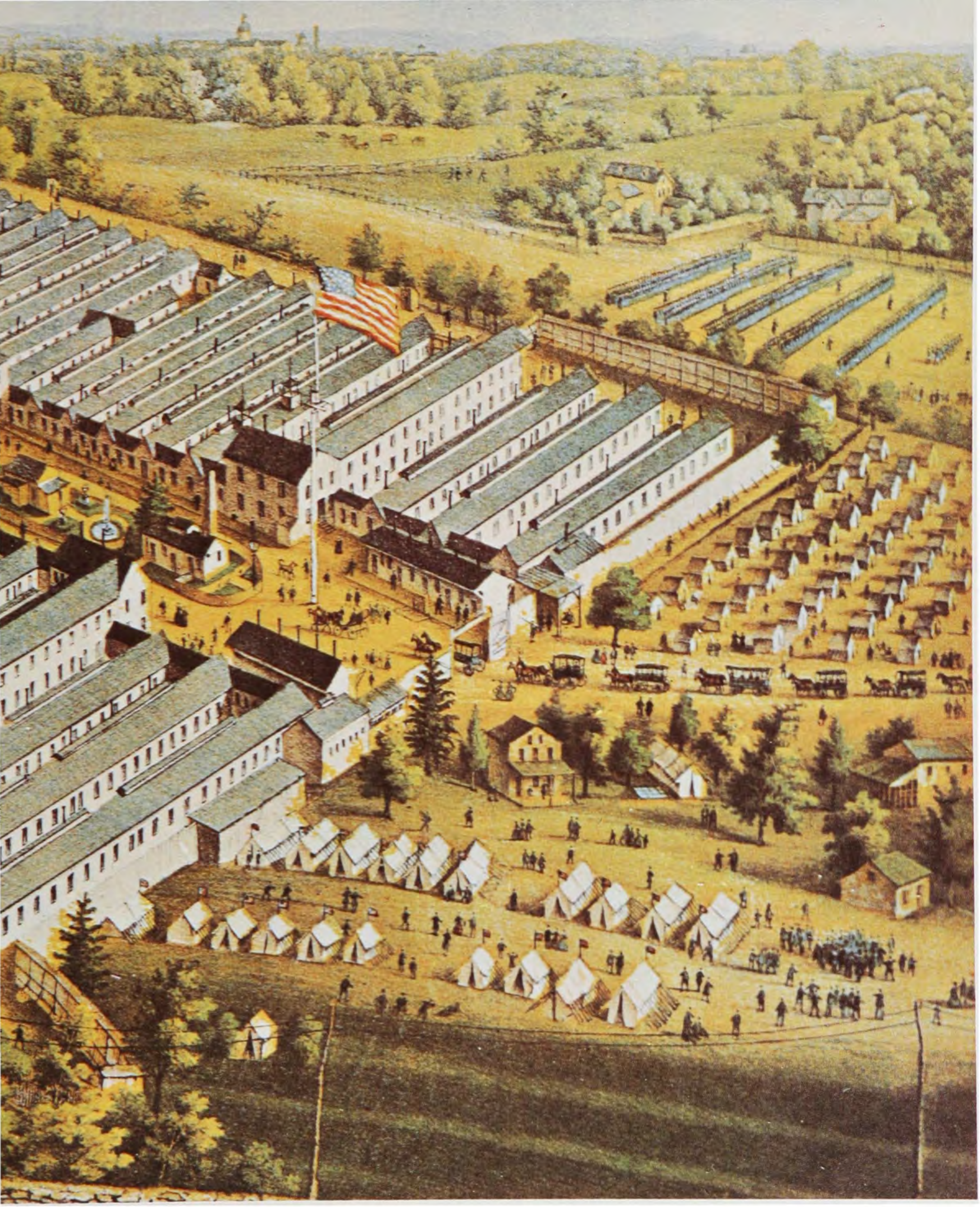
Ferry, where they were disembarked, transferred to ox-carts, and trundled off to Satterlee General.[19]

In 1866, with the founding of a permanent Philadelphia Engineer District, contracts were let to complete work on Forts Mifflin and Delaware, and to examine other sites along the River which might strengthen the region's defenses. War-time introduction of rifled artillery on a mass production basis made possible accurate long-distance bombardment of fixed masonry fortifications and rendered them obsolete almost overnight. The damage done to masonry scarps by armored monitors, and occasionally by distant guns on land where such was possible, showed conclusively that the masonry scarp on sea fronts must be dispensed with, as it had been centuries before on land fronts. Consequently, beginning shortly after the Civil War, all new batteries built for our seacoast defenses had earthen exterior slopes, and no additional masonry scarps were built.[20]

Later, concrete emplacements were added to protect the increasingly heavy guns needed for sea coast defense. In the Philadelphia District, work went on, repairing and refurbishing Forts Mifflin and Delaware. At Fort Mifflin in 1871, a detached "high" battery of large guns was begun south of the main fort, towards Hog Island. It was to have mounted nine guns, two magazines, and six mortars—and while earthworks, foundations, and gun mounts were built, funds ran out in 1875 and no guns were mounted. Mifflin did acquire "a new earthen battery for heavy guns" in 1875, and extensive repairs to a breached dike caused by heavy storms in 1878. At Fort Delaware, a general repair effort was initiated—concrete magazines and *barbette* platforms for contemplated fifteen inch guns were constructed (1871-1873), and dike and storm damage repaired in 1879.



Satterlee U.S.A. General Hospital was, as this 1864 poster relates "perhaps the largest and most complete Army Hospital in the world. It covers sixteen acres of ground. There are 24 wards, containing 4500 beds. The length of the buildings is 900 feet. There are altogether 7 acres of floors. It was opened for the reception of our brave, sick and wounded



soldiers, June 9th, 1862. Admitted up to May 27th 1864—12,773. Deaths, 260. Since the great battles of the Wilderness and Spottsylvania, there have been several hundred tents put up outside of the enclosure, as the accommodations are not sufficient for the large number of patients daily arriving from the field."

—Free Library of Philadelphia

Col. J.N. Macomb

Other sites along the Delaware which had been employed as temporary batteries during the war were examined as possible locations for new river fortifications. Land was acquired at Red Bank, New Jersey, and general improvements were made on it, but no defenses were constructed.

Opposite Fort Delaware, however, on both the New Jersey and Delaware shores, new fortifications were begun. A ten gun earthen battery with emplacements for two fifteen inch guns was erected on the Jersey side, and dubbed Fort Mott, while additional mortar and gun emplacements were installed at nearby Finn's Point. On the Delaware side, below Delaware City, a new fort was begun. Known at first as the "Fort Opposite Fort Delaware," it began as a ten gun earthen *barbette* battery built by Lieutenant Colonel H. Brewerton in 1864. Between 1870 and 1876, an additional earthen battery to mount twenty guns, wharves, and emplacements for two fifteen inch Rodman guns were constructed under the direction of Lieutenant Colonel John D. Kurtz, and later Colonel J. N. Macomb and Captain William Ludlow, for the new fort, now renamed Fort Dupont.[21]

The storm of 1878 did tremendous damage to all works along the Delaware, as can be attested by this extract from the report of the Philadelphia District, dated 2 January 1879.

> *The storm of October 23 ultimo, though fortunately of brief duration, was very severe, and its greatest strength seems to have been developed in the valley of the Delaware River, where it was accompanied by an unprecedented rise of the water surface. The tide surmounted all the dikes, inclosing the low and reclaimed lands bordering on the river, caused immense damage to all owners and occupants of such lands by the destruction of their crops and costly dikes, and exaggerated the disasters to shipping by sweeping inland many of the smaller class to distances from the river ranging from a few yards to one and one half miles. The reports to the Chief of Engineers by Colonel Macomb, of November 6 and 15, supply many of the details of the damage done to the government property, but the estimates submitted therewith were partial only, and contemplated merely making such repairs as were absolutely necessary. The total public and private losses at the forts and batteries could not be repaired for less than double these estimates.*
>
> *At Fort Mifflin, the tide attained its maximum of eleven feet and three inches above mean low water at 10 a.m., and was maintained at this height until 12:45 p.m., when it began to recede. At Fort Delaware many of the people living on the island barely escaped with their lives, the water rising five feet in an hour and a half and reaching a height of eleven feet and eight inches above mean low water.*
>
> *At both forts the outlying buildings most exposed to the storm were either gutted or destroyed, and the magazines, storehouses, and quarters flooded to a depth of from two to four feet. Had they been garrisoned at*

The defenses of Fort Mott, opposite Fort Delaware on the New Jersey side, eventually encompassed three 12-inch breech-loading rifles on disappearing carriages; three 10-inch breech loading rifles on disappearing carriages; two 5-inch rapid fire guns on balanced pillar mounts and two 3-inch rapid fire guns, on pedestal mount. Construction began in 1872, and through a series of incarnations the work was completed in December 1906.

Ten-inch breech-loading rifle on disappearing carriage in firing position over parapet of Battery Harker, Fort Mott, New Jersey. Guns were capable of firing at five-minute intervals.

—National Archives

> *the time, the destruction of property would have been much greater.*[22]

In the years following the flood, much of the military construction authorized was for funds to repair and dike the fortifications devastated by the flood of '78. Construction languished in the 1880's, except for "torpedoes" or submarine mine defenses, which were continually being installed and repaired at Forts Mifflin and Delaware from 1873 through the turn of the century.

From 1871-1873, and for nearly twenty years thereafter, seacoast fortification construction was almost abandoned in the United States. Before it was resumed—about 1890—a number of important developments had taken place. Breech-loading guns had completely replaced the older muzzle-loaders for all large guns and mortars. Disappearing gun-carriages had been invented and had proven a success. Breech-loading mortars were shown to have sufficient accuracy for seacoast use and had consequently become a principal element of seacoast defense. Because of these new developments, seacoast emplacements in the United States consisted either of direct fire

Destruction of Admiral Cervera's Spanish Fleet off Santiago de Cuba.

—Library of Congress

guns mounted on disappearing carriages in concrete emplacements, with thick sand parapets in front on top of their magazines, or of mortar batteries with concrete mortar platforms placed behind concrete magazines surmounted and protected in front by heavy parapets of sand.[23]

Work on rebuilding Fort Delaware in the new style began in 1897, following a Congressional appropriation the year before. Half of the three story brick building west of the parade and the entire building fronting the New Jersey side of the fort were razed, and replaced by heavy concrete emplacements for three twelve-inch disappearing guns (Battery Torbert) together with ammunition storage rooms and elevators. At the north end of the island an earth-covered concrete mine-control center was built. Three batteries of three-inch guns were also installed south of the fort—Batteries Allen, Alburtis, and Dodd.

Forts Dupont and Mott were provided with still more powerful armaments—Fort Dupont mounted two eight-inch mortar batteries, two twelve-inch disappearing guns, two eight-inch guns and four five inch guns. Fort Mott was armed with three twelve-inch guns, three ten-inch guns, four five-inch guns, and two three-inch guns. Mine fields surrounded the Pea Patch, and the Delaware was finally considered impregnable.[24]

Although the three forts were not completed by 1898, at the outbreak of the Spanish-American War, they were heavily manned, as anxiety swept the Atlantic coast, in anticipation of a breakout and raid by Spanish Admiral Pascual Cervera and his squadron of four armored cruisers and three destroyers, currently bottled up in Santiago Harbor. The threat was never realized. Cervera's fleet was destroyed, and the coastal forts settled down to somnolence once more.

World War I Engineer Recruiting Poster. One of a vast number of Engineer Recruiting Posters of the period. The treatment appears to be at least partially jocular if one recalls the central figure's resemblence to Charlie Chaplin in the World War I hit, "Shoulder Arms."

—National Archives

WORLD WAR I

Not until World War I was the Corps of Engineers again called upon to engage in military construction. During that war the Corps mushroomed from 256 officers and 2,200 enlisted men to an incredible 11,175 officers and 285,000 enlisted men, or twelve percent of the Army's total strength. Much has been written of the Corps' activities in France—the bridges and roads they built, the battles they fought in. By Armistice Day 1918, over 117,000 men were engaged in military construction alone. These men built 18 new ship berths; 225 miles of barracks; 127 miles of hospital wards; 80 miles of warehouses; they cut 190 million board feet or lumber—3-1/2 million cross ties, 302,000 cords of fuel wood, and 38,000 piles.

In France, all the conflict was not with the enemy. An inter-departmental battle was being waged between the Engineers, the Quartermaster Corps and the Transportation Department, each wanting exclusive rights to the military construction mission; as a result, the command continually shifted back and forth among the three of them.[25]

Back in the States, all military construction was under the aegis of the Cantonment Division of the Quartermaster Corps. Across the country the cry had gone out for new warehouses, depots, and troop cantonments. Thirty-two cantonments (big enough to house over a million men) were to be built in the four months between May and September 1917, at a cost of $90 million. On 14 June 1917 in the Philadelphia District area, work began on Camp Dix, at Wrightstown, New Jersey, fifteen miles south of Trenton. By 16 July construction was in full swing. When completed at a cost of $9,623,067, the 6,500 acre facility was responsible for training eight infantry divisions, a full 60,000 men, with the post population reaching a 1918 peak of 70,000 soldiers.[26]

Another major area project was the construction of a great military port terminal at Philadelphia, to serve as part of a vast system of interior depots and port terminals designed to move men and material quickly and efficiently to France. One such terminal—

> *occupies a tract of land 3,800 feet in length along a ship-canal that has a depth of twenty-five feet and a length of 1,600 feet. Special tracks have been constructed measuring 1,100 by 160 feet; nine large storehouses; open shed 1,200 by 500 feet, together with quarters for the stevedore troops. A series of warehouses have also been built 160 feet in width, in multiples of 140 feet in length. Another of the*

Philadelphia Quartermaster Terminal, through which untold thousands of tons of war supplies moved on their way to the battlefields of France.

—Library of Congress

great port terminals has a pier extending 1,500 feet, and utilizes 400,000 square feet of shed-storage.[27]

In the twenties and thirties there was little military construction in the District, and none outside of fortifications. The Construction Division of the World War I Army had been absorbed by the Quartermaster Corps on 15 July 1920 and had become the Construction Service of the Quartermaster Corps. This independent arm of the Quartermaster Corps held uninterrupted sway over the diminished field of military construction for the next twenty years, while engaging in a continuous battle with the Corps of Engineers to keep that sway. When war finally came, suddenly on 7 December 1941, major military construction projects were just being transferred to the Corps of Engineers—including, in the Philadelphia District, Fort Dix, Fort Monmouth, and the giant Quartermaster Supply Depot in Philadelphia.

Camp Dix, Wrightstown, New Jersey, January 1919. General View of the Camp.

—National Archives

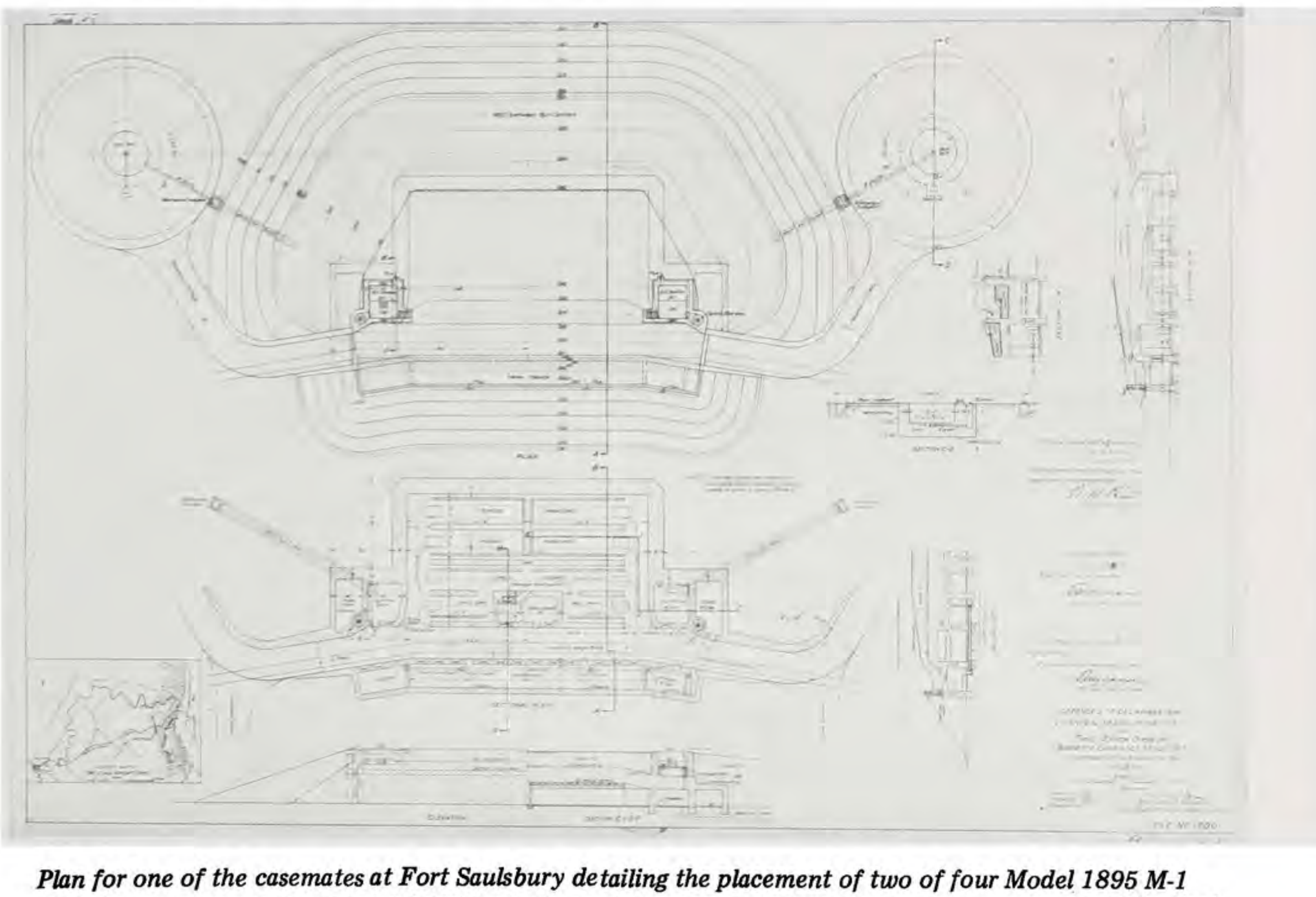
WORLD WAR II

War clouds were looming in Europe. In September 1939, Hitler's panzers plowed through Poland, and in a matter of days, the continent was ablaze. As the "arsenal of democracy" and Britian's chief military supplier, the United States felt herself being drawn closer to the war.

Before the war, the only military construction the Philadelphia District Office of the Corps engaged in was for coastal and harbor defense. Four twelve-inch guns were installed at Fort Saulsbury, near Milford, Delaware, shortly after World War I. In 1940, the Corps began the installation of massive eleven-foot thick concrete emplacements for sixteen-inch guns at Fort Miles near Lewes, Delaware. These guns, with a range of twenty-six miles would, in combination with a twelve-inch battery transferred from Fort Saulsbury, two six-inch support batteries, and an additional six-inch battery mounted on the opposite

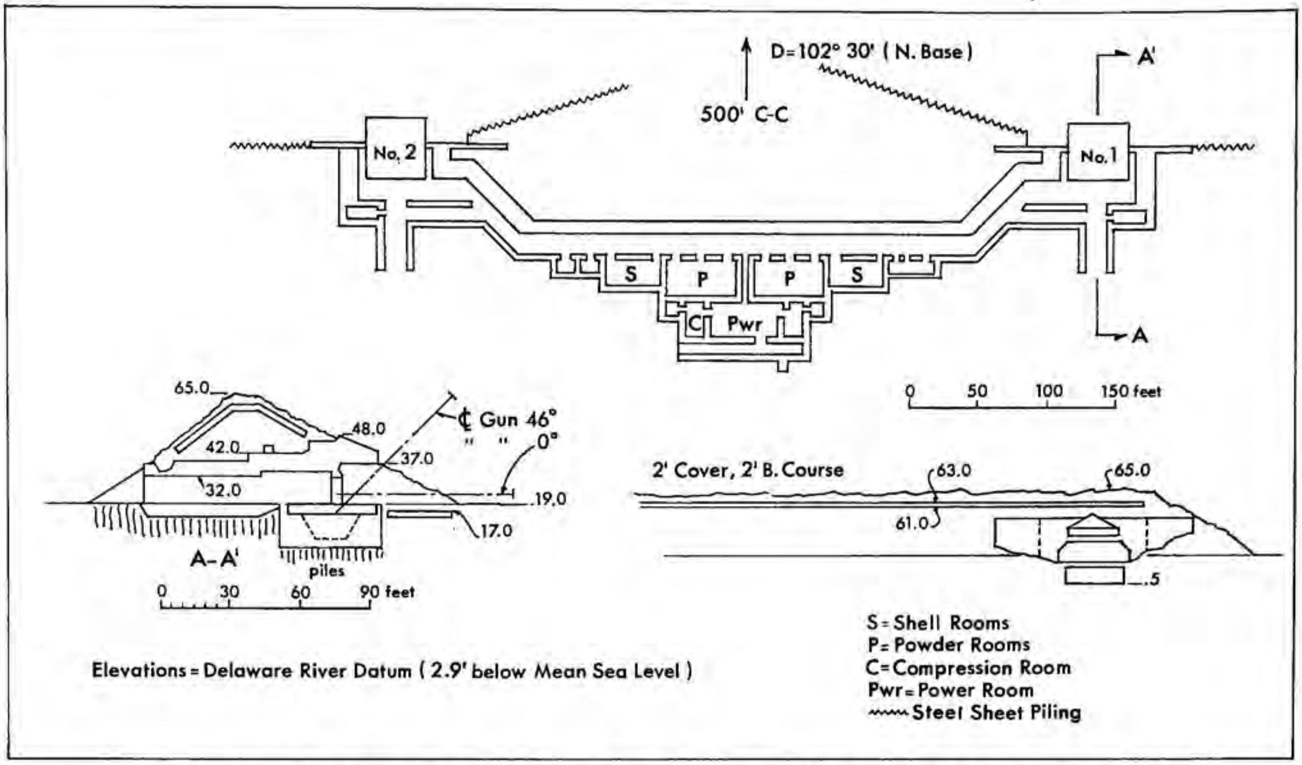
The Model 1895 12-inch rifle was 37 feet long, and could fire a 900 pound steel shell approximately 29,000 yards.

—U.S. Army Photograph



Plan for one of the casemates at Fort Saulsbury detailing the placement of two of four Model 1895 M-1 12-inch rifles mounted on Model 1917 barbette carriages, which comprised the main armament of the Fort.

—National Archives



Battery #118 (Smith), Fort Miles, Delaware, near Cape Henlopen. The massive 16-inch rifles of this Battery, protected by over twenty feet of concrete and earth, guarded the entrance to Delaware Bay. A proposed sister 16-inch battery (#119) was never built, but was superseded by a 12-inch battery (#519) in 1942, utilizing two 12-inch artillery rifles on Model 1917 carriages transferred from Fort Saulsbury.

—E. R. Lewis

Cape May shore, seal off the entire Delaware River basin from seaward assault. The Fort Miles project was the District's first new assignment in what was eventually to become a full-blown military construction program. In addition to the camouflaged coastal guns and their concrete emplacements, a separate underground concrete mine control center was installed at Fort Miles, so that the mines defending the entrance to Delaware Bay could be detonated independently in case of emergency. During the war, coastal fire control towers were installed along the New Jersey and Delaware coasts, above and below the Miles and Cape May emplacements, to permit triangulation of the big guns on possible seaward targets.

In 1940 Congress permitted the Secretary of War to transfer part (one-third) of the Military Construction Program—specifically all Air Corps construction and all work on Atlantic Island bases—from the Constructing Quartermaster to the Corps of Engineers. By 1941, it was found to be more institutionally appropriate to transfer the entire program to the Engineers. In a memorandum to the President of 28 August 1941, Under Secretary of War Patterson speaks of having drafted ...

Coastal fire control towers, Rehoboth Beach, Delaware.

Under Secretary of War, Robert P. Patterson, 1891-1952. His support of the Corps of Engineers was a major factor in the President's decision to transfer the entire military construction mission to the Corps.

—Library of Congress

> *a bill which will put all Army construction work with the Engineers. It seems plain: First, that responsibility for construction work should be concentrated in one branch; Second, that the Corps of Engineers is the branch best suited for handling the work.*
>
> *The Engineers, as you know, do a great deal of civilian construction in normal times, rivers and harbors, flood control, etc., and are a going concern. The Quartermaster, on the other hand, has normally no adequate organization to handle construction. If we had the Engineers on the entire construction program last year, they would have moved in with an experienced organization and much waste would have been avoided.*[28]

Even before Senate Bill 1884 passed both houses of the 77th Congress, and was signed into law by the President on 1 December 1941, the Philadelphia Engineer District moved to expedite the transfer. A memorandum dated 17 October 1941 lists the QM projects to be assumed by the Engineers, including "Optical Shops, Storehouses, etc., at Frankford Arsenal, Miscellaneous buildings at the Delaware Ordnance Depot and Warehouse, and the Laboratory at the Philadelphia QM Depot."[29]

By 16 December 1941 the consolidation of the construction services into one three and one-half billion dollar organization under the Corps of Engineers was considered effective.

Prior to Pearl Harbor, the District had engaged in the construction of airports under the aegis of the Civic Aeronautics Authority, as well as its traditional fortification activities. Within a week of the Japanese attack, the Quartermaster Corps Military Construction Program had been transferred to the District, followed shortly by an extensive Marine Construction Program (in addition to the Marine Design Program, transferred here from Washington in 1940).

After the outbreak of war, Division boundaries were changed to agree with those of Army Service Commands, for Military Construction purposes. However, it was not considered practical to change District boundaries. Consequently, the Philadelphia District reported to the Middle Atlantic Division at Baltimore on Military Construction in eastern Pennsylvania, and to the North Atlantic Division in New York on all other Military Construction work. All Marine Construction was to be carried out under direct orders of the Office, Chief of Engineers, as the program was spread out over the country from Boston to Miami to Brownsville, Texas to St. Paul, Minnesota. Sometimes, contracts were made by the Philadelphia office; sometimes they were assigned by Philadelphia to other Districts. Military construction was carried on through a number of area offices, including those at Fort Dix; Fort Dupont; Fort Miles; Fort Monmouth, Picatinny Arsenal; Cape May County Canal; Millville, Mercer, Cape May, Reading, Allentown, and Northeast Airports; Valley Forge and Philadelphia, with sub-offices at Atlantic City and New Castle, Delaware.

Roughly speaking, the Corp's World War II Military Construction Program in the Philadelphia District can be sub-divided in the following manner:

a. Cantonment construction, including the construction of housing, station hospital, mess and recreational facilities at such major posts as Fort Dix, Fort Monmouth, Fort Miles, Fort DuPont, and miscellaneous scattered locations within the District.

b. General hospital programs such as the Valley Forge General Hospital, which this office initiated and carried to substantial completion before transferring jurisdiction to the Baltimore District.

c. Arsenal and Depot construction, such as alterations and renovations to Frankford Arsenal, Philadelphia Quartermaster Depot, Picatinny Arsenal, and Hog Island.

d. Fortifications, such as installations at the main and sub-posts of the Harbor Defense of the Delaware.

e. Air Warning Service, including numerous scattered locations throughout the District.

f. Airport construction, which included eleven facilities scattered throughout the States of New Jersey, Pennsylvania, Delaware, and Maryland.

At the end of 1941 the Military Construction Program of the District had a total estimated cost of over $6,000,000, of which about two-thirds was already in place. By December 1942, the program had expanded

Aerial View of the Frankford Arsenal, Philadelphia. —*U.S. Army Photograph*

Steel Hull 2000 H.P. Twin Screw Towboat, Midway Islands. Measured 180 feet in length by 52 feet in breadth, with a draft of 11 feet. Shown in bow view immediately after a complete 180 degree turn at 185 RPM.*

Artist's conception of an experimental concrete oil barge, with cutaway depicting steam piping required to heat the viscous crude oil.

The concrete barge, being towed through the Lewes Canal. The barge measured 195 feet in length by 35 feet in breadth, drew 11 feet of water and displaced 850 DWT. Built in sections which were later joined together, the weight of the reinforcing steel proved so great that the vessel bowed amidships from the strain.

to a total cost of over $111,000,000 (90% in place), and reached close to $150,000,000 (approximately 97% in place) by December 1943. During 1942, the peak year of Military Construction, nearly $100,000,000 worth of construction was completed with approximately $33,000,000 finished in the first nine months of 1943. The largest volume of work per month came during November 1942 with $10,000,000 completed. During 1943, work averaged $3,500,000 per month, or $122,000 per day. More than three and one-half million square yards of paving were laid down as runways, taxiways, and aprons at eleven airport sites under the jurisdiction of the District, roughly equivalent to what would be required to push the forty-eight foot wide Pennsylvania Turnpike from Philadelphia to Washington, D.C.[30]

Under the Marine Construction programs of Marine Design Division, there were two major sub-divisions: the Tug, Barge, and Towboat Program carried out with Defense Plant Corporation funds and the Derrick-Boat Procurement Program for the War Department. The latter $11,000,000 Program started about March 1942 and included 26 fifty-ton derrick barges 8 seventy-five ton assembled derrick barges, and thirty sixty-ton derrick barges, some assembled and others knocked-down for shipment. The $80,000,000 Tug-Barge-Towboat Program was designed to furnish the oil-starved eastern seaboard with equipment to move the vital fluid. The program got underway early in 1943, with the construction of 370 wooden barges, each of 6,000 barrel capacity; 100 eighty-five foot steel tugboats, powered by 600 hp Diesel Engines; 21 two thousand hp Mississippi

River-type steam towboats; and an experimental concrete barge, which failed miserably upon launching, when the empty vessel (which had been designed in anticipation of a shortage of structural steel) rode so low in the water that its decks were almost awash. It was towed to New York harbor, and put into service as a platform for a debris and driftwood incinerator. Later the barge was rammed by a tug and, considered unsalvageable, was taken out to sea and sunk. In May 1943, the Program was enlarged to include construction of 155 welded steel barges, 195 feet long, of which 100 were designed to carry gasoline and 55, dry cargo.[31] Keeping this brief outline of the District's World War II military and maritime construction programs in mind, let us now examine the major programs in a bit more depth.

AIRPORTS

Long before Pearl Harbor, the nation realized that numerous airports would be needed for defensive air operations. Congress reacted by appropriating funds for additional facilities at established airports and the construction of new airports by the Civil Aeronautics Authority.

Realizing the magnitude of the task and the necessity for getting operations underway in the least possible time, the CAA requested the Chief of Engineers to plan and supervise the construction.

Late in December 1940, the Philadelphia Office was granted $553,815 and directed to proceed with the work of providing new airports, each with two runways, at Dover, Delaware, and Millville, New Jersey. Improvement on the existing Allentown-Bethlehem Airport in Pennsylvania by constructing an additional runway was also ordered.

The Preliminary work involved close coordination between District Office and field forces. As quickly as field surveys were finished, detailed plans were drawn and specifications drafted. From this mass of swiftly accumulated data, separate specifications for each airfield were mailed to prospective bidders.

The initial contracts including grading, draining, and paving. Although the ground surface of each selected site was fairly level, soil conditions differed widely for each location. For instance, at Millville, New Jersey, the site was covered by scrub oak and pine on sand, while at Dover, Delaware, a sand base without timber growth presented a different problem, and at Allentown, Pennsylvania, an established airport, the subsoil was heavy with numerous "sink-holes" in underlying limestone—involving still another problem.

Specifications and advertisement for bids for construction of the Millville project were issued in approximately three weeks. Completion of specifications and advertisement for bids on the Dover and Allentown-Bethlehem projects followed within a few days. For its dispatch in this work the District received special commendation from the Chief of Engineers.

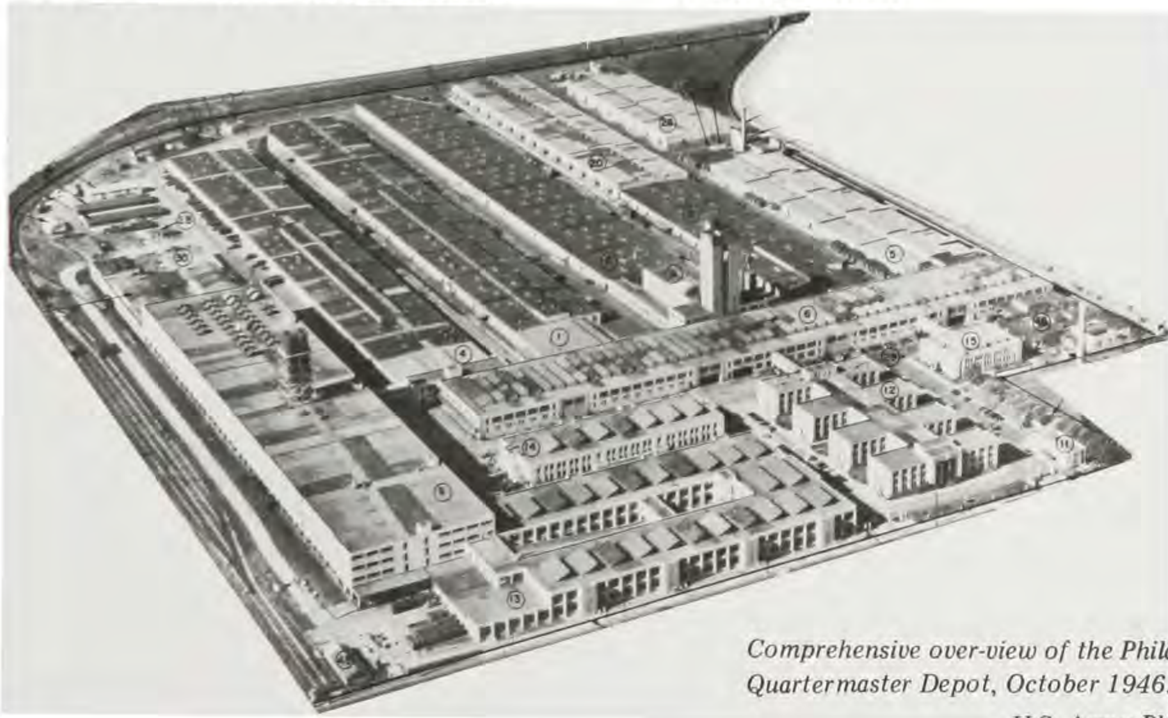
The contracts awarded provided paved runways 4,000 feet long and 100 feet wide with surface-treated shoulders twenty-five feet wide on each side. Turn-arounds were provided at the ends of the runways. The maximum grade allowed on runways was one and one-half percent. Runway elevations were

Aerial view of Northeast Airport, Philadelphia.

selected for the minimum amount of earthwork.

The runway paving at the Millville Airport consisted of a coarse graded aggregate type asphaltic concrete wearing surface two inches thick placed on a compacted base of natural soil after a priming treatment with refined tar. At the Allentown-Bethlehem and Dover Airports, the runways were surfaced with a fine graded aggregate type asphaltic concrete, two-inches thick. At all three of the airports under construction, longitudinal drains of vitrified clay or concrete pipe were placed in trenches parallel to the runways and back-filled with granular material. Work was also done at Reading, Pennsylvania; Cape May, New Jersey and New Castle, Delaware, Airports.[32]

By 16 December 1941, the duties and functions of the Construction Division of the Quartermaster Corps had been transferred to the Corps of Engineers. The contracts in force as of that date involved approximately $30,000,000 in cantonments, ordnance buildings, and supply depots, and expanded the mission of the Philadelphia District considerably. Contracts at Picatinny Arsenal, Dover, New Jersey; Fort Monmouth; Fort Dix; Philadelphia Quartermaster Depot, Signal Corps Depot, and Frankford Arsenal were included in the transfer, with officers in charge of those projects being similarly transferred to the Corps of Engineers and continued in their general capacities under the District Engineer.



Comprehensive over-view of the Philadelphia Quartermaster Depot, October 1946.

—U.S. Army Photograph

Wooden barracks construction, Fort Dix, New Jersey.

—U.S. Army Photograph

In December 1939, there had been 1,044 employees in the District. By December 1941, the number had risen to 2,314 and peaked at 2,961 in April 1942.[33] Initial emphasis at the new Engineer facilities was on the rapid construction of barracks to house the troops now pouring into the area through the selective service system; new school facilities for the troops were also a priority item. Large open structures were built for the mess halls and barracks with a heavy emphasis on "austerity of materials" (regardless of cost). Consequently, standard sixty-three man barracks were built of wood, with the eaves removed to save lumber. In addition, an attempt was made to save steel by using wooden water mains (it failed). The buildings were coal-fueled, a tribute to the power of the coal lobby; later economies included the installation of pot-bellied stoves in the barracks.

Much of the army's austerity program boomeranged. Structures which were designed to last ten years and were subsequently utilized at the time of the Korean conflict were found to be in a stage of severe deterioration (which the missing eaves would have prevented). Moreover, the Corps became unpopular with base commanders, when, acting under the austerity directive, it could not provide the construction quality that the commanders were seeking. This may have negatively affected the careers of a number of Corps officers. Occasionally, more money was spent to obtain an ultimately inferior product, as in the directive that termite shields be removed from building specifications, because they were made of sheet metal. Eventually, wood became scarce and barracks were built from concrete slabs and cinderblocks, perhaps giving impetus to the massive rise in cinderblock construction at the war's end. As an additional economy measure, by 1943 stateside cantonments were being built using standard plans for theater of operations construction.

The District was also extensively involved in the construction of arsenal and ammunition facilities: For the Hog Island ammunition depot, the Corps dredged a channel, and put in roads and railroad tracks, all in the space of a year (May 1940 through May 1941). A similar facility was built at Newark, Delaware. In addition, the Corps expanded the mammoth Picatinny Arsenal in New Jersey, and the Delaware Ordnance Depot. Much of the early World War II construction the District was involved in was done under the cost-plus fixed fee contract system, in which a contractor was guaranteed his legitimate costs, plus a fixed fee, or commission. This type of contract was found to be most efficacious when construction time was a limiting factor.

Responding to the mounting tide of submarine attacks on allied freighters and tankers along the New Jersey coast, which threatened to strangle the flow of oil to the industrial northeast, the Corps of Engineers dug the three mile long Cape May Canal to facilitate the movement of oil and freight barges from Cape May Harbor to Delaware Bay, a project paid for by the U.S. Navy.

In Atlantic City, New Jersey, the main hotels were taken over and refurbished for government use (rather arbitrarily and without written documents, in the fever pitch of

The Cape May Canal, as seen from Delaware Bay.

emotion following the attack on Pearl Harbor) as barracks, hospitals and recreational facilities; at war's end, they were completely renovated and return to their owners intact. Not all District projects were quite so successful.

The District explored the field of camouflage during the war, at a good deal of effort and expense, and occasionally with less than heartening results. Some of the attempts to camouflage major area industrial facilities failed miserably, as in the attempt to disguise the Delaware Ordnance Depot, a facility with the straightest and longest pier in the Delaware River—by creating a pattern of "forest" from refuse coal.

By late 1943, the Corps began to retrench, and ordered all District area offices closed. By 1 October 1943, the offices at Fort Dupont, Delaware City, Cape May Airport, and Philadelphia Northeast Airport were closed, and their staffs transferred to the District Office in Philadelphia; on 2 February 1944 all area offices in the North Atlantic Division were abolished.[34]

Atlantic City, New Jersey, doffed its mufti and took on wartime dress.

—M. Abrahams

During the war years, the Philadelphia District was given responsibility for military construction projects in both the First and Second Army areas, reporting to the North Atlantic Division at New York City, and the Middle Atlantic Division, at Baltimore, respectively. The projects under the aegis of the North Atlantic Division in 1944 included:

1. The Delaware Ordnance Depot, Pedricktown, New Jersey.
2. Fort Dix, New Jersey.
3. Dover Army Air Field, Delaware.
4. Fort Dupont, Delaware.
5. Fort Miles, Delaware.
6. Millville Army Air Field, New Jersey.
7. Fort Monmouth, New Jersey.
8. New Castle Army Air Base, Delaware.
9. Picatinny Arsenal, Dover, New Jersey.
10. AAF Distribution Command, Atlantic City, New Jersey.
11. AAF Redistribution Center No. 1, Atlantic City, New Jersey.
12. England General Hospital, Atlantic City, New Jersey.

Those projects performed under the authority of the Middle Atlantic Division included:

1. Frankford Arsenal, Philadelphia, Pennsylvania.
2. Philadelphia Cargo Port for Embarkation
   a. Hog Island Terminal.
   b. Newark, Delaware (back-up storage).
3. Penncoyd, Pennsylvania (Ordnance Storage Depot).

Louis A. Johnson, 1891-1966. Secretary of Defense, 1949-1950.

—Library of Congress

4. Quartermaster Depot, Philadelphia, Pennsylvania.
5. Signal Corps Depot, Philadelphia, Pennsylvania.

Effective 1 October 1944, all military construction projects administered by the Philadelphia District under the North Atlantic Division were transferred to the New York District Office; all military construction administered by the Philadelphia District under the Middle Atlantic Division was transferred to the Baltimore District. This was done partly because, as a part of the North Atlantic Division, the Philadelphia District's territory overlapped the Middle Atlantic Division's area of responsibility, and partly because the Philadelphia District already had an extremely heavy civil work load, and the Corps wanted to distribute the work more evenly.

Following the war, the Department of Defense underwent a significant period of retrenchment, with Secretary of Defense Johnson advocating and carrying out a severe reduction in the size and mission of the defense establishment. During 1947-1948, Philadelphia was awarded a contract under the Veterans Administration to plan and construct a 320 bed hospital at Wilmington, Delaware, and a 1,000 bed hospital at Philadelphia. The District did build the Wilmington Hospital; at Philadelphia, however, the Veterans Administration chose to substitute their own standard-plan 500-bed facility for the Corps' design, and built the hospital themselves.[35]

The Veteran's Administration Hospital, Wilmington, Delaware.

KOREAN CONFLICT

In 1950, with the imminence of the Korean Conflict, the government's posture changed again, and the military construction mission was returned to the Philadelphia District. The advent of the cold war strengthened the entire defense establishment (and its concommitant war-making potential) and brought about a whole new military defense program. The nation was alarmed by a Department of Defense projection that in 1952 the relative military strengths of both the U.S. and the U.S.S.R. would reach a point at which the balance of power would be most advantageous to the U.S.S.R.

The most significant military construction projects undertaken during that early cold war period included:

1. McGuire Air Force Base, New Jersey.
2. Dover, Delaware, Air Force Base (expansion).
3. Pittsburgh, Pennsylvania, Air Force Base.
4. Fort Dix, New Jersey (rehabilitated).
5. Camp Kilmer, New Jersey (rehabilitated).
6. Frankford Arsenal, Philadelphia, Pennsylvania (construction work).
7. Burlington Ordnance Depot, New Jersey.
8. Birdsboro Ordnance Depot, Pennsylvania.
9. Tobyhanna Signal Depot, Pennsylvania.
10. Pennsylvania Athletic Club, Philadelphia, Pennsylvania (Signal Corps).
11. Fort Monmouth, New Jersey (tremendous expansion).
12. *Nike* sites.
13. General Steel Castings, Eddystone, Pennsylvania (industrial facility).

AIR FORCE CONSTRUCTION: The character of the new military construction program was earmarked first by a significant increase in air force bases, with the purpose of rapidly expanding training and defense facilities for a growing air force.

Unlike similar construction during World War II, austerity was no longer the watchword. Instead, quality of construction became the logo for the new projects — and to the District's credit, high quality facilities were built — including four-man-per-room troop housing units to replace the old World War II open barracks.

These programs dating from 1950 included an initial $6,400,000 housing, hangar apron, and navigation aid project at McGuire Air Force Base, New Jersey, which with supplements amounted to over $55 million in total contracts by 1955; development of facilities at Dover Air Force Base to enable it to serve as the primary port of embarkation for all aerial cargos to our troops in Europe (1952) and further development of the Dover facilities (1952) as headquarters for the Atlantic Division of the Military Air Transport Service (MATS); work was also done at Pittsburgh Air Force Base, at a time when the Pittsburgh District was burdened with a heavy civil works schedule — the program was later returned to the Pittsburgh District as the Korean conflict waned.

Facilities installed by the District at the above air bases included: heating plants; infirmaries; barracks; administration buildings; petroleum, oil, and lubrication facilities to fuel planes; hangars; fire fighting facilities;

lighting systems; instrument handling systems; and radar.[36]

CANTONMENT CONSTRUCTION: In the early stages of the Korean Conflict, great emphasis was placed on producing temporary facilities to meet the needs of a rapidly expanding military establishment. At Camp Kilmer, New Jersey, the Corps rehabilitated abandoned thousand-man Work War II barracks within *thirty days* (including housing, kitchens, and all other utilities). The schedule was met both at Kilmer and in a similar expansion project at Fort Dix.

After the initial housing units had been erected, a significant effort was made to upgrade standard troop housing, in 225-man reinforced concrete and cinder block barracks, with good quality well-finished interiors and no more than four men per room. "Unit integrity" was to be the new criterion for housing and messing facilities, replacing the old standard of providing the most efficient and cheapest facilities feasible. "Unit integrity" may be defined as a plan to locate an entire unit with messing facilities in one building, to create a feeling of *esprit de corps* among members of the unit. Psychological studies had shown that while the marines possessed this spirit to a high degree, the army did not. Individual soldiers tended to think of themselves as civilians in soldier suits; marines saw themselves as marines.

The studies found that early identification with a particular unit and the development of associations within it created the desired group feeling; whereas the army mobilized men on a mass production basis — sending them first through training camp, and then individually out to fill quotas in a replacement center, from which they were sent to the front to fill casualty-caused vacancies. As a result of these studies, cantonment policy was changed and the new policy was implemented in all new cantonment construction in the District.

INDUSTRIAL CONSTRUCTION: At the beginning of the Korean Conflict, Army Ordnance reported a severe shortage of 75 mm, 90 mm, and 105 mm shells. Accordingly, a directive went out to the District to create a facility for manufacturing the needed shells at the Burlington, New Jersey, Ordnance Depot within *90 days*. The facility had been designed originally at a cost of $42,000,000 in 1941 to produce aluminum, and was converted by the Corps at a combined construction and equipment cost of $34,000,000. The shells were the first in this country to be made of steel (not brass, which was in short supply), a material which had been used successfully by the Germans in the Second Word War. Through a unique cold-drawn process, steel discs were extruded into shell casings. The shells were then heat-tempered to distribute the molecules evenly, and the red hot 1800° shells cooled with water which had to be maintained at a temperature of not less than 55° nor more than 70°F. The District designed and successfully built the entire facility from scratch, although not within the 90 day time limit.

Developing strategy in Korea emphasized the use of tanks in battle. The new M-48 medium tank required one piece castings for both the hull and the turret (unlike older models, cast in separate pieces and then joined together). A facility for this express

M-48 Patton Medium tank.

—U.S. Army Photograph.

purpose was created by the District at the old Navy steel castings foundry at Birdsboro, Pennsylvania. A cost-plus-fixed-fee type contract was awarded for this project on 7 March 1952. Plans for the $23 million facility required the most advanced furnace design possible, with an extremely high order or quality control in the casting process (including a special Betatron building with massive 24 million volt X-ray testing facilities). The Main Foundry Extension and Heat Treatment Building were monumental structures 400 feet wide by 575 feet long and 188 feet wide by 907 feet long, respectively.

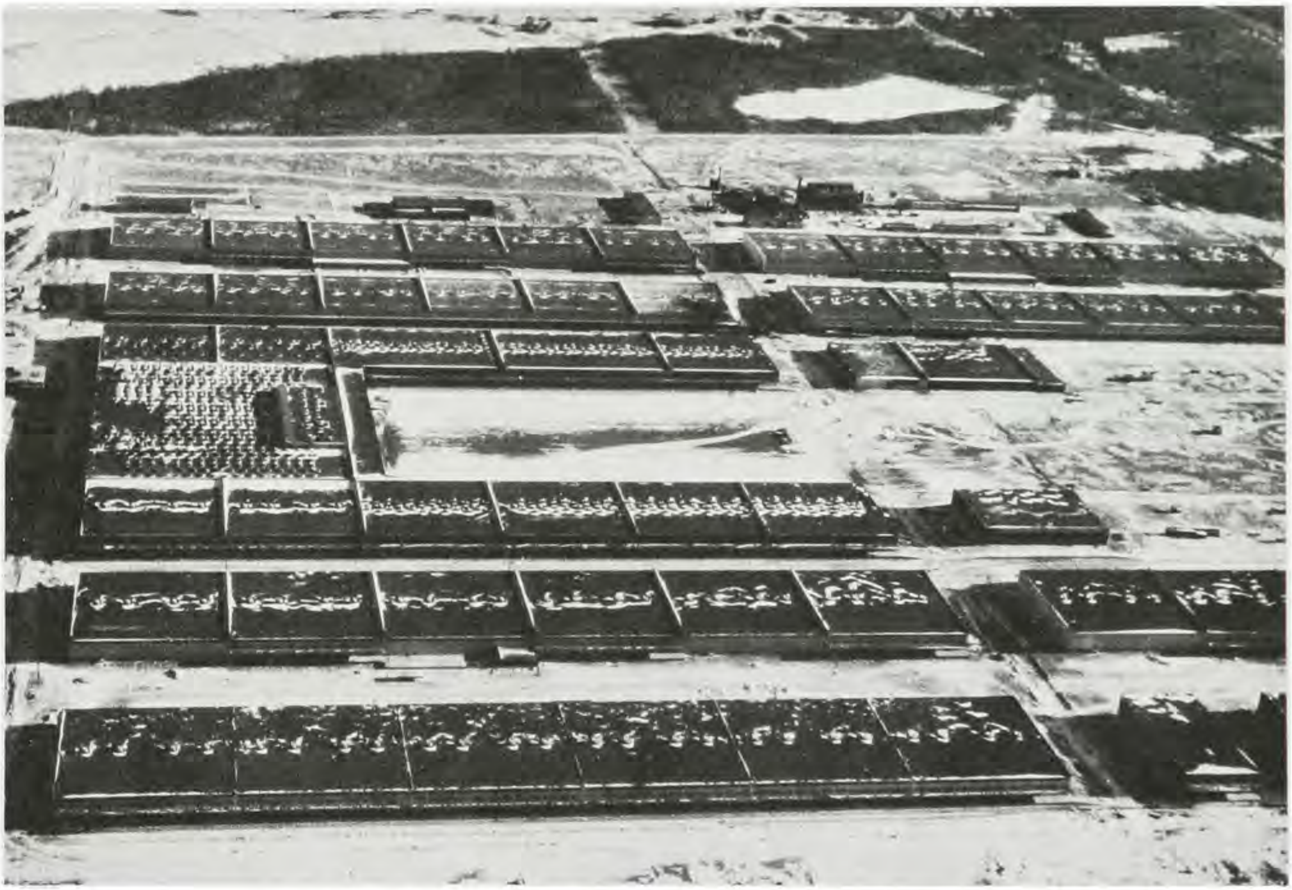
A smaller, similar facility was developed at General Steel Castings, Eddystone, Pennsylvania. Work at these facilities was performed at an accelerated rate. When the facilities were two-thirds finished, the end of the Korean Conflict was in sight. The Birdsboro contracts were finally completed on 1 June 1954 at a total contract cost of $23,268,879.[37]

SIGNAL CORPS FACILITIES: Prior to and during the Korean Conflict, the army determined to expand Signal Corps facilities to make it possible for the Signal Corps to support field forces with the myriad spare parts required to service the electronic gear and components used by a modern army. The Philadelphia District was engaged in several key projects on behalf of the Signal Corps.

Birdsboro Foundry, the east bay looking west, January 1954.

1. Pennsylvania Athletic Club: The District was requested to acquire this facility on Rittenhouse Square in central Philadelphia and convert it to modern office space, to house a Signal Corps facility that would maintain inventory control and warehouse stock level control over items of Signal Corps equipment. The need for the facility was so pressing that condemnation procedings were instituted, and the District was directed to convert the entire building within thirty days, through a cost-plus-fixed-fee contract negotiated with the Turner Construction Company.

2. Tobyhanna, Pennsylvania, Signal Corps Depot: The Tobyhanna Depot was designed in January 1951 as a primary backup warehousing facility, at a cost of $25 million. The 275 acre site was to be located on 1419 acres of land near Scranton, in a move to stimulate employment in a depressed area. The site selection was made with full recognition of the difficulties inherent in the construction. Mountainous terrain had to be levelled to provide sufficient flat area for optimum warehousing. The job went forward under extreme pressures. Shortcuts were taken. Concrete was poured in this, the coldest spot in Pennsylvania, even during severe winter weather, when such work is suspended. Ultimately, large cracks were discovered in the spandrels and beams of a section of the roof of the administration building. Cores were taken through the beams and the area was sealed off for safety. Later inspection revealed serious deficiencies



Aerial view of the Signal Corps Depot at Tobyhanna, Pennsylvania.

Members of Battery D, 707th Gunnery Battalion, Philadelphia, Pennsylvania, prepare to fire a 90mm AA gun.

—U.S. Army Photograph

in the concrete. Discovery of small-time pilferage at the site led to a Department of Justice investigation of the entire project, which resulted in a series of indictments being returned against contractors, a union business agent, a congressman, the congressman's assistant, the architect-engineer and the District's Resident Engineer at the project. The indictments involved conspiracy to defraud the government, bribery, and conspiracy to violate the labor laws. The Resident Engineer and labor representatives were eventually convicted on separate counts of wrongdoing, but the Resident Engineer's convinction was voided on appeal. The $32 million facility was fundamentally complete by the end of 1954 and is currently in service.

Aside from the Burlington and Birdsboro projects, which were awarded as cost-plus-fixed-fee contracts, the general architect engineering contracts negotiated during this period were of two types: The Title I contract, in which a lump sum for design specifications and estimates was negotiated with a specific architect-engineering firm; and the Title II contract, which contained an option for inspection and was also negotiated with an architect-engineering firm.

Nike missile site at Newportville, Pa. showing four Nike-Ajax missiles raised on launcher, 24th Artillery Group, Philadelphia, Pennsylvania. Defense, 20 October 1959.

—U.S. Army Photograph

Firing of Nike-Hercules Anti-Aircraft Missile. —*U.S. Army Photograph*

After the termination of the Korean conflict, the major military construction contracts engaged in by the District primarily involved artillery and missile defense contracts for the Philadelphia metropolitan area, and military housing contracts for major area bases.

Immediately following the Korean conflict, the Corps was ordered to develop a ring of twelve anti-aircraft gun emplacements situated around the clock at a radius of six to seven miles from central Philadelphia. This was followed by an authorization to develop an outer defensive ring, this time at a distance of twenty-five miles from central Philadelphia, of *Nike-Ajax* anti-aircraft missiles. These missiles were to form one link in a defensive chain reaching up and down the East coast and ringing the major cities. Up to the time of this construction, "*Nike*," name of the Greek goddess of victory, was a *verboten* word, and construction proceeded under heavy security. The *Ajax* armaments were eventually declared obsolete, and were ordered replaced by the newer, more advanced *Nike-Hercules* generation of defensive missile. The District was ordered to convert all twelve sites for the *Nike-Hercules*, with four sites to be fully and eight sites partially converted. Warheading buildings were constructed at each of the four chief *Hercules* sites. These sites were computer connected by long-range radar scanning devices into a major overall network integrated by a major headquarters located in Pedricktown, New Jersey. This facility, dubbed "*Missile Master*" was designed and built by the Philadelphia District "for the purpose of high speed coordination of defense warnings and fire power for all tactical facilities in the Philadelphia Defense Area and coordination on a larger plane of the east coast region."[38]

"Missile Master," Pedricktown, New Jersey.

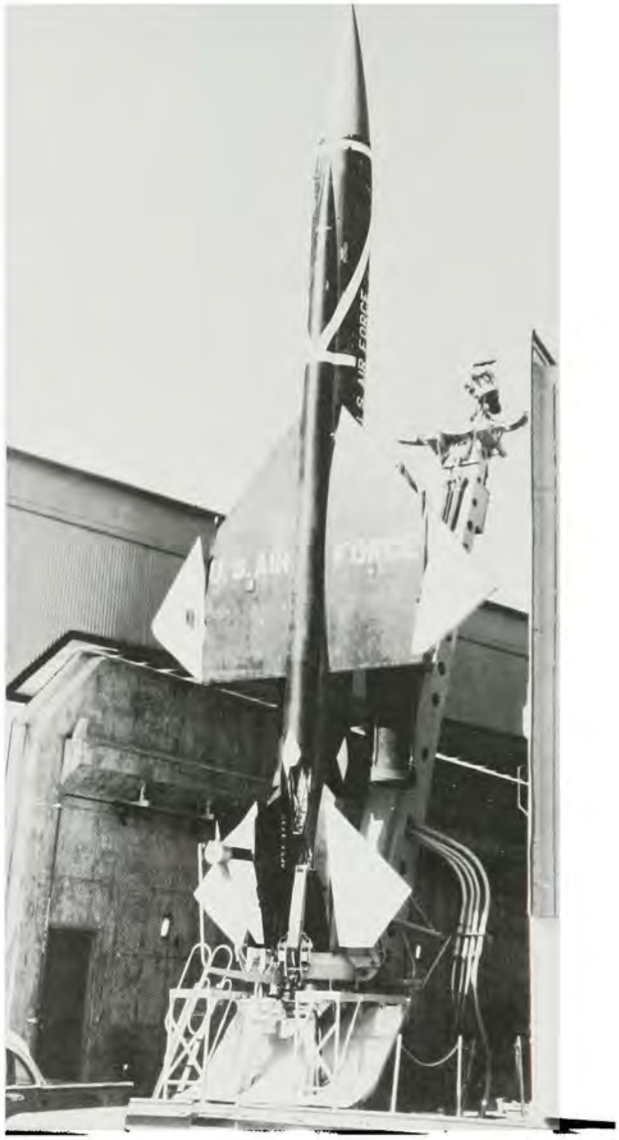
NIKE: It should be remembered that in the mid-1950's the intensity of the cold war was so great that a genuine fear of a possible nuclear attack by enemy aircraft permeated the air. The nation's initial reaction was a frantic attempt to encircle our major cities with a ring of iron, an attitude which later gave way to a policy of retaliation rather than a posture of total defense. The nation knew that Russian bombers had the capability of reaching the United states. Consequently, the *Nike* defense — in all three generations, *Nike-Ajax*, *Nike-Hercules*, and *Nike-Zeus* (never implemented under the District) were developed — together with the most advanced target acquisition radar facilities, to identify, track, lock in and destroy enemy targets automatically. All flight plans nation-wide were checked and evaluated by computer. The missiles were stored underground and were provided with elevators to raise them to firing position. During the construction phases of the project, the emphasis was on speed of construction, at premium cost plus overtime. These sites were first manned by the air defense artillery, then turned over to the National Guard for training purposes. Finally declared surplus, the *Nike* installations are now considered obsolete.

The D.A.M.P. (Downrange Army Missile Program) building at Moorestown, New Jersey.

In conjunction with the missile defense programs, a new missile ranging facility, the DAMP (Downrange Army Missile Program) structure was erected at Moorestown, New Jersey.

BOMARC: Extending the missile defensive ring outward, the 300 mile range *Bomarc* (liquid-fueled and twin-ramjet powered) guided missile program was designed to intercept enemy aircraft before they reached American shores. Forty-seven feet long, with a wing span of eighteen feet, two inches, the missile weighed 15,000 pounds at take-off. The first *Bomarc* installation in the nation was activated at New Egypt, New Jersey, between Fort Dix and Lakehurst Naval Air Station. The sites were designed for wider diffusion than the Nike installations, with the next closest *Bomarc* facility located in Long Island.

Although the *Bomarc* eventually proved to be a less than successful missile defense



Bomarc missile, elevated and ready to fire. Note the massive open steel doors.

system (a number of test firings were failures), it was pushed as a propaganda defense against Russia. The District built the hardened missile shelters and their ancillary buildings; construction began in January 1958 and took two years for the first increment of fifty-six launcher structures. The project was considered so essential that construction was ordered to proceed at top speed, without all engineering problems completely worked out; however, it proved to be so complicated that many on-the-job engineering changes required and put into practice by Roscoe-Ajax and other contractors, resulted in litigation, which, as of December 1971, had not yet been finally resolved. The litigation emerged from difficulties inherent in the development of the massive steel doors required for each missile housing. Each leaf of this bi-parting roof structure, sixty feet long by twelve feet wide, weighed ten tons, and the door mechanism was designed to move those twenty tons and raise the missile into firing position

Bomarc installation at New Egypt, New Jersey, with missile launching structures and powerplant.

within ten seconds. To produce a workable mechanism, changes were made in the pre-negotiated contract specifications. The changes worked, but differences arose as to the cost of the project, and these ultimately resulted in the previously mentioned litigation. When military construction was transferred from the Philadelphia District to the New York and Baltimore Districts in October 1960, *Bomarc* and *Nike* were among the major continuing programs transferred. The introduction of the ICBM in the early 1960's rendered both of these systems obsolete.[39]

In a minor way, the District was also engaged at the time in expanding and developing the Beverly National Cemetry in Beverly, New Jersey, grading and draining, and erecting the administration building at a facility which at the time of its transfer to the New York District (1960) was averaging eight burials per day. At the same time, the District worked on a number of reserve training center armories (Wissahickon Avenue Armory, Philadelphia, Pennsylvania; Willow Grove Armory, Norristown Armory, Pennsylvania; Atlantic City Armory, New Jersey.[40]

Beverly National Cemetery, Beverly, New Jersey.

MILITARY HOUSING: The last major military construction projects worked on by the District were for expanded and improved housing facilities at military bases. Under provisions of the continuing MCA (Military Construction, Army) housing program, the District built 100 NCO; 100 company grade; and 78 field grade housing units at Fort Dix, New Jersey in 1956, at a cost of $6,800,000. Four hundred units had previously been built at Fort Dix under the authority of the special Wherry Housing Act, which enabled private contractors to build family housing on government land (which they leased for 99 years)

M.C.A. Housing, Fort Dix, New Jersey.

Wherry Housing, Fort Dix, New Jersey.

with an FHA (Federal Housing Administration) commitment based on a government guarantee to keep the housing filled. The project included 292 enlisted men's units; 98 company grade officer's units, and 10 colonel's quarters, built in 1954-55 at a cost of $5,000,000. The buildings were multiple-family dwellings, with carefully legislated spending limits on both enlisted mean's and officer's housing, which the army had some difficulty in meeting. The Philadelphia District was given the responsibility of inspecting this construction.

The Capehart Housing Act of the 84th Congress, which in a sense superceded the Wherry bill, provided for family housing of a more individual nature. An all-government project, it was designed to make government housing on military bases as attractive to military personnel and their families as possible within the fiscal limits of the program. At Fort Dix, from 1957 to 1959, the Corps contracted for and built living quarters for the families of 702 officers and men, in 351 separate buildings. These included 172 two bedroom units for Company Grade Officers; 174 three bedroom units for Company Grade Officers; 178 two bedroom units for Non-Commissioned Officer; and 178 three-bedroom units for Non-Commissioned Officers. All units were without basements.[41] During 1957, 1958, and 1959, the Philadelphia District completed $23,364,492; $24,929,478; and $47,773,189 in military construction projects respectively (including over $11,500,000 in Capehart housing[42]). In early 1960, authorization was granted for the construction of 200 additional Capehart units at Fort Dix.

Capehart Housing, Fort Dix, New Jersey.

Before all construction at Dix could be completed, however, the military construction mission of the Philadelphia District was ordered transferred to the New York and Baltimore Districts, effective 1 July 1960. Engineers in the field, working on such programs as *Bomarc*, *Nike*, Fort Dix, and McGuire Air Force Base were ordered to finish what work they could by 1 July and to box and ship whatever they could not finish by that time to New York or Baltimore. The following memorandum concerning the transfer was ordered placed in the personnel files of all employees of the Philadelphia District.

SECURITY CLASSIFICATION (If any)

DISPOSITION FORM

FILE NO.	SUBJECT
NAPVE	Military Construction

TO	FROM	DATE	COMMENT NO. 1
All Members, Philadelphia District	District Engineer	25 May 1960	

1. I feel the Division Engineer's personal letter to me, 23 May 1960, is one properly the concern of every member of the District. I particularly invite your attention to the second paragraph.

"Dear Colonel Setliffe:

The present foreseeable dollar value of work of military construction within the Philadelphia District area is so small that it cannot economically justify further assignment of military construction to the Philadelphia District. It has been determined, therefore, that the military construction in eastern Pennsylvania and Delaware be transferred to the Baltimore District, and that in New Jersey to the New York District, effective 1 July 1960. Civil Works construction and Military Procurement, which form a large part of the Philadelphia District workload, will continue to be assigned to your office.

I realize that this action will result in a reduction in force of Civil Service personnel primarily in the District Office. The personnel of your District have done a splendid job in military construction work since its assignment at the beginning of the Korean conflict. Please express my appreciation and inform them that it is with regret that this action has to be taken. Every possible effort will be made by my staff to place within the Corps of Engineers' offices in other areas those individuals who must leave your District but who wish to remain with the Corps of Engineers.

Sincerely yours,

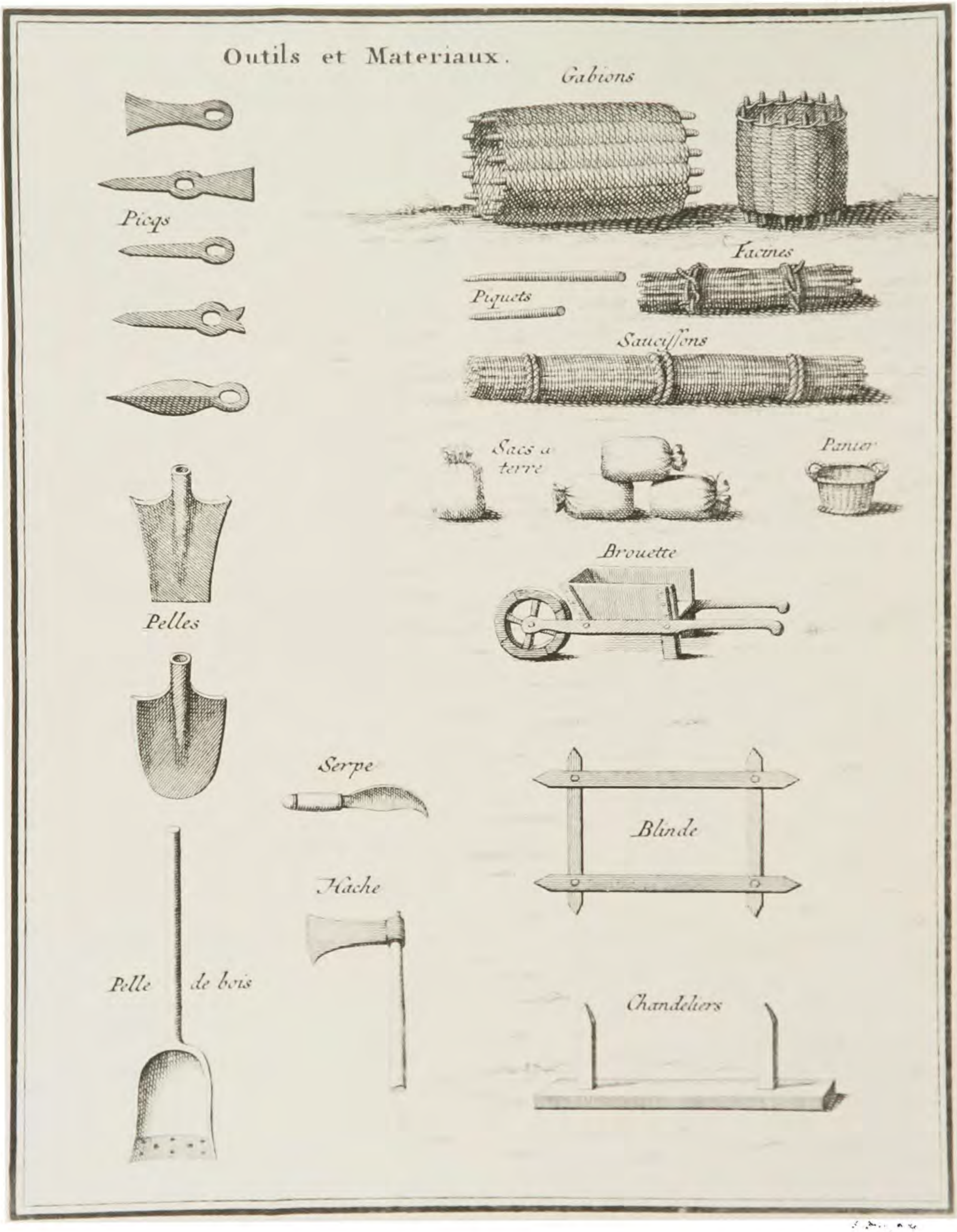
/s/ T. H. Lipscomb
T. H. LIPSCOMB
Brigadier General, USA
Division Engineer"

2. A copy of this Memorandum is being placed in the personnel file of every member of our District.

T. H. Setliffe
T. H. SETLIFFE
Colonel, CE
District Engineer

DD FORM 1 FEB 50 96 REPLACES NME FORM 96, 1 OCT 48, WHICH MAY BE USED

On 1 July 1960, almost a hundred years and hundreds of millions of dollars of District Military construction ended. Many of the most vaunted programs have since faded, new technologies carrying within them the necessary obsolescence of the old, but the record of the Philadelphia District still stands, proud in its accomplishment and secure of its place in the history of military engineering.



Eighteenth Century engineer tools and materials including picks, gabions, sandbags, wheelbarrows, hatchets, stakes, obstables and spades. From Vauban's "Memoire pour servir d'instruction dans la conduite des sieges et dans la defense des places." Leiden, 1740.

—University of Pennsylvania

A WAGON PROVIDED FOR THE PURPOSE:

Procurement and Supply in the Philadelphia District

Colonel Jonathan Williams. —Library of Congress

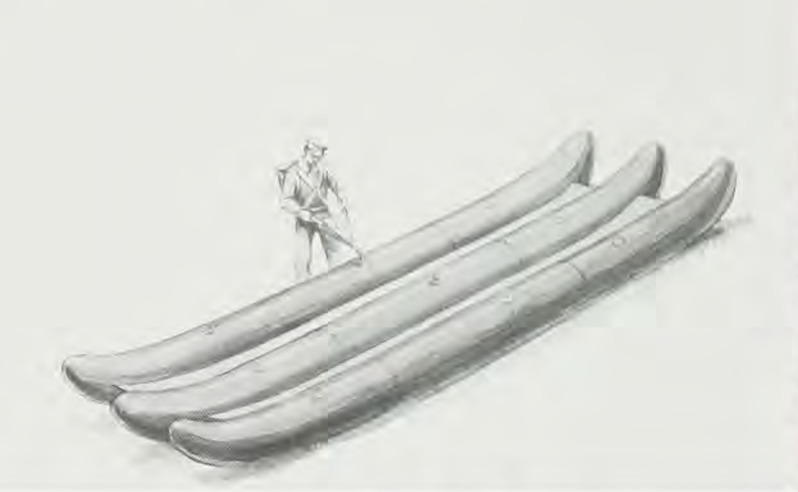
On 18 January 1778, while encamped at Valley Forge, Brigadier General and Chief Engineer Louis le Bégue du Portail prepared a memorial for his commander-in-chief. In addition to recommendations on fortification procedures and on the establishment of three companies of sappers, du Portail noted that engineers needed tools to work and must be trained to take proper care of them. *"Each company,"* he remarked, *"should always have its tools with it, carried in a wagon provided for the purpose — the company should be answerable for all tools lost, and in case any should be broke, the pieces are to be produced to the officer to whom the detail of the Company is committed."*[1] This first written statement of the engineer's concern for his tools and equipment was a small beginning for what was to become, by the end of the Second World War, a multi-million dollar program.

The next incident in the chronicle of supply activities performed by Army Engineers in the Philadelphia area, involved the appointment of Engineer Major Jonathan Williams to the position of Purveyor of Public Supplies under the Secretary of the Treasury, on 28 April 1800, a position which he occupied until 23 May of that year. In that position he was directed:

> *to conduct the procuring and providing of all arms, military and naval stores, provisions, clothing, Indian goods, and generally all articles of supply requisite for the service of the United States.*

On 16 February 1801, President Adams appointed Williams a major in the Second Regiment of Artillerists and Engineers;

Provision Train for General Washington, engr. by C. Tomkins after Imogene Robinson, 1877. —*Library of Congress*



India rubber Ponton boat, circa 1848.

Ponton boat and wagon, 50th N.Y. Engineers, Rappahannock Station, Va. March 1864.

—Library of Congress

shortly thereafter, President Jefferson made him inspector of fortifications, and on 13 April 1802, the Chief of the new Corps of Engineers, and first Superintendent of the Military Academy at West Point.[2]

Until 1866 there is no record of military supply or procurement being handled in any way other than through the Chief's Office in Washington. Engineer supplies included bridge and road building tools and were transported by Engineer troops as part of an "engineer train" of equipment. In the Mexican War, this equipment included "an India Rubber Ponton Bridge," and a large number of pack mules. After the capture of Mexico City, the Engineers sold their tools, which according to Lieutenant Gustavus W. Smith, "brought more than they had originally cost in the United States."[3] Through the Civil War, it is reported that General Totten, Chief Engineer, was personally involved in Engineer Procurement and Supply, and it was only after his death in 1864 that the Corps Military Supply Program, such as it was, began to be decentralized.

U.S. Engineer Supply Train under cavalry attack in Mexican War.

—National Archives

Galvanized iron barrels being stacked at the Philadelphia Quartermaster Depot, 1919.
—National Archives

No real information has surfaced about Engineer procurement and military supply in the Philadelphia District before this nation's entry into the First World War. That conflict saw the establishment of a first Engineer procurement depot in the city, although on a far more restricted scale (as will be shown) than the Corps and the officer assigned to the post originally envisaged. The war, despite the patriotic fervor with which this country entered into it, caught the nation's industrial war machine unawares. Between 6 April 1917, when war was declared, and the armistice of 11 November 1918, an industrial juggernaut was hewn out of the living rock of American ingenuity, and sent on its inexorable way to France. At first chaos reigned; four different chiefs of staff followed hard upon each other and in the procurement branches, several general officers were relieved of command. The rising cost of war materiel staggered the various supply services (nominally united in Europe under the acronym S.O.S., Services of Supply). Between September 1917 and September 1918, six different mobilization plans were delivered to the different procurement branches. The War of 1812 had seen a rise in wholesale commodity prices from an index figure of 175 to 250, or 43 percent; in the Civil War they rose from 100 to 180 or 80 percent; but during World War I the increase was from 100 to 240 or a staggering 140 percent. Fifteen billion dollars were spent to prosecute the war.[4] Item costs skyrocketed. The harness, pack, and saddle equipment purchased by the Quartermaster Corps and worth sixty million dollars at the time of purchase, ultimately cost over three hundred millions.

The Services of Supply (S.O.S.) was the general rubric for coordinating the multiple supply and procurement agencies of the American Expeditionary Forces — including the Quartermaster Corps; the Ordnance Department; the Signal Corps; the Corps of Engineers; the Air Service; the Medical Department; and the Chemical Warfare (Gas) Service.

The following list briefly enumerates the materials procured by each branch:

Items Procured by the Supply Branches[5]

Quartermaster Corps:
- Subsistence and forage
- Clothing and equipage
- Fuel, oil, paints, and chemicals
- Vehicles, harness, and saddlery
- Hardware, stones, tools, furniture, mess equipment, cordage
- Construction materials
- Motor vehicles
- Marine Equipment
- Horses and Mules
- Shoe, hat, and clothing repair machinery, laundry and printing equipment

Ordnance Department
- Machine guns, rifles, and pistols
- Artillery
- Fire Control Instruments
- Ammunition of all kinds
- Special Motor Vehicles
- Target Material
- Grenades, pyrotechnics

Signal Corps
- Wire and cables
- Radio Equipment
- Batteries

View of Engineer Supply Depot. Menil La Tour, Meurthe et Mosselle, France.

—National Archives

Telephone and telegraphic material
Photographic and meteorological equipment
Pigeons

Air Service
Airplanes, engines therefor
Balloons
Engines
Bombs
Special clothing
Special trucks
Special woods
Special metals
Airplane dope and chemicals
Lubricants
Aerial signaling apparatus
Aerial photographic apparatus
Aircraft armament

Medical Department
Drugs, chemicals, and reagents
Surgical, dental, and veterinary instruments
Laboratory supplies
X-ray apparatus and supplies
Field hospital supplies and dressings
Hospital furniture

Chemical War Service:
Chemicals
War gases and their containers
Smokes
Incendiaries
Gas defense equipment
Chemical engineering equipment

Corps of Engineers:
Surveying equipment
Lithographic equipment
Searchlights
Bridge materials
Railroad rolling stock
Railroad shops
Lumber for troops in field
Water supply equipment

In France, there was continued conflict between the different branches, each zealously guarding its own territory while trying to encroach upon the precincts of the other branches. In fourteen months, eight changes were made in the Chief of the Engineer Supply section in France.

But compared to the Quartermaster Corps and the Ordnance Department, which during the war expended $8,074,018,000 and $4,087,347,000 respectively on military supply, the Corps of Engineers involvement was relatively modest. At the height of the War, the Quartermaster Corps shipped enough food each month to feed the entire American Expeditionary Force, in units of 25,000 men, for thirty days (with ninety days reserve cover).[6] Nevertheless, $638,974,000 were spent, and over one and one half million tons of equipment shipped by the Engineers before the Armistice. The Engineers supplied the wants of their own men and furnished engineer equipment to all the other services, assisting particularly in the support of all construction undertaken in the theatre of operations. This included 4,400 miles of standard steel rails; 10,000 switches; 17,000 tons of accessory fastening; 100,000,000 square feet of sheet steel; 100,000,000 square feet of roofing; 25,000,000 feet of copper wire; 10,000,000 feet of pipe; and 115,000 miles of barbed wire. Engineer storage depots in France spread over 420 acres (20 acres covered; 400 acres uncovered).[7]

Back in the states, the Corps began to establish regional depots to feed the mighty military machine. By Armistice day, 394,000 officers and men of the Engineers were engaged in military supply, an increase from

Engineers at camouflage work, Camp Leach, American University, Washington, D.C. Before coming to the Philadelphia District, Captain Kent taught at the Engineer Training Camp here.

—National Archives

the peacetime 3,000 of 131 to 1. The Corps established major procurement branches in Birmingham, Alabama; Chicago, Illinois; New York, New York; Pittsburgh, Pennsylvania; and San Francisco, California.

On 11 June 1917, the Philadelphia District Engineer, Major J. C. Oakes, was directed by the Chief of Engineers to determine whether and where 300,000 square feet of storage space were "immediately obtainable in [the] vicinity of Philadelphia with possibility of expanding to a large depot with railroad and shipping facilities." Major Oakes publicized the matter, sending letters of inquiry to the city's major newspapers, including the *Record, Press, Inquirer, Public Ledger,* and *North American.* Replies poured in and were investigated each in turn — the offers ranged from open swamp-land along the Delaware to a proposal for refurbishing Fort Mifflin as a storage depot.[8]

On 13 August 1917, with the search for a facility in full swing, Captain James D. Kent, Engineer Reserve Officer Corps, was relieved from duty at the Engineer training camp, American University, Washington, D.C., and ordered to report to the Philadelphia District, there to assume command of the inchoate military supply program. On 4 September 1917, Captain Kent reported to District Headquarters at 815 Witherspoon Building in Philadelphia, to take charge of the search for a storage facility. He also contacted the Quartermaster Corps, to coordinate the deliveries of nuts, bolts, spikes, and slice bars that were to accompany rails the Engineers were shipping to France. The office would also disseminate public information about the Engineer Reserve, and recruit civilian employees for Engineer Regiments (over 100 were ultimately hired for the 33rd Engineers and other regiments).

In his search for a depot site, Captain Kent journeyed far afield. Learning on his arrival that *"the District officer here has carefully canvassed the situation and there is no covered storage facilities [sic] in Philadelphia immediately on [the] waterfront,"* he determined that a depot, if it could be provided,

Major J. C. Oakes.

would have to be some distance from the river, and would necessitate hauling overland by rail. Realizing that the District might soon be inundated by a flood of equipment moving through Philadelphia toward France, Kent sought to increase his mobility, and accordingly put in a $2,100 requisition for an automobile, accompanying the requisition with the reminder that it was necessary for him *"to make frequent and hurried trips daily*

The Baldwin Locomotive Works, Philadelphia. —Historical Society of Pennsylvania

to various part of the city, including points on the Delaware River front and Fort Mifflin, where there are no street car connections, and if Captain Kent is forced to walk long distances, he will be greatly handicapped and his work cannot be conducted expeditiously or efficiently."

Receipt of the following War Department letter on 20 September 1917 rendered Kent's search academic:

September 19, 1917

Captain James D. Kent, U.S. Engr. Office, Witherspoon Bldg., Philadelphia
Engineer Depot at Philadelphia

1. You are advised that the following situation exists with regard to the establishment of an Engineer Depot at Philadelphia.

2. Regular Engineer Depots have already been established at New York and Norfolk, with pier, storehouse, and open storage facilities either already existing or in process of construction, on a scale sufficient to handle the receipt, storage, and shipment of engineer material, equipment and supplies for an indefinite period in the future. Depot organizations have been formed at those two points where are now handling shipments.

3. It is not proposed to establish a regular depot at Philadelphia unless future conditions that cannot be foreseen at the present time renders this necessary. However, in connection with the very large initial purchase of locomotives, steel rail, frogs, switches, etc., it was considered advisable to use Philadelphia as a special shipping point. It is not anticipated that future orders for such railroad equipment will be of the same magnitude, and it is expected that they will be handled through the New York and Norfolk Depots, except in the case of locomotives furnished by the Baldwin Locomotive Company, which will probably be continued to be shipped through Philadelphia. Most of the steel rail and connections that are to be shipped through Philadelphia have already arrived there, and it is not expected to make further shipments of rail to that city. In case it should become necessary to do so, the Pennsylvania Railroad will be able to handle the storage of rails and connections (one copy of their letter to Mr. Felton enclosed herewith). The Reading Railroad should be able to handle locomotives and other heavy shipments.

4. Under the circumstances outlined above, it is not considered desirable at this time to acquire or construct piers, storehouses, or open storage yards, nor to build up a depot force beyond that absolutely necessary to handle shipments that are made in care of the Depot Quartermaster and render the necessary reports thereon, the present railway terminal facilities being used as at present.

5. I am forwarding your request of September 15th for authority to purchase an automobile at an estimated cost of $2,100, to the Chief of Engineers, recommending approval for the purchase of a Dodge automobile, or equal, at a cost not to exceed $1,000, for the reason that the Chief of Engineers has recently disapproved a similar request by the Depot Engineer Officer at Norfolk but has approved in lieu thereof the purchase of a Dodge car or equal at a cost not to exceed $1,000.

6. I will hold your request of 15 September for the Inspectors until I hear further from you, in view of the explanation that has been made above.

W. H. ROSE
Major, Corps of Engineers

1918 Dodge Officers car.
—National Archives

At least Kent had his car — true, it was not the $2,100 chariot he had requested, but a serviceable $1,000 Dodge. Beyond that, Kent and his Engineer Depot No. 6 were left with a minimal force and the authority to ship rail-related equipment, most of which had already arrived in Philadelphia, in a program which was rapidly diminishing at its outset. By 1 January 1918, his monthly expenses had dropped to $808.98, with $809.72 in unexpended funds remaining. Every requisition had became a battle.

The Engineer depot functioned as an independent unit, outside the authority of the Philadelphia District Engineer, and relations between the two offices, through civil, were somewhat strained. On 5 March 1918 District Engineer L. D. Shuman informed Kent that *"after this date this office cannot make payments for special drinking water for use in your office,"* unless Kent could establish that the regular tap water available to the depot was *"unwholesome or impure."* Kent replied on 15 March that *"there is no drinking water"* wholesome or unwholesome, *"supplied to the building for the use of the tenants."* Earlier that month, Shuman, a bit of a curmudgeon and quite a character in the history of the District (D.E. 1918-1920), had refused to honor a bill for a new tire for Kent's Dodge, which Kent had obtained from B. F. Goodrich on a trade-in. The incident is amusing enough in retrospect and enough of a bureaucratic paradigm in any case to warrant reproducing the Shuman memorandum in its entirety:

War Department
UNITED STATES ENGINEER OFFICER
Room 815 Witherspoon Building, 1321 Walnut Street
Philadelphia, Pennsylvania

March 1, 1918

FROM: The District Engineer, Philadelphia, Pa.
TO: The Officer in Charge, Engineer Depot No. 6, Philadelphia, Pa.
SUBJECT: Bill of the B. F. Goodrich Rubber Company

1. Referring to the inclosed bill of the B. F. Goodrich Rubber Company for an automobile tire, it is the opinion of this office that the transaction as stated on the bill appears to be irregular and not in accordance with law.

2. The bill should show, on its face, the price allowed on the old tire taken in exchange as part payment for the new tire, if such was the case.

3. The depot is accountable on the property returns of this office for the old tire and it therefore cannot be disposed of excepting through condemnation by a duly appointed inspecting officer or a board of survey. The fact that it was traded in for a new tire does not relieve the depot from the accountability.

4. There exists no authority of law permitting the exchange or trading in of public property without the prior authority of the Secretary of War and it is suggested that such authority be obtained through proper channels in order that the transaction may appear regular and in accordance with law. It is also suggested that the Goodrich people be requested to submit a bill, in duplicate, as outlined in the 2nd paragraph.

L. D. SHUMAN

1 Inclosure

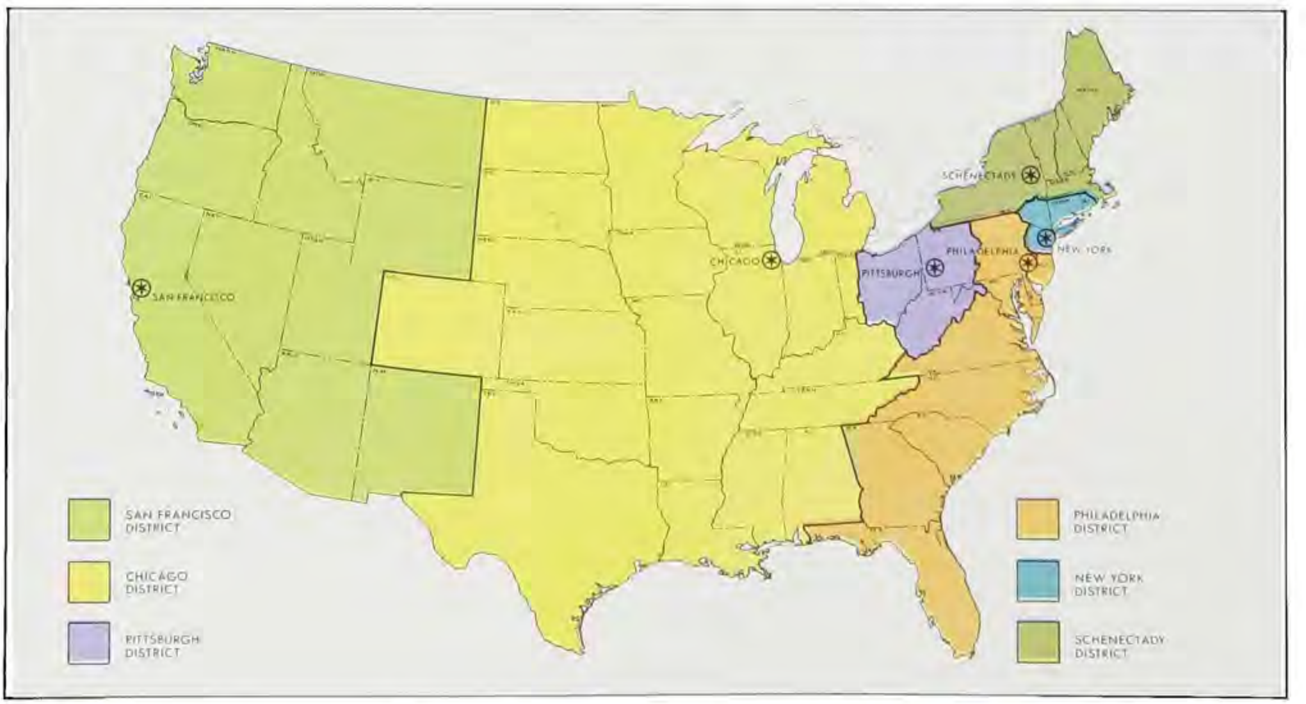
L. D. Shuman, District Engineer and Chief of Operations.

On 1 April 1918, Shuman noted that the Depot's monthly expenses were now up to $1,045.07, including *"expenses . . . certified . . by the Depot Engineer Officer,"* office expenses, public information expenses, and expenses incurred in restoring the barracks occupied by the 19th Railway Engineers to its former condition, after they were embarked. He noted that *"the Depot Engineer does not report to this office."* He was uncomfortable with his position as disbursement officer for the Depot and complained in a letter to the Chief's office that *"while my relations with the Depot Engineer are cordial, the present arrangement is very unsatisfactory and will become more so as time goes on."* O.C.E. took the hint, and after 1 May 1918, the Depot was funded independently from the District.

Armistice arrived on 11 November 1918. By 18 November, a halt was put on all contracts for motor vehicles and spare parts; military supply shifted direction and turned to expediting the cancellation of as many outstanding contracts as possible. Its purpose gone, the Military Supply Depot vanished.

In the general euphoria which followed the "War to end all wars," the military establishment languished. Total army strength fell to 190,000 men. The Engineer Corps' supply budget shrivelled from a wartime $638 million to slightly over $1-1/2 million in the first ninteen months of peace, a proportional drop of 426 to 1.[9]

Quite naturally, the War Department advised caution. The dazzling light of peace was blinding the country to the dangers of



Engineer Corps Procurement Districts, 1923 leaving itself "naked to its enemies." In 1923, industrial war plans were formulated, to protect and organize the nation's essential industries in the event of a future war.

On 4 January 1923, the Philadelphia District was notified of the impending visit on 19 January of the Assistant Secretary of War, accompanied by the Chief of Engineers, the Quartermaster General, the Assistant to the Chief of Ordnance, and their respective entourages. Out of their meetings emerged a plan to divide the United States, organization by organization, into emergency procurement districts. The Corps' plan provided for the division of the nation into *six* industrial procurement districts, headquartered in Schenectady; New York; Philadelphia; Pittsburgh; Chicago; and San Francisco, with central control located in Washington. The initial organization evolved as entirely a planning group, with no procurement function. In the event of mobilization, each District was to be responsible for the following territory:

ENGINEER CORPS PROCUREMENT DISTRICTS[10]

CHICAGO DISTRICT:

ALABAMA
ARKANSAS
COLORADO
ILLINOIS
INDIANA
IOWA
KANSAS
KENTUCKY
LOUISIANA
MICHIGAN
MINNESOTA
MISSISSIPPI
MISSOURI
NEBRASKA
NORTH DAKOTA
OHIO .... (Section west of Fulton, Henry, Putnam, Allen, Auglaize, Shelby, Miami, Montgomery, Warren, and Clermont Counties inclusive.)
OKLAHOMA
SOUTH DAKOTA
TENNESSEE
TEXAS
WISCONSIN

NEW YORK DISTRICT:

CONNECTICUT
NEW JERSEY .... (Section north of Ocean and Burlington Counties, exclusive.)
NEW YORK...... (Section south of Duchess, Ulster, and Sullivan Counties inclusive.)
RHODE ISLAND

PHILADELPHIA DISTRICT:

DELAWARE
DISTRICT OF COLUMBIA
FLORIDA
GEORGIA
MARYLAND
NORTH CAROLINA
NEW JERSEY .... (Section south of Ocean and Burlington Counties, inclusive.

PENNSYLVANIA . .(Section east of Fulton, Huntingdon, Center, Clinton, and Potter Counties exclusive.)
SOUTH CAROLINA
VIRGINIA

PITTSBURGH DISTRICT:

OHIO .... (Section east of Fulton, Henry, Putnam, Miami, Allen, Auglaize, Shelby, Montgomery, Warren, and Clermont Counties, exclusive.)
PENNSYLVANIA. . (Section west of Fulton, Huntingdon, Center, Clinton, and Potter Counties inclusive.)
WEST VIRGINIA

Colonel F. C. Boggs

SAN FRANCISCO DISTRICT:

ARIZONA
CALIFORNIA
IDAHO
MONTANA
NEW MEXICO
NEVADA
OREGON
UTAH
WASHINGTON
WYOMING

SCHENECTADY DISTRICT:

MAINE
MASSACHUSETTS
NEW HAMPSHIRE
NEW YORK...... (Section north of Duchess, Ulster, and Sullivan Counties, exclusive.)
VERMONT

The Philadelphia District was chosen as a trial balloon to test the value of the project. The Chief's Office noted this in a letter to the District Engineer: "*This plan has not been put into operation as yet. Your office has been selected to make a trial thereof and if successful the plan will be extended to other District Offices.*"

The Procurement District was organized into five branches: Reproduction equipment (purchase); Railway equipment (purchase), Electrical equipment (purchase); Bridge and miscellaneous equipment (purchase); and Inspection. Engineer Reserve Officers in the Philadelphia area were then contacted and transferred to the newly titled Branch Organization Group. Under the supervision of Colonel F. C. Boggs, the District Engineer, reserve officers were interviewed to determine their qualifications, and how they might fit in with the new organization. The Chief's Office cautioned Colonel Boggs that in conducting his interviews he remember that:

> "*In all probability this will be the first time the reserve officer has come into actual contact with post-war procurement planning. Emphasis should be laid on the importance of industrial mobilization in the next war and the vital necessity of making our pre-war plans as complete as possible. The selection and training of personnel is an important part of the plan and the enthusiastic aid and support of every reserve officer is desired. The training program is not extensive, due to lack of funds and due to the fact that these men are receiving the the greater part of their necessary training in the process of their business, but a step forward will be made if we can determine upon whom to call in an emergency. No officer will be called to active duty without his consent.*"

In this way personnel could be trained and organized to function in an emergency with a minimum of that delay caused by individuals not being acquainted with their associates. When a reserve officer was recruited, he was asked to recommend other officers of his acquaintance, who might be suitable material for the group.

The Philadelphia Procurement Office, in conjunction with the procurement officers of other service branches in the city (e.g., the Quartermaster General), compiled a list of those companies in the area whose manu-

Captain R. C. Kratz.

factures were considered vital to the national security, should an emergency arise. The Corps was to deal specifically in procuring the same engineer items with which it had been entrusted in World War I.

By 1929, the Assistant District Engineer (in charge of disbursing property and contracts for the Engineer District) was also functioning as the Procurement District Executive Officer. He was assisted by one full-time civilian employee. Together they planned the procurement of engineer items by visiting local plants and preparing emergency contingency plans in cooperation with local suppliers. They also maintained contact with the approximately 300 Engineer Reserve Officers residing in the Eastern Pennsylvania Procurement District, through engineer correspondence and extension courses. These courses, in addition to offering an avenue of advancement for individual engineer officers, provided the District with a ready reserve of trained engineer personnel should they ever be needed. In the summer, this contact was personalized for the reserves by two weeks of active service.

In 1934, records show that the District was requested to assist in the procurement of "folding boats" for army river crossings. The District contacted the Philadelphia Boat Works, and arranged for the procuring of sample light-weight river craft, including "folding boats," wood boats covered with canvas, and aluminum vessels.

A War Department directive of February 1939 ordered the Regular Army Procurement District Executive Officer to consider the functions of that office as constituting his primary mission; it further recommended that his other duties not be allowed to conflict with this primary task of training reserve officer personnel for the Procurement District.

September 1939 saw war come again to Europe. As Hitler's panzers swept through Poland, drawing the continent into the gathering maelstrom of a new World War, shock waves ran through the military establishments of half the world. In June 1940, a war game was held in the Philadelphia Office of the Corps of Engineers. Seventeen officers were on duty, assisted by five key civilian employees from the U.S. Engineer Office. War time conditions were assumed and the actual procurement of some items of Engineer requirements apportioned to this District was put into operation. Contracts and purchase orders were prepared and issued, inspection of materials made, materials shipped and vouchered for payment.[11] On 12 August 1940, a month after the war game was held, the dormant Philadelphia Engineer Procurement District was activated. The reserve officers, trained over a seventeen year period, were called to active service. Captain R. C. Kratz, a reserve officer, succeeded the District Executive Officer as Procurement Officer under the District Engineer.

The Military Supply Program was inaugurated in November 1941. Its objective was to obtain materials and equipment commonly used by Engineer troops in this country and abroad. In addition, many other items were assigned by the Secretary of War for special procurement. Typical of the items procured under the program were — large pontons for bridges; small light-weight 12 man assault boats; refrigerator and meat storage equipment; bulldozers, rollers, cranes, rock drillers, compressors, etc., used in Engineer road buildings operations; gasoline driven chain-saws for field use (these were used extensively on the Alcan Highway); all sandbags for the use of the Army, Navy, and Marine Corps, and huge quantities of camouflage netting. At first even insect powders used by the Army were procured, but this item later was transferred to the Quartermaster Corps. The Military Supply Program started off modestly enough, with the procurement in November 1941 of approximately $50,000. By the end of the following month, this figure had tripled; by October 1942 the program had grown so large that $11,000,000 were procured in that month alone. By December 1943, a rate of $7,000,000 per month had been established, which, though it fluctuated from month to month, remained relatively stable for the duration of the war. These costs included inspection and delivery expediting.

The territory of the Philadelphia Engineer Procurement District in the early days of the war comprised the eastern half of Pennsylvania, the southern half of New Jersey, all of Delaware, half of Maryland, and Virginia. Later, the boundary of the Military Supply Division was changed to conform to River and Harbor District boundaries.

During 1942, the District purchased, inspected and shipped such material and supplies as hardware, electric lighting equipment, bolts, nuts, nails, tool chests, and demolition kits, to the various Engineer Depots for stock distribution to troops both in this country

Experimental traction ditch digger weighed 20,000 lbs. and made 18-inch cut.

—U.S. Army Photograph

Combination railroad and highway bridge, including newly built Bailey Bridge.

—U.S. Army Photograph

and abroad. They also purchased tractor cranes, derricks, road building machinery, landing mats for overseas operations, and even purchased supplies for air raid wardens in the Eastern half of the country.

By the end of 1942, it was evident that the Procurement District needed too much help from regular District personnel to function efficiently. At first, District personnel were transferred to Procurement to alleviate the situation. Finally on 1 January 1943, the functions of the Philadelphia Engineer Procurement District were transferred to the Philadelphia Engineer District together with all personnel. Subsumed within the District, the procurement and supply organization was henceforth known as the Military Supply Division of the U. S. Engineer Office.

During 1943, contracts and purchase orders placed within the District amounted to over $72,000,000 and covered items from tacks to 400 KW generator sets. For the combat engineers and special battalions, over 10,000 portable gasoline driven chain-saws were shipped. These saws cut through a thirty-inch log in approximately thirty-six seconds and were used to good advantage cutting through forests in the preparation of landing fields.

One of the most important functions of the Combat Engineers was the preparation of roads and bridges for rapid troop advancement. A Unit Construction Railroad Bridge, through and deck type, was designed by the Corps of Engineers for rapid repairs to railroad lines. This bridge had a seventy foot maximum span and could be erected and launched with approximately 1400 man hours, or in about two and three-quarter days. The contract for these bridges amounted to $7,500,000.

Over 15,000 inflatable canvas reconnaissance boats, two and five man capacity, costing over $1,500,000, were shipped in 1944. These boats were also used by assault troops for crossing streams. During 1944, over $3,000,000 worth of camouflaged shrimp nets for draping over motor and armored vehicles were inspected and shipped. In order to reduce haulage of petroleum in forward areas, about 1040 miles of light weight pipe

Staff officers look over 2-man canvas boat during inspection of engineer equipment at Fort Belvoir, Va.

—U.S. Army Photograph

Territory of the Philadelphia Engineer Procurement District, 1942.

American supplies and landing craft, shattered by the surf of the North African beaches.

—U.S. Army Photograph

were produced, in addition to heavier pipe supplied at the rate of forty tons per month for the same purpose. Engineers' precision drawing instruments were also shipped in quantity, together with over 170,000 compressed gas cylinders, to all points in the United States and overseas.[12]

Approximately 8,000 tons were shipped per month and to cover these shipments, the Traffic Section issued a monthly average of 750 Government Bills of Lading. Processing and packing materials for shipment to the various theaters of operation was an important part of Supply Division's work.

When the war started, the army envisioned an invasion of Europe through established ports, as had been the practice in World War I. This, of course, meant regular docking facilities, cranes, etc., to handle material from ships' holds to wharves or quays, and regular commercial export packing seemed adequate.

General Eisenhower's North African campaign over the beaches changed all that very quickly; lightering in open seas was resorted to and in many cases, direct flotation of crates and bales was attempted. The resultant losses of material and equipment ran as high as thirty to forty percent. Personnel from the Philadelphia Packing Section were sent to attend courses at Madison, Wisconsin. They came back and trained others and the entire group studied as they worked, in an effort which eventually speeded the final victory.[13]

An extensive military and civilian inspection program was also undertaken during the war, with visiting representatives and finally, on 19 May 1943, resident inspectors supervising the production of vital military supplies, at the plants producing them (e.g., pipes, camouflage, generators). Their function was to:

> *report to this office diversion of deliveries contrary to schedules, probable non-receipt of components, and to advise the responsible procurement agencies, including the Office, Chief of Engineers, as soon as it appears that a schedule will not be met, with reasons therefor. In this way, it is felt that accurate basic information can be obtained for use in forecasting and controlling production.*

The dredges Chester Harding and William T. Rossell at Fort Mifflin. December 1943. Among the dredges militarized by the Philadelphia Engineer District, these vessels were provided with 3-inch deck guns, as well as 20 mm anti-aircraft guns.

> *Production of equipment badly needed on Engineer contracts frequently is held up because of competition of other services. This matter has been observed to be particularly bad in plants where resident representatives of the other services are maintained. It frequently happens that even after materials or critical components have been secured under an AAA secured by the Corps of Engineers, the manufacturer will permit these representatives of other services to coerce him to make delivery to them.*
>
> *It is, therefore, directed that the Division Engineers take action where required to place resident representatives in the manufacturer's plants to insure that proper deliveries of Engineer equipment are made. In general, this action will be required only in plants that produce items or components, such as engines, that are of particular importance to the Engineer Supply Program or where there are competing services.*[14]

Early in the war, procurement was centralized, with requisitions arriving from the Chief of Engineers' office directed to individual districts, which shipped the supplies to Engineer Depots throughout the United States, and sometimes directly overseas. Commodity purchasing of certain key items was retained throughout the war, with Chicago contracting for tractors and cranes; New York for searchlights; Pittsburgh for barrage balloons; and Philadelphia for sandbags and camouflage nets.[15] Otherwise, each district bought what it needed for its own purposes, following the contracts through to completion and inspection.

The Scheduling Section scheduled supply delivery rates on a monthly basis; Property Section had to clear all government purchases from depot to port of embarkation, until the depots themselves assumed that responsibility.

In conjunction with the Marine Design Division, Military Supply procured 121 tug and towboats; 449 barges for the transportation of oil and water; 68 floating cranes of various sizes (shipped to Europe as part of the lend-lease program); five floating powerplants (30,000 K.W. each); and a number of port repair ships.[16] In addition, nine hopper dredges—four new and five already operating—were fully militarized at Philadelphia: that is, guns, gun crews, armor, and ordnance were installed, and the ships sent overseas to participate in combat—all survived the war.[17]

On 31 May 1943, pursuant to Corps of Engineers General Order No. 10, dated 10 April 1943, the procurement functions of the Philadelphia Office and accounts pertaining thereto were transferred to the North Atlantic Division Office. While the District remained actively engaged in Military Supply throughout the war, its military procurement functions ceased as of that date.

When Japan capitulated on 14 August 1945, this action automatically released cancellation orders for practically all military supply contracts. In a few days, however, many of these orders were reinstated. Since an occupation force of four hundred thousand men was contemplated for the western occupation zone in Germany and six hundred thousand men for occupation in Japan, the normal or maintenance supply problem remained a vast one, comparing very favorably, with certain exceptions, to the entire supply problem of World War I. But contract termination did provide the major activity of the District Supply program through the end of 1945.[18]

In 1946, the Military Supply Division was dissolved. A skeleton force of six full-time people engaged in paper work lingered on through 1947, inspecting contracts and purchase orders; shipments; and vendors' shipping documents to a value of $2,302,507. This force engaged in no purchasing at the time. Its secondary duties consisted of expediting shipments for other districts in the Division by telephone and personal visits to suppliers' plants. Through 1948, the items inspected and expedited included fabricated steel bridges; cement; freon gas; creosoted railroad ties and timber; electrical switchboards and generator sets; hose and rubber goods; and all the electric lamps used during the Nuremburg trials before the International Military Tribunal, which were flown to the Rhine/Main Airport.

Effective 15 August 1948, a procurement office was again established in Philadelphia, *"to perform certain procurement functions pertaining to Industrial and Logistical Mobilization Planning."* Translated, this meant that the District was authorized to establish a list of suppliers interested in producing engineer utility items.[19]

The onset of the Korean Conflict in 1950 led to increased decentralization of procurement responsibilities throughout the Corps. Effective 1 October 1950 the functions of the nine engineer procurement offices, including Philadelphia, were subsumed within those District or Divisions in which they were located. By 7 December the major procurement functions of the Corps had been divided between the Central Chicago Procurement Office and the New York, Pittsburgh, Phila-

Engineer Procurement Districts, January 1951

Thousands of Technical Manuals of the TM-5 series were procured through the Philadelphia District.

delphia and St. Louis Districts, with additional Procurement Service and Purchasing Offices established in the Ohio River Division; South Atlantic Division; Southwestern Division; and the Chicago, Detroit, San Francisco, Seattle, Louisville, Memphis, Galveston, and Mobile District Offices.

Earlier that month, on 1 December 1950, the full Military Supply Division of the Philadelphia District was reactivated, briefly under D.R. Neff, and later under E.E. Krauss, Jr., who headed the Division through its deactivation in 1954 and beyond. Its mission: to buy engineer utility items (generators; electrical supplies; firetrucks; water purification units, etc.) for all four services, including the administration of all contracts. As in World War II, the several districts were given their assignments by commodity, based on logic and proximity to sources of supply: Pittsburgh bought steel; Portland, lumber; and Philadelphia, the previously mentioned utility items. The District also functioned as part of the Contracting Officer's Representative (C.O.R.) program on an area basis, inspecting contracts negotiated by other Districts with firms in the Philadelphia District area.

The District was directly responsible to the Chicago Procurement Office, and not to the North Atlantic Division; it had direct responsibility to the Office of the Chief of Engineers for guidance.

From December 1950, the Supply Division grew like "Topsy" from a nucleus of 10-15 people to more than 300 in less than a year, with an average annual budget of $150-200 million (reaching a peak in 1952, and then levelling off). Requisitions arrived at the District from the Engineer Supply Control Office (E.S.C.O.) in St. Louis; upon arrival they were logged in by Promotion Control, then sent to Purchase Readiness, which examined the specifications and developed a list of potential sources of supply; the requisition then went to the proper procurement section, where it was logged in and turned over to a buyer, who began bidding negotiations; the Industrial Utilization Branch then administered the contracts which procurement had negotiated through the offices of a Contracting Officer's representative (C.O.R.) working out of the District Office closest to the point of manufacture (including all Engineer Districts having a Military Inspection capability).

With the end of the Korean conflict (27 July 1953) and the winding down of the Military Supply mission, the Military Supply Division was deactivated (30 June 1954) and its major procurement functions were returned to the Chicago Procurement Office. At a later date, all procurement functions of the army were transferred to the Army Materiel Command (part of the U.S. Mobility Command).[20]

During the Korean conflict, in conjunction with its military supply program, the District had been heavily committed to the preparation and production of Technical Manuals and Item Plant Manuals for the Army. In 1950, the program was transferred to the Philadelphia District from the Chief Engineer's Office, at Fort Belvoir. Its primary mission was to update World War II technical manuals in a crash program. Between 1950 and 1963, when the program was transferred to the

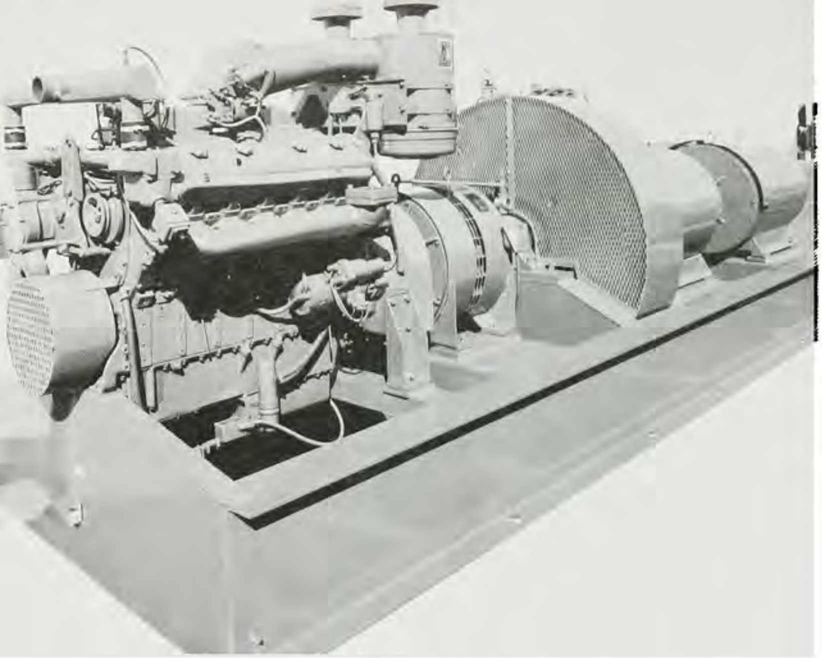
USAHOME — Modular second floor core being lowered into place, with all first floor panels in position. Proficient technical work crews could rapidly assemble the prefabricated coded units, on masonry foundations laid by other workers at locations throughout the world.

Columbus, Ohio Engineer Depot, over 5,000 manuals were produced. During the height of the program as many as 232 contracts, with a value of over $7,000,000,were being handled at the same time; the average annual value of the program was over $3,500,000. Begun under publications officer Edwin A. Peeples, the program later came under the authority of Samuel A. Chestnut (on Peeples' promotion to Assistant Chief of the Supply Division), under whom it remained until it was transferred to Columbus. The District, working with 20-25 technical writing houses, itself prepared procurement of the manuals, to insure compliance with the government style guide for TM-5 series (Corps of Engineers) manuals. The office then advertised, negotiated, and administered the contracts; completed manuscripts were sent to Fort Belvoir for review, and then printed by the Government Printing Office.

The Item Plant Manuals were developed to guide manufacturers and suppliers in the inspection of government equipment. They were written with such clarity and lucidity that government inspectors took to using them for inspections, rather than refer to the recondite legal language of the actual contracts. Complaints were raised, and the Inspector General's Office was informed, resulting in the program's cancellation. At their height, more than twenty people worked on the manual programs.

Despite the end of the Korean conflict, the Supply Division continued to buy in support of the District's activities in both civil and military construction; contract administration; inspection of engineer-procured materials; and Industrial Mobilization Planning. Hundreds of units of both Wherry and Capehart housing were procured for District construction projects at Fort Dix and other area installations. From 1957 through the mid-1960's, the District bought more than $100,000,000 worth of frequency converter generators, radome towers and other equipment for *Nike* missile sites throughout the country, on the authority of the Military Construction Directorate, OCE.

In 1963 and for five years after, the District bought $18,000,000 worth of pre-fabricated family housing for overseas locations, under the USAHOME program, designed to "*make possible the use of American-built houses at American military installations overseas to help reduce the flow of gold to foreign*

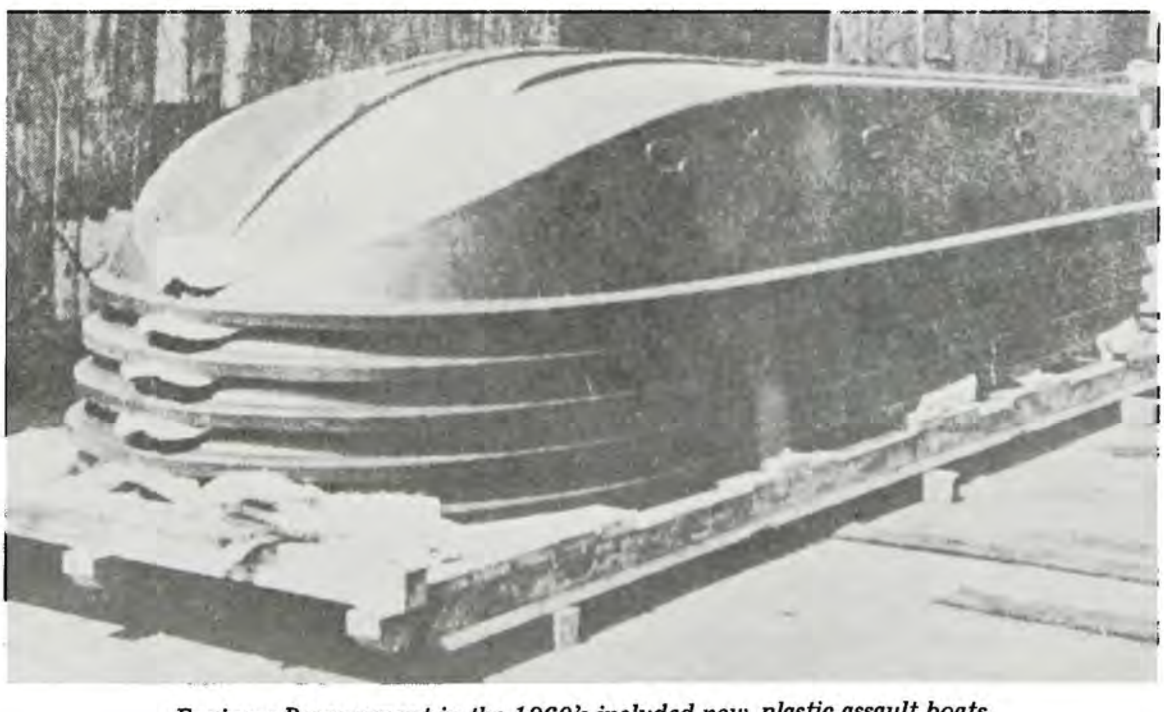


200 K. W. uninterrupted Power Generation set with control console. Eleven units were procured and installed at five Air Force Bases within the Continental U.S., as back-up equipment to provide uninterrupted power for the Air Warning System.

countries." This was a new concept in prefabrication—to produce, crate, and ship completed housing units with full bath and utility cores to overseas sites, to be erected on foundations prepared by others. The first procurement (1963) was of wood and gypsum board with wooden siding; in the second (1964) procurement, aluminum siding was used. The units were designed to be erected by a crew of 20 men in one working day, with two additional days required for final trim and finishing.[21]

One of the four designated procurement offices for engineer troop equipment, the District remained on stand-by basis through the early 1960's. As Contracting Officer's Representative for the Corps' Chicago Procurement Office, the District handled some $85,000,000 worth of contracts, including plastic assault boats, aluminum bridge components, electric generator sets, mobile electric shops, and liquid oxygen plants capable of supplying 5, 20, or 50 tons of liquid oxygen a day, in support of the Army's guided missile program.

This vast organization was administered through June 1963 by E.E. Kraus, who was succeeded in that office by Mary A. Wilson, former Chief of Procurement. Miss Wilson has



Engineer Procurement in the 1960's included new plastic assault boats.

Lay-day on board the Comber. Every Wednesday fresh produce and canned goods are taken aboard the Comber, currently engaged in dredging the Delaware Shipping Lanes.

continued to administer the Supply program throughout the time-frame of this history, with its cut-off date of 31 December 1971. An on-going program, it is presently limited to items in support of civil works, including all materials required by the District's dredges and field offices (oil, food, miscellaneous supplies), as well as those office supplies necessary to the normal operation of the District.

The Supply Division services the four dredges operated by the North Atlantic Division, providing them with mechanical equipment; contracting for shipyard repairs; and (in the case of the one District dredge, the *Comber*) procuring food and supplies for the crew. Maintenance equipment and materials are supplied to area offices at District dam sites, the C & D Canal, and the Fort Mifflin Project Office. Supply Division also awards construction contracts; handles procurement for major items in Marine Design's floating plant; and acts as central procurement office for the Corps for barges, rubber dredging sleeves, flags, pennants, and insignia. Its average annual budget for the past three years has been in the vicinity of $8,000,000. In the tradition of du Portail and his sappers, Supply will continue to provide the Corps with its proper tools.

DREDGING THE DELAWARE

The activities of the District, however far-flung and complex, return to a theme which remains their perennial concern—the Delaware River. The river embodies most of the problems which are, for Philadelphia and the District area, both prime cause and end result. Annually the river generates total income of over two billion dollars for 100,000 area job holders; its ports rate second in the nation in total water-borne commerce. Its uncounted tributaries, including several sizable rivers, drain a basin of more than 12,765 square miles. Eventually, a part of almost everything finds its way down to the river; silt, sand, fertile topsoil, mine culm and waste from industrial and municipal outfalls.[1] Some of this material is carried free of the river by currents and tides to join the migrant spoil which shapes and reshapes the bottom of Delaware Bay; a large quantity of it settles to the river bottom and impedes the channels of navigation.

The development of a ship channel from Philadelphia to the sea began with the plan for permanent improvement of 1885; for many years prior to this dredging in the Delaware River had been performed only sporadically. Permanent improvement of the river now involves much more than the clearance of annual deposits of sediment from the ship channel; construction and maintenance of anchorages, dikes, revetments and harbors are standard operations; nearly standard are the periodic requirements for deepening and widening the channel to accommodate vessels of deeper draft.

The War in Europe in 1940 underscored the need for a deeper channel to facilitate the passage of capital ships to and from the

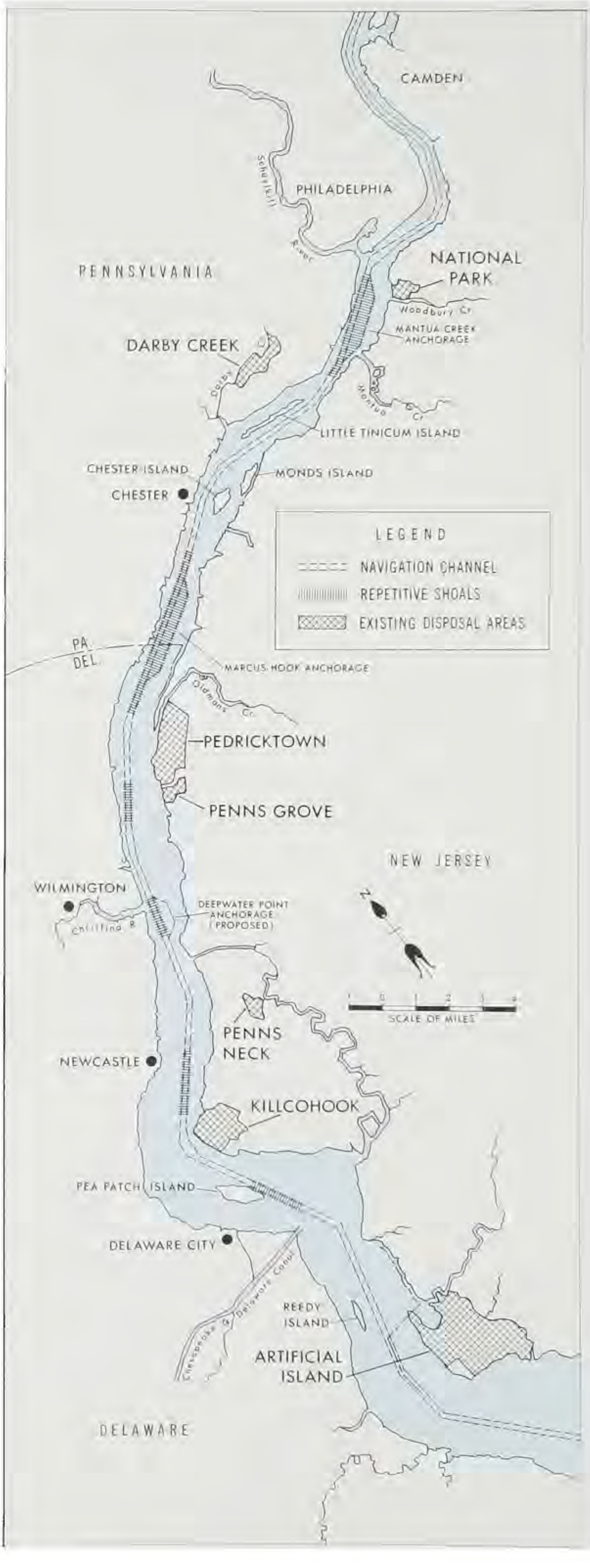


Chart adapted from the Long Range Spoil Disposal Study of 1969 showing the Delaware River between Philadelphia and Artificial Island. The bulk of the maintenance load of Delaware Channel dredging is concerned with the areas of repeated shoaling.

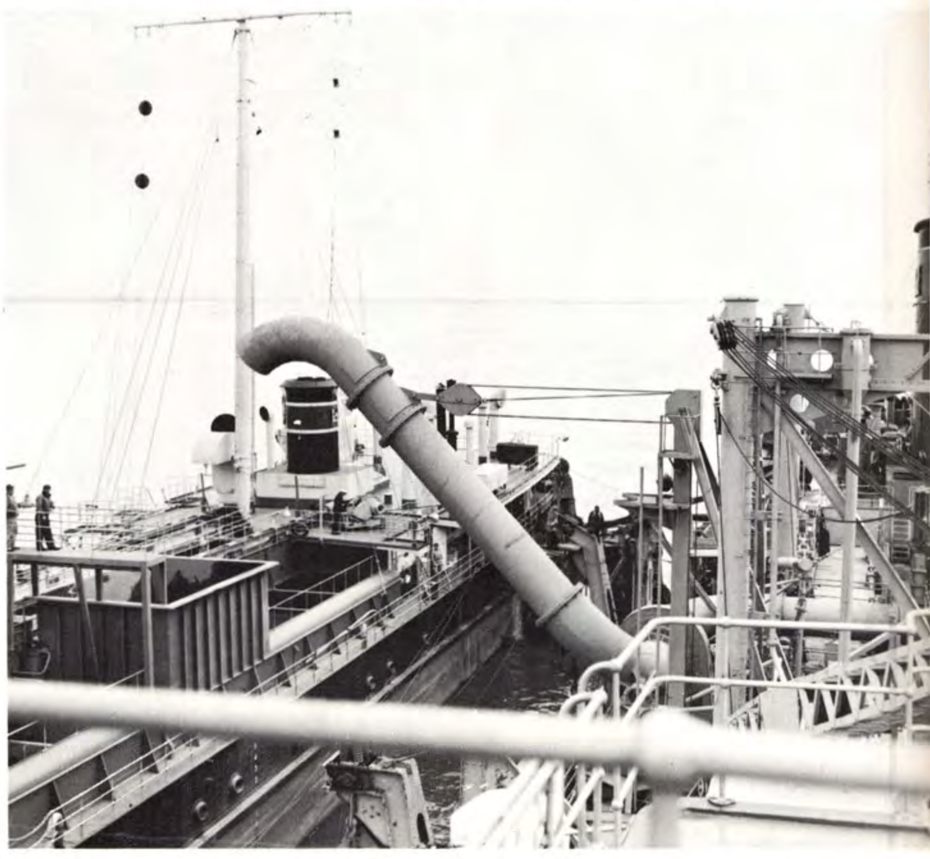
Philadelphia Navy Yard. A crash program was undertaken to deepen the existing channel to forty feet, from the Navy Yard to deep water in Delaware Bay. Dredging began 16 December 1940 and continued through 28 February 1942. The vessels assembled for the job included the U.S. hopper dredges *Atlantic, Chinook, Clatsop, Delaware, Goethals, Harding, Manhattan, Marshall, Navesink, New Orleans, Raritan* and *Rossell,* and the pipeline dredge *Gulf Port.* More than 42,048,005 cubic yards of material were removed from the river and deposited in rehandling basins or outside the channel limits at a cost of over four and a half million dollars. In addition, 2,378,852 cubic yards of material were removed by scouring by the hopper dredges *Chinook* and *Goethals,* and 499,833 cubic yards were removed by the pipeline dredge *Gulfport.*

To maintain that channel, from July 1942 to June 1943, more than 29,000,000 cubic yards of additional material were dredged from the Delaware- a volume of mud which confined within the building lines of Philadelphia's Broad Street would form a wall 100 feet wide, 122 feet high, and 12 miles in length reaching from City Line on the north to the Philadelphia Navy Yard. Beyond that, 121,000 cubic yards of rock were drilled and blasted from the river bottom.

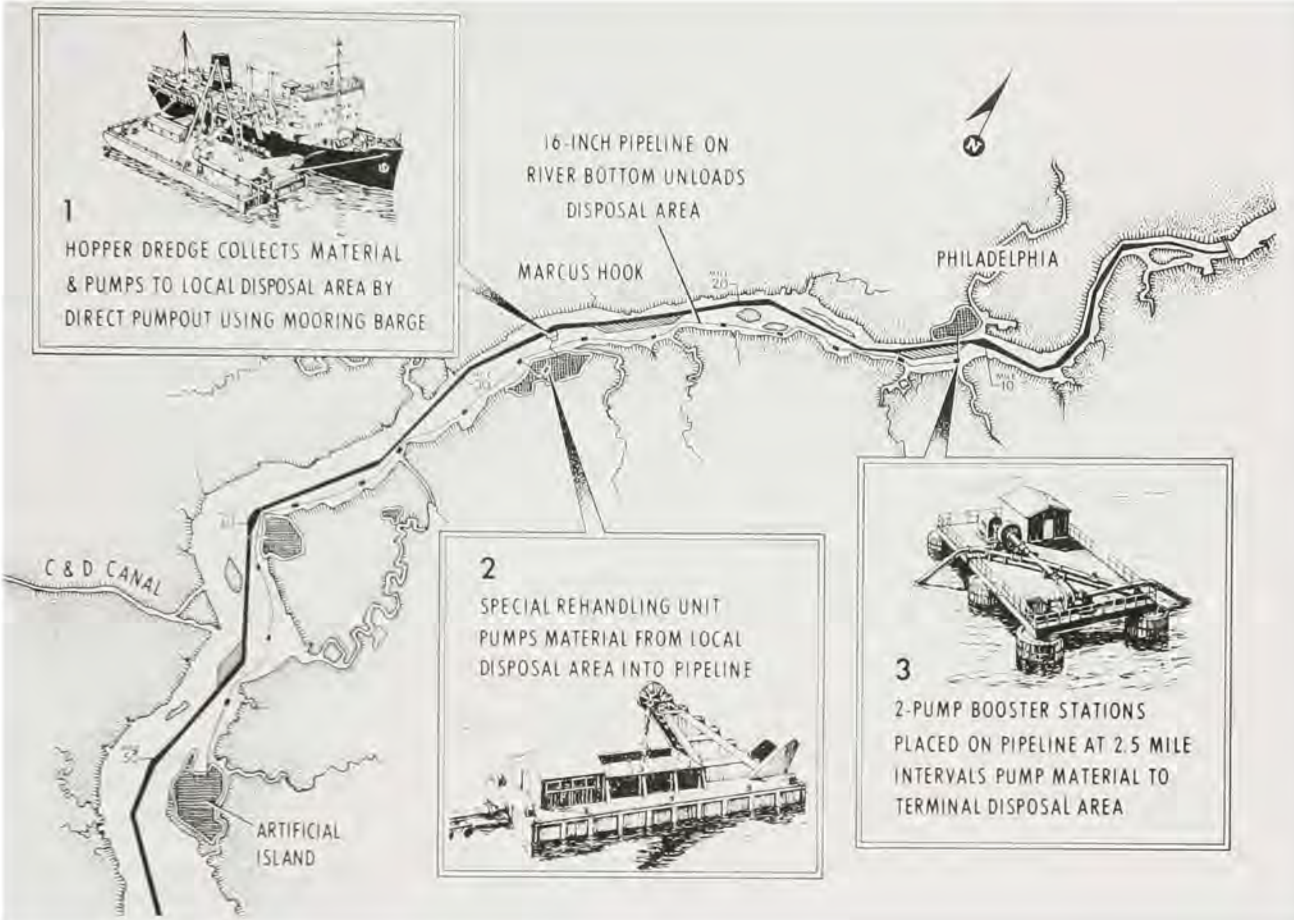
The river's behavior patterns have been graphed and charted throughout the years; logs of the tides and currents, surveys of the river bed and samples of collected sediment provide clues for defining the river's essential character. Model studies are regular planning features in all of the District's surveys for water-related projects. These are carried out at the Corps of Engineers' Waterways Experiment Station at Vicksburg, Mississippi. Today, the conformation and volume of recurrent shoals can be effectively predicted and the cost of their removal realistically estimated. The major assignment of the District's Operations Division is the physical care and management of the Delaware River and is handled by a staff of civil engineers and survey crews, working with maintenance depots and a sophisticated floating plant. The pride of the fleet are the District's three seagoing hopper dredges.

In order to keep abreast of the combined inflow of solids, it is necessary to remove about five million tons of material each year from the river. This material is drawn into the dredge hoppers, hauled to prepared locations and pumped ashore. All hopper dredges are equipped with dump valves in the bottoms of the hoppers; years ago these were used to dispose of all dredged material. Today, bottom dumping is practiced selectively, the preferred method being to place the material in dike-inclosed shore sites, exercising considerable precaution to prevent spillage into the stream. Planning the regimen of a spoil disposal area is, in itself, a demanding feat of engineering.

The state of the art is such that virtually any known material can now be removed from subaqueous sites. An array of versatile cutters, drills and dragheads, rigged to powerful engines and pumps, are there to implement the empirically well-established techniques. However, even under usual conditions, the planning and pricing of a maintenance dredging job is far from being a perfunctory exercise. While the usual condition, with all of



The Sump Rehandling System.
Converted hopper dredge New Orleans, the rehandler, (above, left) is about to receive and pump ashore the material from a dredging run of hopper dredge Comber.
Dredge Goethals' distribution pipe (right) is being lowered to the receiving bin of the rehandler.



A Dredging Scheme for Delaware River

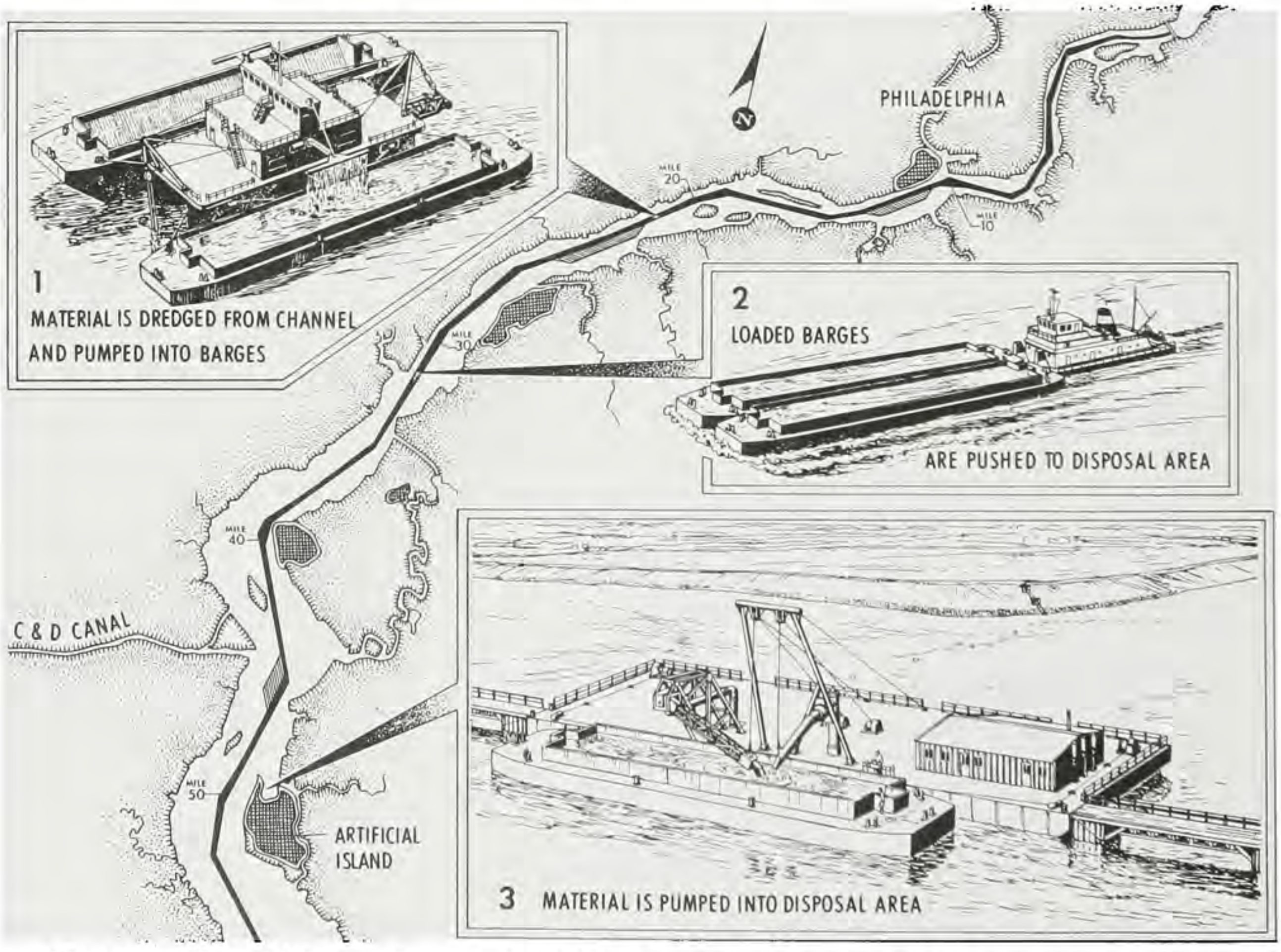
Pumping dredged spoil through pipelines 25 to 50 miles long is a feasible solution to the problem of unavailable upriver depositories. Using existing disposal areas as rehandling basins, the material is deposited in the usual manner after the hopper dredge has made a dredging run; an endless chain bucket dredge then delivers it to a 16-inch pipeline through which it is pumped to a final fill area.

Practical application of the system and its economic feasibility are contingent upon the availability of accessible, satisfactory fill sites.

its variables, is adequately resolved by the existing mechanical plant, the District's engineers maintain a forward view, seeking to anticipate the river's changing requirements.

Upland erosion will undoubtedly continue to contribute largely to the sedimentation of the Delaware River; proposed land management programs, to be activated by other agencies, may eventually reduce upstream sediment production, but doubtfully in amounts that in turn would significantly reduce the annual dredging load. Mine clum is a lesser problem than it was prior to the Schuylkill River Regeneration Project of 1945.[2] The Clean Streams Act of that year put teeth in the State's directives interdicting the discharge of industrial effluents into the Schuylkill River. There is little prospect of effectively reducing the work load of the District's dredging plant in the foreseeable future; on the contrary, an augmented program is anticipated due to constant pressures for enlargement of the navigation channel. The current project calls for a channel 40 feet deep with a width ranging from 400 feet in Philadelphia Harbor to 1,000 feet in Delaware Bay. Local maritime interests have requested that channel dimensions be increased to a depth of 50 feet and widths of 1,000 to 2,000 feet. Channel studies in progress in the District seek to determine the need for modification of channel and anchorage dimensions. District planners have met informally with representatives of the petroleum industry[3], who desire a 72-foot channel between the Atlantic Ocean and a proposed unloading terminal in Delaware Bay.

The disadvantages of an inland port have been clearly recognized in assessing Philadelphia's capacity to have commerce with an increasing number of supertankers and gigantic ore carriers. Most of the crude oil shipments arriving at Delaware River refineries originate at foreign deep water ports; 350,000-ton tankers with drafts of over 70-feet are already in operation. Similarly, the area's steel mills are nourished by ore from foreign sources. This trend to mammoth hulls necessitates serious consideration of available alternative methods to assure delivery of vital cargoes to Delaware River ports. The attributes of a deep water Terminal Facility in lower Delaware Bay[4] from which crude oil could be transshipped by barge or pipeline to up-river refineries, are receiving considerable attention in the oil industry. However Delaware River Channel depth in the 70-foot range is regarded by District engineers as unfeasible; any further modification of the channel, even to 45 or 50 feet, should be preceded by a thorough study of the subsurface materials. An access channel from the Atlantic Ocean to the proposed Deep Water Facility in Delaware Bay is deemed physically and economically practicable; natural depths in the project area range from 60 feet to well over 70 feet; material requiring removal for a 72-foot channel in the lower bay would amount to less than one-thirtieth of that required to provide a 50-foot channel to Philadelphia.



The proposed special dredge, shown in sketch No. 1 with barges alongside, is the core of this scheme for Delaware River channel maintenance.

There is, then, a large and potentially increasing requirement for annual removal and disposal of channel refuse from Delaware River. The rapidly changing river scene portends drastic revision of the traditional concepts of local channel dredging. Old disposal areas are filled or will soon be filled to capacity and the availability of new disposal areas becomes more restricted with each passing year. Riparian real estate is being absorbed in the general industrial-urban sprawl and land values are spiraling upward. Tidal marshes between Philadelphia and Trenton, once available as potential disposal areas, today are virtually nonexistent; many of the coastal marshlands below Wilmington are reserved for wildlife habitat. The situation in prospect is one of a continuing superabundance of material and a diminishing availability of disposal space.

An overall engineering study was undertaken by the District in response to a request by the Chief of Engineers to seek long-range solutions of Delaware River dredging problems. The Long Range Spoil Disposal Study, in seven parts, was prepared and issued under date of June 1969. Starting with the premise that removal of channel maintenance silt to shore locations could not proceed indefinitely, the six substudies investigated the causes of shoaling and the development of new dredging equipment and techniques; the merits of transporting spoil through extensive pipelines; river training works; anchorages and the alternatives to continued enlargement of the channel. Plate I of Appendix "G," Substudy 1 showed the relative locations of existing disposal areas and the recurring shoaling of the ship channel; the proximity of the two revealed a convenience and economy of operation not to be equaled after these disposal areas are filled to capacity.

Alternative solutions were proposed which assumed the continued availability of dumping sites farther down river, requiring longer lines of transport for the collected material. One scheme evolved a concept of pumping through a pipeline from a disposal area near the dredging run to a remote repository, using successive booster stations. The proposed system would utilize the existing plant, combined with new units of special design; shoaled material would be removed from the channel by hopper dredge and deposited in the rehandling basin by the direct pumpout method. The endless chain bucket rehandling method was selected for its simplicity and its capability of delivering the material in near-original density. Components of the projected pipeline and booster pump stations included standard industrial hardware.

A second concept focused on a proposed special Delaware River dredge, a self-propelled twin hulled craft with two centerline dragarms, one pointing fore, the other aft. Propellers at either end of the hulls would afford maximum mobility and avert the necessity of turning about at the end of each cut. Essentially a pumping plant, the stripped-down system provided no space for spoil storage; barges secured at either side would receive the material directly from distribution pipes as it was raised from the river bottom by the dredge pumps. Loaded barges were to be tugged to the distant disposal area and emptied by an unloading unit, consisting of a permanently moored barge equipped with a hydraulic hopper unloading facility.

Direct Pumpout.
Dredge Comber, moored to Mooring Barge No. 1, uses her own pumps to deliver spoil directly ashore through a floating pipeline.

This scheme appears to be the most practically innovative yet formulated for the specific needs of Delaware River maintenance, since the Direct Pumpout system of dredging was inaugurated by the District in 1963. Each new system has been a forward step toward the goal of achieving positive retention and disposal of the particles of dredged material. Prior to 1954, material was bottom-dumped into rehandling basins, then pumped into near-by disposal areas; other material was free dumped in the estuary. Particles returned to the stream by this system amounted to a loss of 77 percent of the total dredged material. The Sump Rehandling system was put into operation in December 1954; concurrently, new, stringent practices were adopted which prohibited pumping into hoppers beyond overflow, the rehandling of dredged material in open waters and free dumping. The 42-year old hopper dredge New Orleans was converted to receive the loads of the dredging unit, store the mixture and then pump it ashore. It soon became obvious that the Sump Rehandling method reduced dredging effort by one half and produced a markedly improved channel.

The Direct Pumpout system become operative in March 1963, replacing the Sump Rehandler with a method of improved efficiency and greater economy. The Rehandler unit was supplanted by a simple receiving facility—a substantially-secured mooring barge devoid of pumps and spoil storage space. Its channel-depth anchorage permitted the hopper dredge to tie up alongside and couple with the barge's distribution pipe; the dredge pumps supplied all the power needed to deliver the spoil to a shore-based disposal area through a ponton-mounted pipeline. The improvement lay in the simplification of the system, the removal of a needless step and its corollary cost; little change was effected in the system's capacity to efficiently retain and store dredged fines.

Direct Pumpout is the maintenance dredging system currently operating in the Philadelphia District. Essential to the system is the disposal of spoil in confined, controlled areas. The adoption of new systems to implement new urgently-anticipated technique awaits only the definition of the new programs; but basic to any program is the problem of disposal area availability. The long view demands the appraisal of a host of hard questions; the needs of future commerce; effects of oil import restrictions on the economy; possible dangers of salinity intrusion; problems created by the increase in vessel size and draft; influence on both the marine life and the geology of the river bed are among the most urgent.

A new ingredient, which must leaven every projected formula for development, is con-

Hopper Dredge Goethals

sideration of the possible damage to the environment. The ecological repercussions of large scale dredging operations in the Delaware River are at this time imponderable. Although in-depth specific studies are not yet available, it is possible to speculate concerning extensive channel digging. An inevitable by-product would be enormous magnification of the spoil disposal dilemma. An acceleration of the rate of shoaling could be expected, if data for the Marcus Hook Range may be used as a precedent. In that area, where one-half the total Delaware River maintenance effort is expended, the shoaling rate has increased 700 percent since the enlargement of Marcus Hook Anchorage, the silt accumulation averaging one foot per month. The implications of a channel bottom at depths in of 70-75 feet include not only the added mechanical difficulty of materials removal, but more critically, the probable deleterious effects upon ground water supply sources in Delaware and Southern New Jersey. There is plausible concern that salt intrusion would increase in range and volume, to the detriment of estuarine marine life and Philadelphia's water supply. Moreover, dredging might seriously endanger the ecological cycles of the bay's bottom life, severely damaging the oystering and fishing industries of the region.

There can be no easy answers to the complex problems confronting those who work for the continued vigor of Philadelphia Port area. District planners and others pursue their endless search for effective and equitable ways of resolving these issues, while the dredges continue working around the clock to keep the Delaware channel clear.

Hopper Dredge Comber

MARINE DESIGN—UNIQUE MISSION

The most likely progenitor of the hopper dredge, general work-horse of the Corps of Engineers, was in all probability the GENERAL MOULTRIE, built in the United States and first operated under Corps of Engineers contract between 1855 and 1857. The MOULTRIE and two subsequent acquisitions, the HENRY BURDEN and the WOODBURY, were converted steamboats fitted with pumps, suction pipes and hoppers. Though small and moderately powered, their successful performance in coastal waters proclaimed the opening of a new field for dredging. A favorably impressed Congress appropriated funds for an additional half-dozen hopper dredges before 1900, intending them primarily for channel maintenance.

Failures of private firms to fulfill urgent channel deepening contracts in New York Harbor and the subsequent dearth of bidders on new contracts produced a situation which demanded intervention by the government itself. Accordingly, in 1902 the government initiated a program of hopper dredge construction, adding 16 vessels to the dredging fleet by 1908. United States hopper dredges were then operating in the coastal waters of the Atlantic and the Pacific, in the Mississippi River Passes and in the Great Lakes.

Recognizing the need for a central design agency to develop the plant and programs of a growing dredging fleet, the Secretary of War in 1908 established a Marine Division in the Office of the Chief of Engineers in Washing-

Hopper Dredge Hyde

Hopper Dredge Hains

ton, D.C. The new agency was staffed by one ship draftsman and one clerk. The staff increased slowly, reaching strength of thirty by 1933. This design group made significant contributions to the development of dredge pumps and other specialized machinery; the first diesel-electric dredges were designed and built in 1918. The hopper dredge soon developed into a complex specialized plant requiring maintenance and occasional updating and conversion. The kind of liaison necessary for intimate contact with developing technologies and available industrial services were not to be had in Washington.

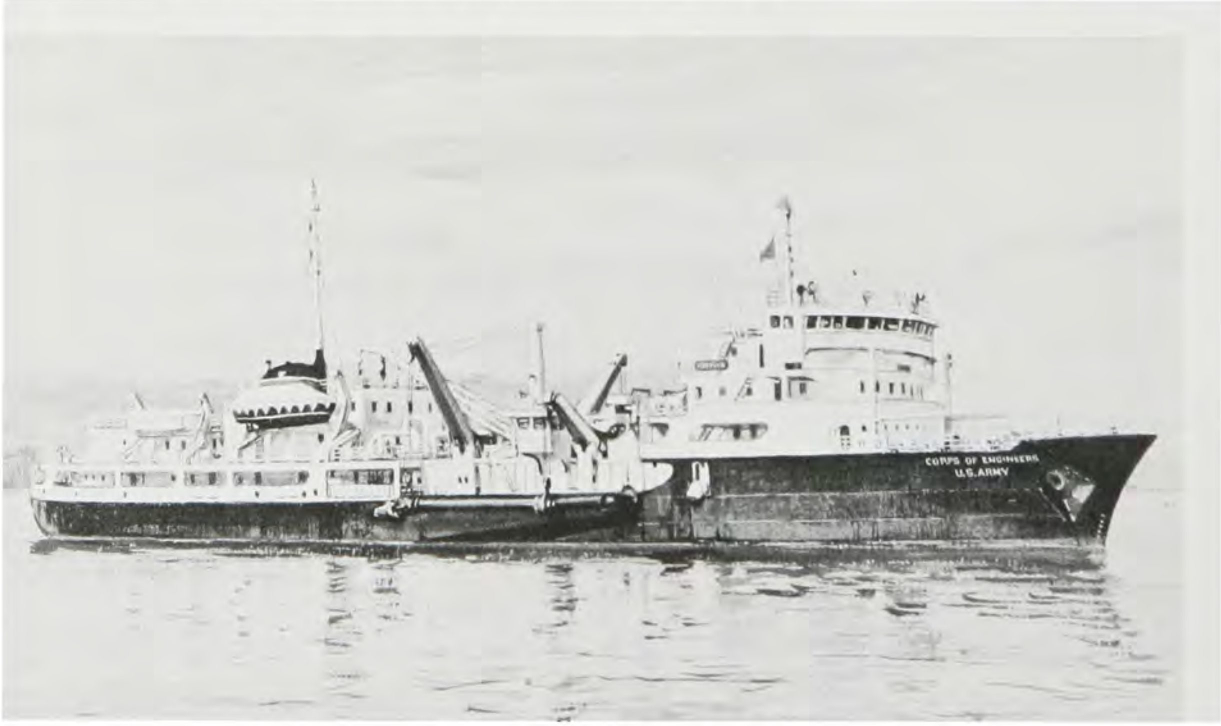
In 1938, it was deemed expedient to remove the Marine Division to an industrial center where the Corps of Engineers functioned on a District level, thus offering it ready access to industry and to the close staff work of a Contracting Officer. The assignment in 1938 of the Marine Division to the Philadelphia District[1], was concurrent with the appointment of Major H.B. Vaughan, then Marine Division Chief, to the post of Philadelphia District Engineer.

The relocated group was redesignated Marine Design Division (MDD) and has continued under that name. Hopper dredges

Hopper Dredge Davison

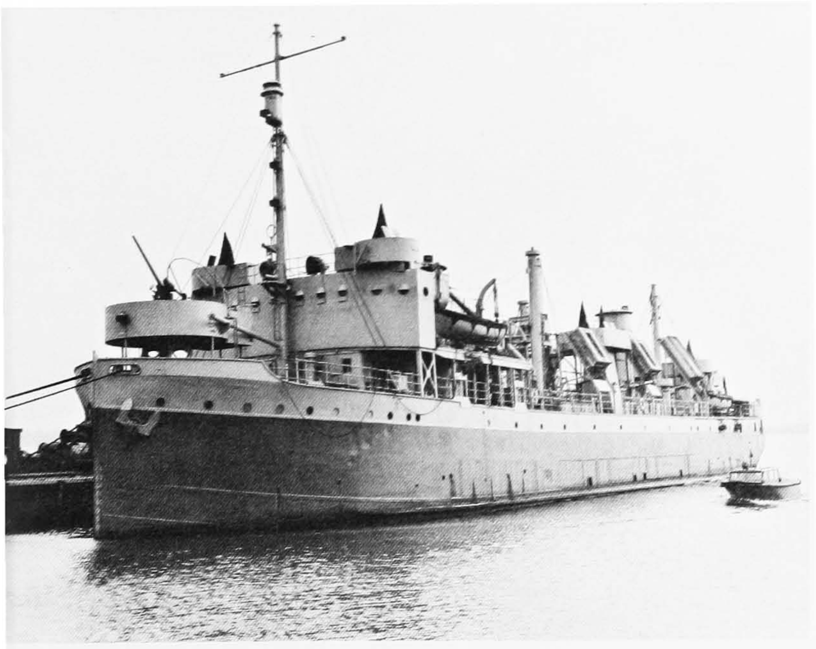
Hopper Dredge Essayons

HAINS and HOFFMAN were designed and built by 1942. Between 1945 and 1947 four dredges of the COMBER class came off the drawing boards and were activated. They were COMBER, BIDDLE, GERIG and LANGFITT. The World War II years were filled with a variety of design and construction projects: tugboats, towboats, barges of wood and steel, floating cranes, floating machine shops, port repair ships and floating power plants. New hopper dredges, too—LYMAN, BARTH, DAVISON and HYDE were turned out, fully outfitted with guns, gun crews, armor and ordnance. Five previously commissioned hopper dredges were equipped with gunnery and armament; they were: ROSSELL, MARSHALL, HARDING, HAINS and HOFFMAN.



Hopper Dredge Markham

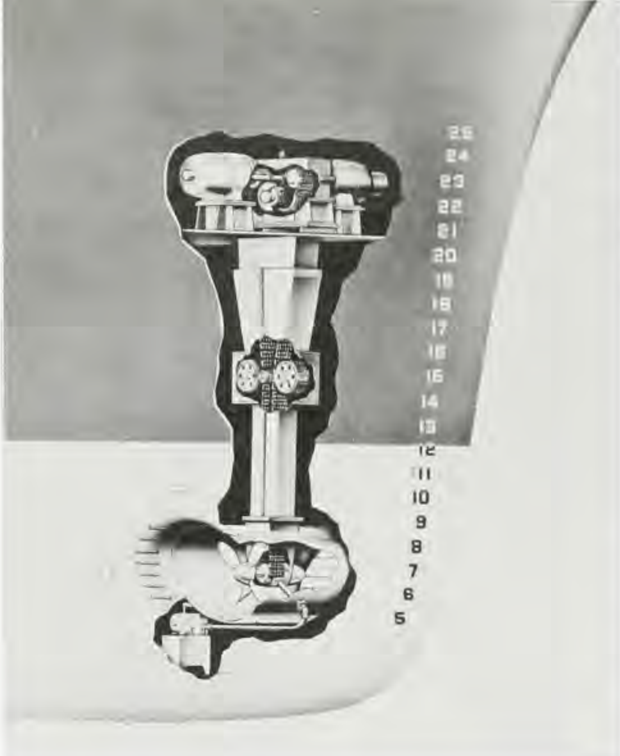
Hopper Dredge ESSAYONS was delivered in 1950. At 525 feet in length, with a hopper capacity of 8,000 cubic yards and twin dredging pumps of 1,850 horsepower each, Essayons was the largest hopper dredge then afloat. This truly ocean-worthy dredge embodied all the features of a refined special tool. Built especially for maintenance of New York Harbor channels, her large payload offset the long disposal run to deep water off Sandy Hook. Sliding trunnious were provided to remove the dragarms from the water and stow them on deck, considerably lessening the resistance otherwise imposed on propulsion of the vessel. The sliding trunnion had previously been used only on hopper dredges SAN PABLO and TAYLOR. This desirable feature enabled trimmer hulls to reduce drag, increase speed and save fuel; it also facilitated drags and dragram repairs, as well as docking and operating in congested waters. It received further refinement for its installation on MARKHAM (1960) and MCFARLAND (1967).



The port repair ship Henry Wright Hurley, equipped with armament.

Marine Design Division was active in design and construction projects for the Foreign Aid Program between 1950 and 1957. A dozen hydraulic pipeline dredges were completed and delivered—four to Vietnam and Cambodia; eight to the Phillipines. No new hopper dredges were constructed in this period but three old ones were repowered: NEW ORLEANS, built in 1912; PACIFIC, built in 1937 and HARDING, built in 1939. During this period a new dredging technique was developed for maintenance of the Delaware River channel. The Sump Rehandling Program involved the conversion of three existing hopper dredges. The old NEW ORLEANS was decommissioned and converted to a sump rehandler; GOETHALS and COMBER were modified to pump out topside through a discharge "snorkel." Carried along concurrently were research and development projects on prefabricated portable piers and breakwaters.

Dredge MARKHAM was designed especially for service on the Great Lakes and embodied some innovative features of MDD design. Delivered in 1960, MARKHAM was the first U.S.-built vessel equipped with a unique maneuvering device: the enclosed duct-type bow thruster. MARKHAM'S retractable sliding trunnions were an improvement over previous systems and its capability for direct pumpout was the first installed on a new dredge. The direct pumpout system was then in the planning stage and would be inaugurated in the Delaware River in 1963, superseding the sump rehandling system and sending into retirement NEW ORLEANS, last of the stern-dragram dredges. Implementation of the new system involved reconversion and repowering of GOETHALS and COMBER and adaption of two large mooring barges.



The enclosed duct type bow thruster was installed on Dredge Markham—first United States-built vessel to be so equipped.

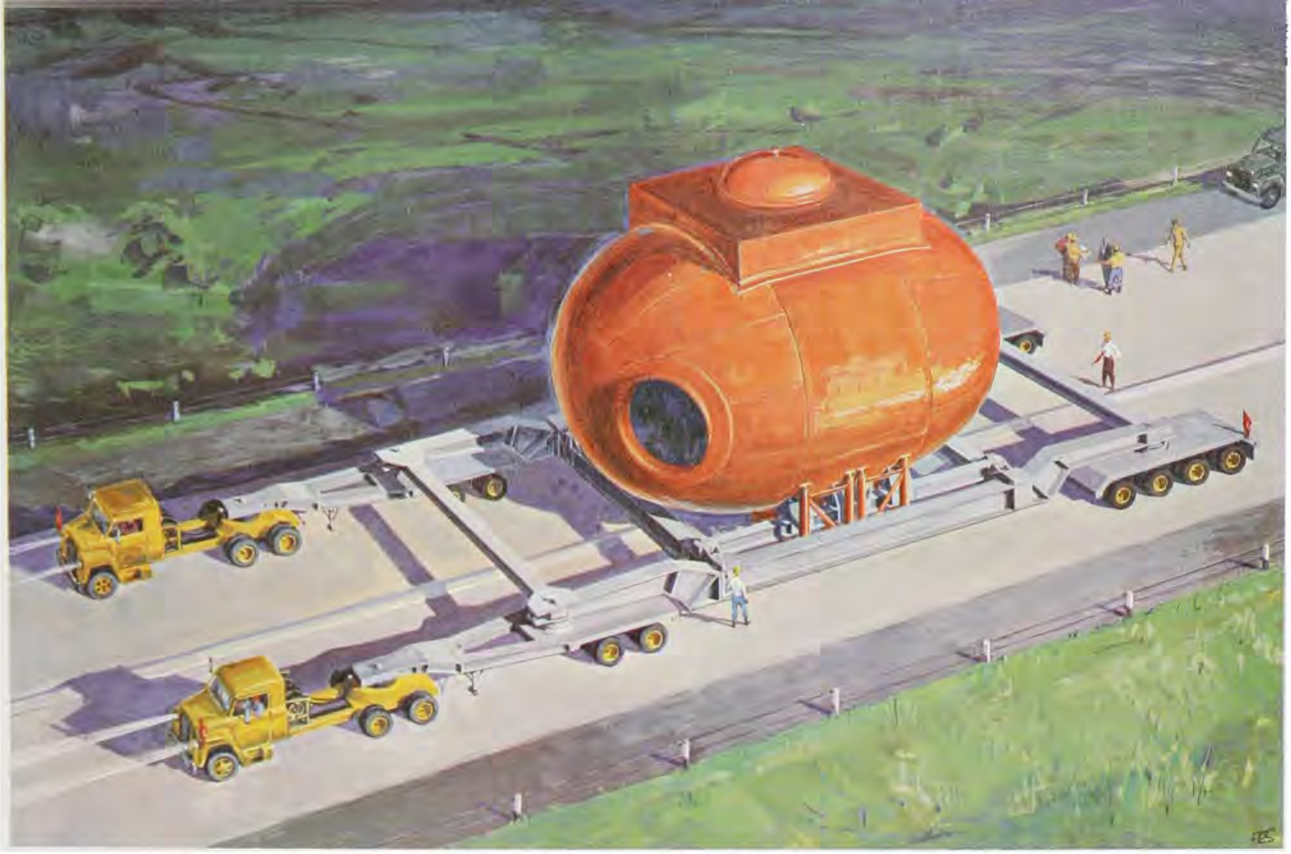
Two unique products of the 1958-67 period were STURGIS (MH-1A) and GRASSE RIVER. The former was a non-propelled floating power plant of 10,000 kilowatt capacity, powered by a pressurized water nuclear reactor. The vessel's hull was a converted Liberty Ship of World War II vintage. The huge steel containment vessel to house the reactor was fabricated in Baton Rouge, La., and transported by a special mammoth rig overland on a five-day trip to the Mississippi River, then transited by water to a shipyard in Mobile, Alabama, for installation in the hull. STURGIS has operated in the Panama Canal Zone since its deployment in July, 1968. GRASSE River is a 350-ton lock gate lifter, designed and constructed for service in the St. Lawrence Seaway.

The Dredge HAINS, built in 1942, was later equipped for discharging over jetties by sidecasting dredged material through a long distribution pipe suspended outboard. Though small, with a hopper capacity of only 700 cubic yards, HAINS has demonstrated considerable usefulness as a type. The sidecaster discharge principle, in a substantially expanded version, was combined with all the updated hopper dredging capabilities in the design of the McFARLAND, newest addition to the Corps of Engineers dredging fleet. Completed and delivered to the Galveston District in 1967, McFARLAND performs all the operations of a conventional hopper dredge, as well as sidecasting and direct pumpout for shore disposal.

The McFARLAND is the most recently constructed of a series of hopper dredges developed for maximum proficiency and versatility. The capability of the current dredging fleet, in terms of volume of material handled, is at least one and one-half times greater than that of the fleet operating in the 1940's. The trend toward reduction in fleet size is due to progressive improvement in the efficiency, performance and speed of each new dredge, necessitating fewer units to carry on the work.

Marine Design Division's annual agenda is guided by a ten-year program established by the Chief of Engineers, to acquire new and

Hopper Dredge McFarland



The containment vessel to house the Sturgis' nuclear reactor is seen in an artist's conception on its five-day transit between Baton Rouge and the Mississippi River.

The Sturgis (MH1A), first floating nuclear power plant.

rehabilitate old items of floating plant. The Hopper Dredge Board, created by the Chief of Engineers in 1944, meets periodically *"to review all plans for any hopper dredge construction and pass on matters of policy and general features of design."* The Dredge Board's function was later expanded to include "recommendation" of policies and general design features. Dredge Board members are appointed by the Chief of Engineers and consist of representatives of Divisions in which dredges are based; members are personnel who have direct responsibility for dredging operations in their respective areas.

In addition to hopper dredges, MDD, in fulfilling its design responsibilities must provide a variety of craft, from barges to snag boats and survey boats. Recently delivered to the Mobile District was the new snag boat-tow boat ROS, 170 feet long with a lifting capacity of 60 tons. Survey Boat SHUMAN was commissioned on 11 June 1970 and deployed in the Philadelphia District. This 65 foot aluminum catamaran was named to honor Leigh D. Shuman, former District Engineer and long time Chief of Operations, who gave 41 years of distinguished service to the Philadelphia District. Currently under design is the STE. GENEVIEVE, a pipeline dredge with a 26-inch, long-line disposal capability. It replaces a 40-year old dredge of the same name which operates in the St. Louis District. Work programs for Marine Design Division are generated continually through the annual submissions of Engineer Districts under the Nine Year Plant Replacement and Improvement Programs.

Survey Boat Shuman

Looming largely in MDD's future planning is a revised system of Delaware River maintenance and channel improvement. Deep channel dredging, to accommodate new, larger merchant ships will require new plants or modified existing plants; imminent repletion of nearby disposal areas demands a fresh look at the whole problem of dredged spoil disposition. Several plans have been formulated and are subject to further study (*"Dredging the Delaware,"* p.p. 183 to 184); in the development of new techniques and applicable technology, a valuable rapport is maintained with the District's Operations Division and, through consultations of mutual benefit, with representatives of the dredging industries of the United States and of foreign countries.

In pursuit of its unique mission as central marine design agency for the Corps of Engineers, MDD endeavors to stay abreast of new developments in dredging and marine technology, by participating in research programs at laboratories and universities and by discussions with members of the Dredge Board and other able dredging personnel throughout the Corps and the industry, world-wide.

Through the years the group has remained a compact force of specialists, divided between its two branches, Design and Contract Liaison. The larger Design Branch handles design, plans and specifications of vessels; the smaller group does cost estimates, contract administration and inspection. A number of complete professional careers can be tallied to Marine Design's accomplishments—substantive, consistent accomplishments over the long term. MDD's chiefs have been few and of long tenure; Major Vaughan appointed P.T. Samuel as first chief when the group began its mission in Philadelphia in 1938. W.H. Roberts succeeded to the post in 1948 and the incumbent, G.A. Johnson was made chief in 1958.

A number of marine design features have been pioneered in Philadelphia: the bow thruster and pilot house control of propulsion, both widely adopted in the marine industry. Controllable pitch propellers for dredge use were installed on the HARDING some eleven years ago and MDD was among the first in the field to install sewage treatment equipment on floating plants.

A typical unit of the huge tug fleet supplied to Defense Plant Corporation.

THE VALLEY REPORT

The role of the Corps of Engineers in the formulation and implementation of programs for flood protection evolved as a logical extension of the Corps' traditional function in the improvement of the nation's waterways. The early water-related civil works projects dealt almost exclusively with improvement of navigation; the related problems of stream flooding were given little study prior to the establishment, in 1902, of the Board of Engineers for Rivers and Harbors.

The first flood Control Act, in 1917, linked navigational responsibilities with flood control and brought the Corps officially into a new area of responsibility. In 1928, the first large-scale federal works of flood control were constructed by the Corps in the Mississippi River Valley after the disastrous flood of 1927, which brought about the Flood Control Act of 1928 and triggered the first effort by Federal government to undertake a country-wide appraisal of all water resources problems. The surveys which followed[1] were general in nature and were intended by the Corps of Engineers as guidelines for an overall program. They were used, however, as the basis for specific authorizations contained in the first general Flood Control Act in 1936.

Policy concepts for Federal flood control were spelled out in two important statements of the 1936 Act:

> *1. That flood control is a proper Federal function and that the Federal Government should improve or participate in the improvement if the benefits to whomsoever they may accrue are in excess of estimated costs.*
>
> *2. That a flood control program is justified if the lives and social security of people are otherwise adversely affected.*

These basic precepts, along with the watershed concept of water resources utilization, framed the essential formula for the considerable number of improvement projects which followed.

The make-work programs of the depression thirties included numerous projects related to conservation and control of the nation's water resources. Much experience was gained through them in construction of flood control structures and in the basics of watershed management. Expenditures of large sums of public funds during that period for protection of people and natural resources significantly affected general recognition of government's responsibility in the maintenance of the public's welfare. The widespread flooding which occurred in Pennsylvania in March 1936 again focused attention on the importance of formulating broad measures for flood control.

A four-state government agency was organized in 1936 "for the purpose of entering upon a program—to develop integrated plans to conserve and protect the waters and other resources of the Delaware River Basin". The member States: New Jersey, New York, Pennsylvania and Delaware cooperated as the Interstate Commission on the Delaware River Basin (INCODEL).

A resolution by the United States Senate Committee on Public Works, adopted April 13, 1950, requested the Board of Engineers for Rivers and Harbors to review the "308" survey for the Delaware River[2] and determine the advisability of its modification. The resolution was the first of seven authorizing an investigation which initiated a series of surveys extending over a 10-year period, the final results of which were published as House Document 522, 87th Congress, 2nd Session, and titled "*Report on the Comprehensive Survey of the Water Resources of the Delaware River Basin.*" The Philadelphia District was assigned the task of coordinating the survey studies and of preparing the report in its final form.

The project, known in the District as the "*Valley Report*," was formally launched at a public hearing held July 19, 1950 in Philadelphia and attended by 48 persons whose interests were presumably most vitally affected. The sense of the meeting, extracted from the digest of the minutes, indicates a public mood of caution and defensiveness, due partially to limited comprehension of the effects of the proposed main stem dams.

The peculiar implications of a plan affecting the vital interests of four states stimulated the organization of variously oriented control groups, some intended solely for local protection, others attempting to coordinate planning for the mutual benefit of the four-state partners. Power groups bestirred themselves to probe, oppose and/or offset real or imagined repercussions of anticipated Federal electric power generation in the Delaware Valley. Pennsylvania and New Jersey enacted legislation to permit construction of a dam on the Delaware at Wallpack Bend as a mutual state venture. On June 2, 1951, the State of Delaware acted to establish a Delaware River Basin Water Commission, contingent upon similar action by New York, New Jersey and Pennsylvania. Three weeks later, New Jersey passed a similar act, to become effective only if the commission should include all four states. New York approved an act to form such a commission in August 1952, but Pennsylvania held out until July 19, 1955.

Before the proposed interstate commission could come into being, the Delaware basin received the disastrous impact of two closely-spaced hurricane storms. Torrential rains saturated the watershed during the second week of August 1955 in the onslaught of hurricane "Connie." On August 18, hurricane "Diane" swept in, her rains increasing run-off in the valley to major flood proportions. Damage was widespread and severe; the regions affected, centering in the Pocono Mountains, were designated major disaster areas by President Eisenhower and on August 23, the Corps of Engineers was assigned the engineer function for relief: "Operation Noah." The clean-up work of succeeding weeks, supervised by a Philadelphia District engineer team, entailed emergency expenditures of six and a quarter million dollars. The cost to the region in tangible assets was estimated at $100,000,000; one hundred lives were lost.

The floods of August 1955 did, in fact, mark a major turning point in the scope and procedural emphasis of the investigations under way in the Delaware Basin.

The tentative, preliminary version of the Valley Report which had been forwarded to the Chief of Engineers on July 7, 1955, was returned to the District on August 22 for reconsideration in view of the recent floods. Reaction to the "Connie"—"Diane" disaster brought about further resolutions of the

Senate Public Works Committee, calling for specific flood protection measures and a general re-evaluation of the recommendations already proposed.

The Delaware River Basin Survey Commission came into being through agreement of the Governors of Delaware, New Jersey, Pennsylvania and New York and the Mayors of Philadelphia and New York City, and met for the first time in March 1956.

A field survey of flood damages was undertaken by a firm of consulting engineers under a District contract; its findings were forwarded to Valley Report group engineers by the end of 1955. In January 1956 four public hearings were held, to determine the views of local interests and to further assess flood damage in the highly affected areas. These meetings were attended by people crucially involved in the activities and public affairs of the watershed, whose expressed concerns embraced a wide range of water-related problems.

The fourth resolution of the Senate Public Works Committee affecting the basin investigation was adopted in February 1956. It initiated action leading to feasibility studies by the District of a main stem dam and reservoir on the Delaware River, a project which was to become the paramount feature in the comprehensive survey. (Originally designated as "above Delaware Water Gap near Wallpack Bend or Tocks Island," the site search was pursued by every available method of engineering, geologic and economic test for a dozen years. It was eventually located at Tocks Island and became the principal structure of a project which had exceeded merely

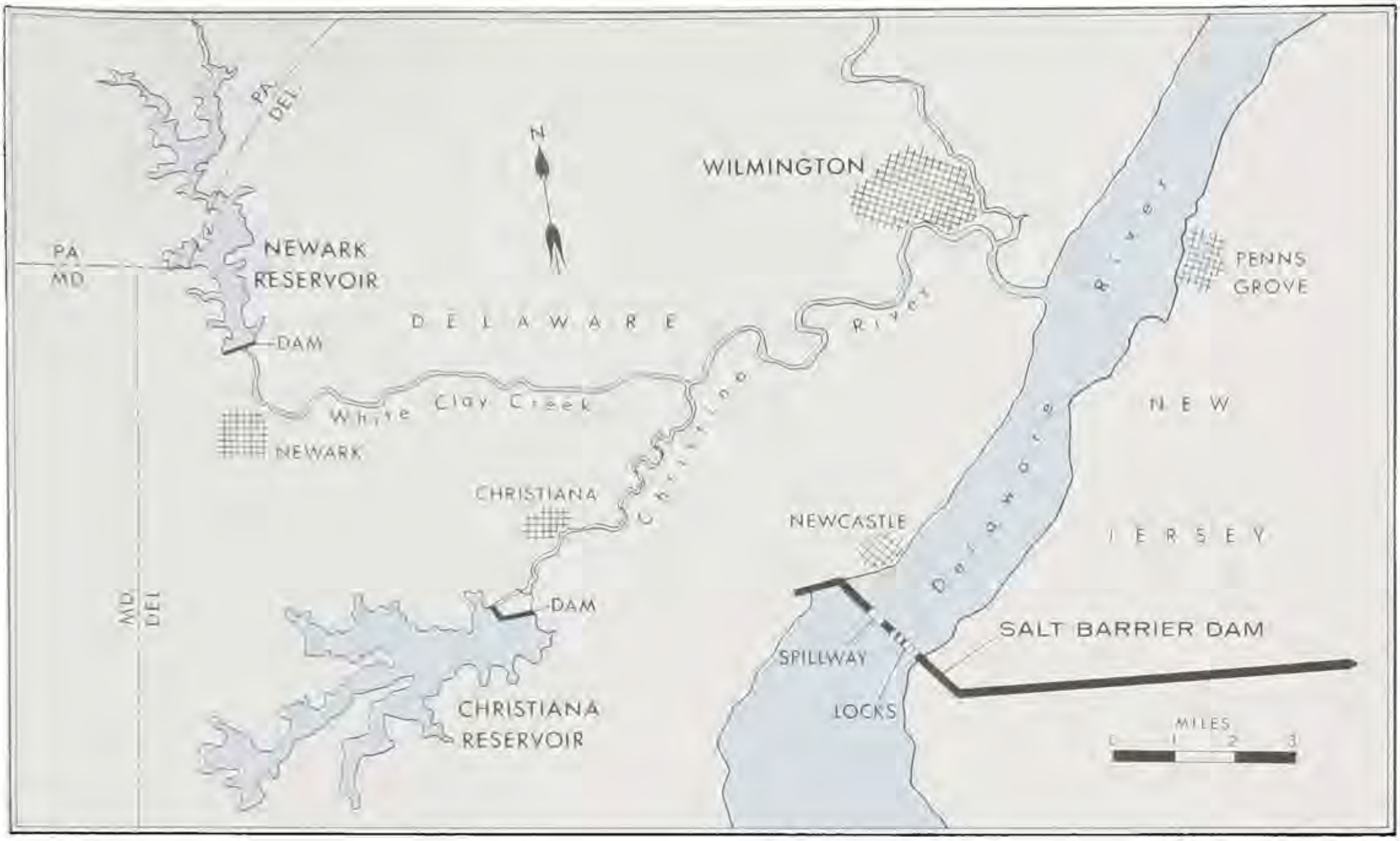
Studies to seek solutions of Delaware's water needs embraced proposals for two fresh water reservoirs and the controversial salt barrier. Proposed Newark and Christiana Reservoirs were included in the Comprehensive Basin Plan; the salt barrier investigation assumed aspects of a Pandora's Box and was curtailed after the initial surveys.

regional importance by its new designation as the *Delaware Water Gap National Recreation Area.)* The recently constituted four-state *Delaware River Basin Survey Commission* met to restate its objectives; the new emphasis was symbolized in its revised title, in which "Advisory" was substituted for "Survey."

On April 2, 1956 the District distributed copies of its Procedural Plan to all agencies cooperating in the Basin survey. The plan, though labeled "preliminary," essentially contained the elements and scope ultimately resolved and reported; it aspired to "consider the (water) demands and uses of the present (1960), those for the long-range future (at least 2060) and phased increases between these two limits." It proposed assessment in depth of the water-related problems of industry and commerce, of agriculture, navigation and recreation. Other objectives were: to probe the potential of hydroelectric power development and uses; to determine the environmental needs of fish, wildlife and the control of salt intrusion; to study the economics of pollution abatement and project the domestic water demands of a population expected to double within a half century.

Flood control was still basic to the program; a review of survey scope was required by the Chief of Engineers, and assigned to the Philadelphia District; its coverage of the Delaware River and its tributaries, to embrace "the engineering and economic aspects of flood control, water supply, low-flow regulation, hydroelectric power and allied uses of water." The Secretary of the Army stressed the role of the Corps of Engineers as being mainly that of coordinator in the development of the Comprehensive Basin Plan, since many of the requisite functions were outside the Department of the Army's sphere of authority and much of the work would be carried out by other agencies and non-federal interests. President Eisenhower sent a directive dated October 22, 1956 to the Secretary of the Army, urging extended efforts to utilize the technical resources of Federal agencies and of state and local governments in preparing the Basin Study. Subsequently, the *Delaware Basin Survey Coordinating Committee* was constituted, its members comprising representatives of the Departments of Interior, Commerce, Agriculture, Labor, and Health, Education and Welfare. Representatives were delegated by the Federal Power Commission, the Commonwealth of Pennsylvania and the States of Delaware, New Jersey and New York and for the Cities of New York and Philadelphia. The Committee was chaired by the District Engineer, Philadelphia District Corps of Engineers, for the Department of the Army.

Authorizations, guidelines and organizational structures were fairly established by the end of 1956 and, in 1957, the productive final study and review period began. The District, as author agency, set up the lines of communication and promoted the numerous inter-agency conferences, reviewed and edited reports submitted by the cooperating study groups and negotiated the resolution of differences where divergent interpretations occurred. The District Engineer, or his authorized deputy, conducted the ten official meetings of the *Delaware Basin Coordinating Committee*, assisted by a capable Valley Report Group staff. The first meeting, held on April 2 - 3, 1957 at Atlantic City, New



Jersey, was opened by Chairman Colonel Allen F. Clark, Jr., who suggested the Quaker way of conducting meetings[3] as a substitute for conventional parliamentary procedure. The profusion of agenda which filled and overflowed the next three years of activity concerned a range and scope of situations not previously undertaken by the Federal Government for a regional water resources survey.

The Senate Committee on Public Works adopted a resolution in April 1958 calling for feasibility studies for a salt barrier in the Delaware River Estuary. The primary purpose of the structure was to provide fresh water supplies for Delaware and in particular for the Wilmington metropolitan area, where the potential for the accelerated growth of population and industry were considered to be the greatest in the Delaware Basin. The District's Valley Report Group prepared a preliminary report which indicated the complexity and far-flung consequences of such a project. The proposed structure, to span the river at a location 3,500 feet downstream from New Castle, Delaware, consisted of levees, earth embankments, locks, spillways and a sump and drain system.

Effective storage of 250 billion gallons of fresh water, available at the shoreline, was an amiable prospect to the water-poor State of Delaware. However, the inevitable effects of such a barrier on ship movements, icing, and the entrapment of sanitary outfalls could only begin to be estimated. Ground water supplies in Delaware and New Jersey would probably have been augmented by retention of the large pool; elimination of dense saline intrusions would have been welcomed by upstream municipal water commissions. But Navy spokesmen were quick to object that lockage would nullify the strategic effectiveness of naval vessels in the estuary and biologists feared that any inhibition of the tidal regimen would be seriously detrimental to the estuarine ecology.

The preliminary report concluded that it would be physically feasible to construct, operate and maintain a barrier across the Delaware estuary and that the barrier would effectively impound fresh water and prevent salt intrusion. The first cost of the project was estimated at $345,000,000; an alternative scheme to satisfy the area's water needs at half the cost involved diversion of water from the Susquehanna River through a pressure tunnel. Two of the major control projects in the proposed Watershed Plan of Improvement, Newark Reservoir on White Clay Creek and Christiana Reservoir on the Christina River, were cited as alternative sources of fresh water supply. The apparent high cost was not the most prohibitive aspect of the barrier project; every step of the investigation had served to reveal the intricate ramifications raised by the project. An exhaustive survey was deemed essential before any recommendatons could be made; such a study would have required at least two years of preparation at a cost of over two million dollars. With the target date for completing the comprehensive basin survey less than a year away, postponement of the basin survey seemed inadvisable, and it was decided to include the tentative survey in the final report without recommendations.

Appendix "P" of the comprehensive survey report contained an analysis of "gross and net water needs" in the Delaware River Basin. A statement in the syllabus of Appendix "P" declared that "the growth of water use in this basin is expected to accelerate rapidly during the next fifty years. Commensurate with projected increases in population, industrial and agricultural activity, and standards of living, the gross water needs of this basin are expected to exceed four times the present needs, reaching a daily basin-wide requirement of thirteen billion gallons by the year 2010." Therein lay the crux of the whole water problem—the provision of water supply adequate for future needs.

In Appendix "Q—Formation of the Plan of Development," the Valley Report Group presented an integrated assembly of concepts and solutions for comprehensive long-range development of the water resources within the Delaware Basin. The overall scheme, evolved without any strict or formalized precedent, analyzed the multiple uses of three classes of control structures, specifically sited throughout the watershed. Eleven major dams were proposed, each to embody the multiple functions of water supply, flood protection and recreation. Tocks Island Dam, one of the eleven, would also supply hydroelectric power. These projects were to be fully operative prior to the year 2010. A second group of eight projects planned for construction before 2010 was to be used solely for recreation, and expanded for other purposes as needed after 2010. In addition, 39 small dam projects, selected from the 386 potential sites evaluated, were included in the Plan of Development.

As fiscal 1960 drew to a close, the Valley Report received its final editorial touches. Prompton Dam, one of the Report's major control projects was within a month of becoming operational. Bear Creek Dam[4], designed to impound 35 billion gallons of water, was approaching completion and would be dedicated on June 10, 1961. An important flood control structure had been built a few miles from Prompton Dam and dedicated on August 19, 1959 as Dyberry Dam, (later renamed General Edgar Jadwin Dam). The Comprehensive Basin Plan had begun to take substantial form even before the Report was collated, not only through the design and construction of water control stuctures, but also through a myriad of other projects set in motion by the Survey's collaborative efforts. Tangible benefits had to derive from a document shaped by the coordinated, intensive research of a great many committed concerned persons, over a ten-year period. The coordination of the desires, dreams and purposes of so many area spokesmen and government agencies ranked as one of the more notable performances of the District, and satisfied a wish expressed by the President in a letter to the Secretary of the Army: "*. . . I have in mind more than the customary circularization of completed reports as now required by law and by executive orders. I desire that your Department, through the officers responsible for the direction of the survey, establish arrangements and procedures which will assure a full and continuing exchange of views and information among the parties concerned.*[5]" That was essentially the way it was done.

The ultimate measure of the report's merit lay not solely in the magnitude of the solutions, projections and statistics which issued forth, but equally in the degree to which a primary goal had been achieved: the formulation of a living document. While statistics would change, writing variations on the solutions, they would not impair the vitality of the Report itself.

BIG STORMS—BIG FLOODS

Records of storms date back to very ancient times. Until relatively recently, descriptions of storms dealt principally with the terror and havoc they wrought, infrequently with causative meteorological phenomena. Old accounts told of men, trees and livestock felled, fields awash, buildings demolished and bridges swept away. This assessment of property loss is still the common criterion for computing storm values. Having acquired more sophisticated concepts and instruments, we have renounced much of the awe which our ancestors held for the elemental forces of wind, rain and flood. Gages, tracking devices and instant communications systems have given us an edge on the old-timers, but when the winds have abated and the water receded, we go back as they did, tote up our losses and build again in the same place.

Many of us live and work in flood plains in which the flood frequency may range between two and 1,000 years. We return home, and home for many is located in long-established areas, settled centuries ago by agrarian forebears who staked their claims on fertile lands near navigable streams. The periodic devastation of floods becomes an accepted, calculated risk; like parking in a restricted zone, one takes the risk and if caught, one pays the fine. Simple logic suggests the impossibility of forestalling every danger; though we were to establish our habitations on the summits of a thousand Ararats, yet would there be that chance that a millenial flood, sweeping all before it, would come to mock our vain preparations.

It is unlikely that recent storms were more frequent or of greater magnitude than those of the past. Damages to property and loss of life due to storms have greatly increased because of the greater numbers of people and vulnerable properties occupying the flood plains. While warning systems have been effective in removing populations from the path of onslaughts of wind and rain, precautionary advice concerning the perils of flood plain habitation goes generally unheeded. Inhabitants of river towns keep records of the extreme stages of recurrent inundations marked on their surviving walls and accept the unalterable periodicity of storms and floods; losses in the money column are a fraction of the total damage; the floods bring temporary discomfort—of nuisance value—but relocation is rarely contemplated. In areas without histories of flood frequency, the survivors of an occasional washout return to the old site, humanly confident that lightning, snakes and floods do not strike twice in the same place.

Students of river basin regimen know that floods do recur and may occur almost anywhere with an appropriate combination of conditions. Effective measures to alleviate flood damage have been taken and more are planned by continuing programs of the Federal Government. Familiar to all are the great public works, the dikes, dams and reservoirs which constitute the protective features of the flood control projects; less familiar but equally important is the preventive Flood Plain Management Program. This program seeks to resolve the flood risk problems of vulnerable zones right down to the home-site level; obviously, the amount of local cooperation required for success makes it preponderantly a citizen participation effort.

Waters of the Lehigh River in the streets of Bethlehem, Pa. Flood of May, 1942.

The Flood Plain Information Studies Program was conceived originally as a technical guide for States and municipalities in regulating the uses of flood plains by: identifying specific susceptible areas, establishing general criteria for regulation; and providing engineering advice upon request to responsible State and governmental agencies, subject to approval by the Chief of Engineers. Authority for the studies was contained in the Rivers and Harbors Act of 1960 under Section 206 of Public Law 86-645. Numerous agencies in the District area, duly organized as local Planning Commissions, have availed themselves of the program. Brochures are prepared by the District's Flood Plain Management group and printed copies made available to local requesting agencies. The specific area under study is presented in maps, photographs, formulae, flood profiles and cross sections, together with a brief history of the area and of local floods. A condensed version of the study is supplied in leaflet format. The studies provide estimates of the flood potential of area streams, defined by type and frequency of flood, and offer technical assistance in interpreting the data contained in the reports.

The term "Flood Control" has often been misinterpreted, it being assumed by many that Corps of Engineers Programs so designated assure complete control, with permanent protection under all conditions. "Flood protection" more accurately characterizes the design of the control systems now in operation or planning. The existence, in 1942, of the eleven major dams projected for the Delaware Basin would have prevented much of the damage inflicted by one great storm. For three weeks in May 1942, heavy rains overcharged the basin's watercourses to flood stage: on the Schuylkill River at Reading, the third highest since 1757; on the Lehigh River, the second highest in 156 years of record; and on the Lackawaxen River, the highest of any recollection. Property losses amounted to $15,000,000, 33 persons died and 35 bridges and ten small dams were destroyed. Four of the eleven dams of the Comprehensive Basin Plan are now operational: Walter Dam on Lehigh River, Prompton Dam on Lackawaxen River, Jadwin Dam on Dyberry Creek (a tributary of the Lackawaxen), and Beltzville Dam on Pohopoco Creek (a Lehigh River tributary).

The memorable floods of January 1841 on the Delaware, Lehigh and Schuylkill Rivers brought ice, rain and snow surging destructively down the valleys; in October 1869, after a summer drought, torrential rains overtopped the banks of the Delaware and Schuylkill Rivers and "swept houses and barns and even men down the furious element." The canals suffered heavily; their ditches, paralleling or penetrating the streams, were highly vulnerable, their ashlar locks and earthen banks no match for the swirling flood. With a characteristically casual

Two-lane Bailey Bridge constructed on piers of destroyed Yardley span.

Stoicism, the canallers returned and patched up their works, continuing their struggle to wrestle profits from adversary elements. Casual, too, was the succession of events which culminated in the nation's worst dam break disaster. On 31 May 1889 the South Fork Dam discharged its contents down Little Conemaugh Valley, sweeping everything before a 40-foot wall of water to Johnstown, Pennsylvania, 15 miles below. South Fork Dam was a 70-foot high earth-fill structure, built in 1852 to impound water for the Pennsylvania Canal. Upon abandonment of the canal in 1857, the obsolete reservoir was allowed to deteriorate. It was purchased by private interests in 1879 and modified for use as an exclusive sportsman's resort. Modifications included closure of the discharge pipes; construction of a roadway across the embankment, reducing the freeboard by two feet; and

Delaware River at Yardley Bridge, flood of August 1955 (Operation Noah) installation of fish guards and trestle supports in the spillway. The obstructed spillway lacked an adequate discharge capacity; two days of concentrated rainfall in May 1889 gorged the upland feeders; the dam was overtopped and collapsed. Lower Johnstown was virtually obliterated and more than 2,100 persons died.

Intelligent application of flood plain zoning can be an extremely effective way to preventing costly damage in the aftermath of heavy rains and stream overflow. Seashore areas require special preventive measures to counter their unique storm problems. The difficulty of applying such measures emanates particularly from the areas' unusual economies; sand beaches and contiguous shore-front real estate are the major commercial resources; the construction of protective dunes or seawalls could forfeit the economic benefits of a unique natural asset. Extreme precipitation with stream overflow is not a typical flood problem at the District's ocean front areas; the severest, most damaging storm of record on the New Jersey and Delaware coasts was accompanied by an insignificant amount of precipitation.

The "Five-High" storm which pounded the Atlantic Coast from the sixth to the eighth of March 1962 was classified by the U. S. Weather Bureau as an "extratropical cyclone, unusual in composition and behavior." The

Major breach at Harvey Cedars. "Five-High" storm.

Inundated West Wildwood in foreground, looking northeast. "Five-High" storm.

already high tides, augmented by high winds, slammed giant waves and breakers into shorefront facilities from New England to Florida. This storm, with five successive record-high tides, wrought destruction to 65 million dollars worth of beaches and shore facilities and damaged homes, automobiles and utilities for an additional loss of 169 million dollars. More than 70,500 dwellings were damaged or destroyed; 28 lives were lost. The States hit hardest were declared to be "disaster areas" by the President: New Jersey, Delaware, Maryland and Virginia, on March ninth; New York and North Carolina, on the sixteenth.

The impact of "Five-High" was as unexpected as it was unusual: continuous successive low pressure systems, spread over the whole North Atlantic with no well-defined center, made it difficult to plot the storm's path of development. However, early portents seemed to signal potential disaster and emergency groups began relief mobilization before the storm was one day old. A Presidential Disaster Declaration set in motion the official relief and rehabilitation agencies of the Federal Government and "Operation Five-High" went into full swing. The Office of Emergency Planning established regional disaster headquarters at New York City; Trenton, New Jersey; Dover, Delaware; Pikesville, Maryland; and, Richmond, Virginia.

84th Street and Beach, Stone Harbor, N.J. "Five-High" storm.

The Corps of Engineers was assigned the responsibility for organizing, planning and carrying out emergency restoration of coastal damage. The District's Disaster Control Center, with responsibility for the New Jersey coast south of Manasquan Inlet and the entire shore line of the State of Delaware, deployed its units to cover the stricken region. Field parties made damage estimates and recorded relevant data. A master plan for rehabilitating the affected areas evolved through close liaison between District, Division and Regional Group disaster control centers. Contractors were on the job at daybreak of March tenth closing breaches in the barrier island at Harvey Cedars, New Jersey. Heavy equipment was at work on the fifteenth closing critical gaps in barrier beaches above Indian River Inlet, Delaware.

Dragline moving sand at Harvey Cedars. "Five-High" storm.

But little could be done until the storm had subsided; the unrelenting three-day assault allowed no time to recoup between tides, so that each tide compounded the damage of its predecessor. Up and down the Atlantic coast, 11,800,000 cubic yards of sand were hauled or pumped into 85 miles of emergency dunes and beaches; 8,600 feet of bulkhead were constructed and 35 miles of sand fence erected. To this must be added the considerable operations of removing ruined houses and cleaning up debris. By August 1962, most of the emergency work by the Corps of Engineers was complete. Costs of rehabilitation operations were met by Office of Emergency Planning funds authorized under Public Law 875, 81st Congress, except for the cirtical first contracts funded out of appropriations authorized for the maintenance of navigation channels.

A "Great Storm" can be many things: that storm which eventuates in a downstream urban cataclysm may have delivered only providential irrigation to upland acreage. The accumulated fury of a storm is essentially measurable, its generative forces discernible, its path and peak predictable. Rainfall, runoff and stream flow are constantly being gaged to fill in that myriad of detail which defines the land's behavior patterns. The analysis of acquired data gives a base for formulating plausible protective measures and for anticipating the probability of flood recurrence. Conditions of minimal flood risk are achievable through intelligent application of existing guidelines; locally-regulated flood plain zoning should be as essential to community planning as fire prevention and pollution control.

It is ultimately as unrealistic to expect absolute flood protection as it is foolhardy to scorn those protective measures which may be utilized. Safety factors are built into the control structures erected by the Corps in the District and throughout the world. United States Geological Survey records reveal with sobering consistency the recurrence of large storms and floods across the country since 1543; the cyclic cataclysms of our most ancient legends were often imaged as diluvian downpourings followed by universal inundation. Most certainly floods will come; some probably will exceed the greatest now on record. To design control systems for the greatest of all possible floods would entail contemplating a total revision of the American life style and a financial outlay of unimaginable proportions.

From January to December, 1892 was a flood year throughout the United States. Ohio, particularly Dayton, remembers 1913, for days and nights of terror when fire and flood led to the loss of 467 lives. Mississippi River floods made headlines in the spring of 1927 and focused the attention of the federal government on national flood problems. In 1936, storms and floods were widespread in the land; Pennsylvania was especially stricken and the Congress of the United States passed the first general Flood Control Act. The Delaware Valley became a disaster area again in 1955, following the one-two punch of tropical hurricanes "Diane" and "Connie;" Federal, state and private agencies collabo-

Destroyer-escort Munson beached at Holgate, N.J. "Five-High" storm.

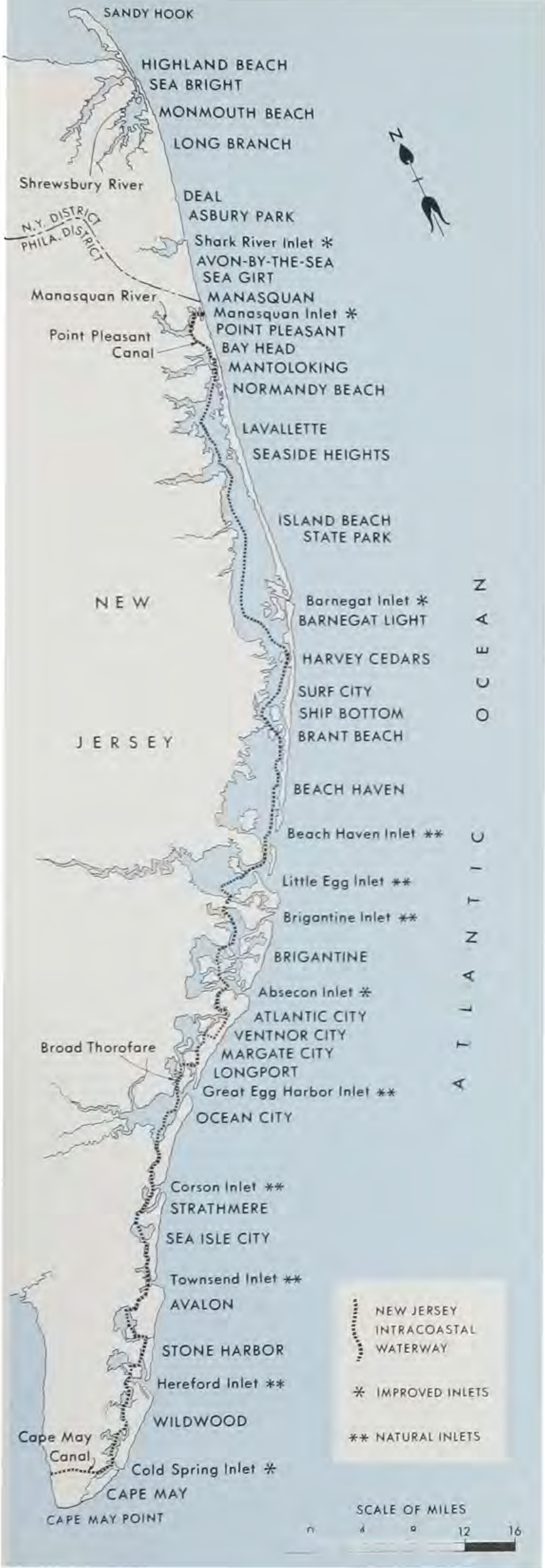
rated with the District's Valley Report Group in a comprehensive water resources survey on a basin-wide scope.

The first main stem control project for the District is in the advanced planning stage. When completed, Tocks Island Dam and Reservoir on the Delaware will function as an important element of the basin's flood protection system. Its essential mandate is husbandry of the indispensable life ingredient: water for human consumption. The voracious demands of population and industry constantly threaten to overtake the limited supply. Every move creates a measure of ecological imbalance; to General F. P. Koisch[1]:

> "*. . . we're concerned, but people don't know enough about it to give good advice. You have to stand still and study life cycles, and we don't have time. We have to develop before 1980 as much water resource development as has taken place in the whole history of the nation.*"

Man's mode of living runs counter to nature's economy. The life apparatus with which he has surrounded himself and upon which he has become dependent exacts a constant drain on the earth's resources and returns little. We must recognize the need to halt and reverse what is wasteful in the accepted regimen. Water resource management increases in importance with the escalating demands of proliferating industry and an exploding population. With little prospect for reversing consumption, it is doubly urgent that efforts to increase the water supply be pursued, employing the best available expertise in engineering and biology.

Flood of August 1955. Confluence of Lehigh and Delaware Rivers at Easton, Pa. and Phillipsburg, N.J.



PRESERVING A COASTLINE

On the map, the seacoast of New Jersey is depicted as a finely-fretted contour, loosely girdled by a delicate, fragmented pattern of islands and barrier beaches. It appears and is fragile and vulnerable. Constantly exposed to wave action, gale winds and tidal currents, its precious sands migrate perpetually. Its one unique asset — the miles of glistening white sand beach — is also its most erratic and unstable feature. This shifting material constitutes the basic natural element in the predominantly recreation-oriented economy of the New Jersey seashore; together with surf and sun it draws an annual average of seven summer residents for each local inhabitant, beyond the countless transients who "week-end" at the shore.

The tenuous barrier islands exhibit a precarious semblance of permanence. Now densely covered by real estate development, they were, within the memory of living residents, a nearly-continuous chain of large, grassy dunes. Many inlets were etched into the barriers by wave action across their narrow width—at least 21 above Barnegat; now there are two inlets in that reach and only 12 in the entire New Jersey coast. The regimen of the inlets is inseparably linked with the beaches. Inlets tend to migrate; to disappear and reappear; hopefully, they may be trained to the role of beach feeders as well as navigation channels. A new inlet may be cut through the neck of Sandy Hook near the mouth of the Shrewsbury River; another, to bisect Island Beach, has been proposed.

The new plans call for modification of the old inlets by providing sand bypassing systems at the updrift jetties. Extensive changes are planned for Barnegat, the oft-reworked

Barnegat Light.

"problem" inlet, where vast shoaling occurs and sand accretion exceeds that of all other New Jersey inlets. The first jetties were built there between 1938 and 1940; a House Document of 1892 reported unfavorably on a proposal to create a harbor of refuge at Barnegat Inlet. Protection for Barnegat Light through the years has required countless projects funded by the State and Federal governments for construction of bulkheads, groins and revetments. The light, designed by Captain George Meade, was installed in 1858 by the Lighthouse Board.

The District Engineer has recommended the installation of jetties at Hereford Inlet and the maintenance of a navigation channel between the ocean and the Intracoastal Waterway. Dredged channels and channel markers are proposed for the wide-open reaches of Beach Haven and Little Egg Inlets, where navigable depths are hard to find in heavy seas. Any decision about jetties there, awaits the results of studies in progress in 1971 at the Waterways Experiment Station. Absecon Inlet, near one of the country's most popular resort areas, requires maintenance dredging to facilitate navigation; the volume of material removed from that channel by Corps hopper dredge averages 240,000 cubic yards annually.

Cold Spring Inlet is guarded by two stone jetties constructed between 1908 and 1911. The channel gives access from the ocean to Cape May Harbor and to Delaware Bay via the Cape May Canal. Connection is made in Cape May Harbor with the New Jersey Intracoastal Waterway at its original southernmost terminus. The east jetty diverts the down-drifting sands and influences the wave scour of Cape May Point. Around the point on the western shore, up to the Cape May Canal entrance, accretion rates have increased since 1948.

Manasquan Inlet, 96 nautical miles up the Intracoastal Waterway from Cape May Harbor, is the oldest of the improved New Jersey inlets. At this point the coastline has receded more than 300 feet since 1879, when an inlet project was approved and $12,000 appropriated for construction of timber crib jetties. (See "Inland Waterway," p. 91) Here, the net direction of littoral drift is northward, the south jetty is on the updrift side and is flanked with sand almost to its outer tip. The situation, here, is essentially the same as with all the jetties: while effectively aiding navigation, these projecting structures entrap the shifting sand and create problems of beach and channel maintenance.

Beach loss by littoral sand transport and shore damage from storms always occurred, but efforts to control it are of relatively recent origin and are tied to the pressures of an increasing population in the Northeast Corridor and its expanding recreational needs. Control of beach erosion was attempted at Ocean City in 1907 and at other South Jersey resorts between 1915 and 1929 by the efforts of municipal, State and Federal agencies and by private interests. In 1922 the State of New Jersey began an extensive program of assistance to shore communities

Manasquan Inlet

and issued a Report on the Erosion and Protection of New Jersey Beaches, prepared by its Board of Commerce and Navigation. Other studies, examinations and reports followed: in 1933, by the Beach Erosion Board; in 1949, by the State Beach Erosion Commission of New Jersey; from 1945 to 1965, four reports on flood and beach erosion control and improvements of navigation, by the Corps of Engineers. The Philadelphia District prepared a detailed interim report covering New Jersey Coastal Inlets and Beaches - Great Egg Harbor Inlet to Stone Harbor, which was published as House Document No. 91-160 on 17 September 1969. These studies were the product of extensive inter-agency collaboration.

It wasn't all language; money was spent on measures to correct, protect and prevent, and on surveys leading to a better understanding of the idiosyncrasies of littoral drift. However, not all of the new techniques were universally beneficial. Groin construction undertaken by some communities damaged the beaches of their down-drift neighbors; some ill-placed storm bulkheads accelerated erosion. Development of shore-front property increased as its availability dwindled, with consequent encroachment of the storm wave zone and loss of the dunes as natural storm barriers. The installation of revetted stone seawalls for storm protection was a desperate measure, but fully one-third of the beachfront communities along the 126 mile shoreline constructed seawalls or solid bulkheads behind their beaches. The problem differed from one locality to another. Varied patterns of sand migration were revealed in studies by the Coastal Engineering research Center. In the "nodal zone," Point Pleasant to Seaside Heights, depletion of the shoreline was seen to be less than for the reach above to Sandy Hook. The southwestward drift below Barnegat Inlet deposited the transported material at the lower extremities of the barrier beaches. There, the inlets became shoaled inside the mouth or at the downdrift side of the entrance.

The use of groins to train shorelines has been practiced for many years. The technique has its confirmed advocates and opponents. As applied on the New Jersey beaches, groining has yielded mixed results. Best results appear to have been obtained where sufficient breadth of local cooperation has permitted comprehensive, rather than piecemeal, solutions and, of course, where the littoral transport brings an adequate supply of sand. Eventually, groin fields designed as components of the whole coastal regimen may vindicate the method by retaining a major portion of the trapped sand. This is highly desirable, in view of the increasing scarcity and high cost of suitable material obtainable by man's efforts. Meanwhile, the installation of groins continues, the instances of their effectiveness are observable in many places.

Beyond beach stabilization, local communities sought to protect homes and other property from storm damage and to provide navigational aids for the vast numbers of

Timber groins at Rehoboth Beach, Delaware. Damage to shore-front properties was caused by the "Five-High" storm of March, 1962.

pleasure boats and fishing craft plying local waters. Jetty designs tried to incorporate the needs of navigation, erosion control and recreation. Inlet channels, protected by two jetties, were to be self-maintaining; updrift jetties would function as depository basins for down-shifting sands, which could be moved by dredge to denuded, downshore beaches. The bulkheads contiguous to inlet jetties were supplemented with parking areas and other features to facilitate sport fishing.

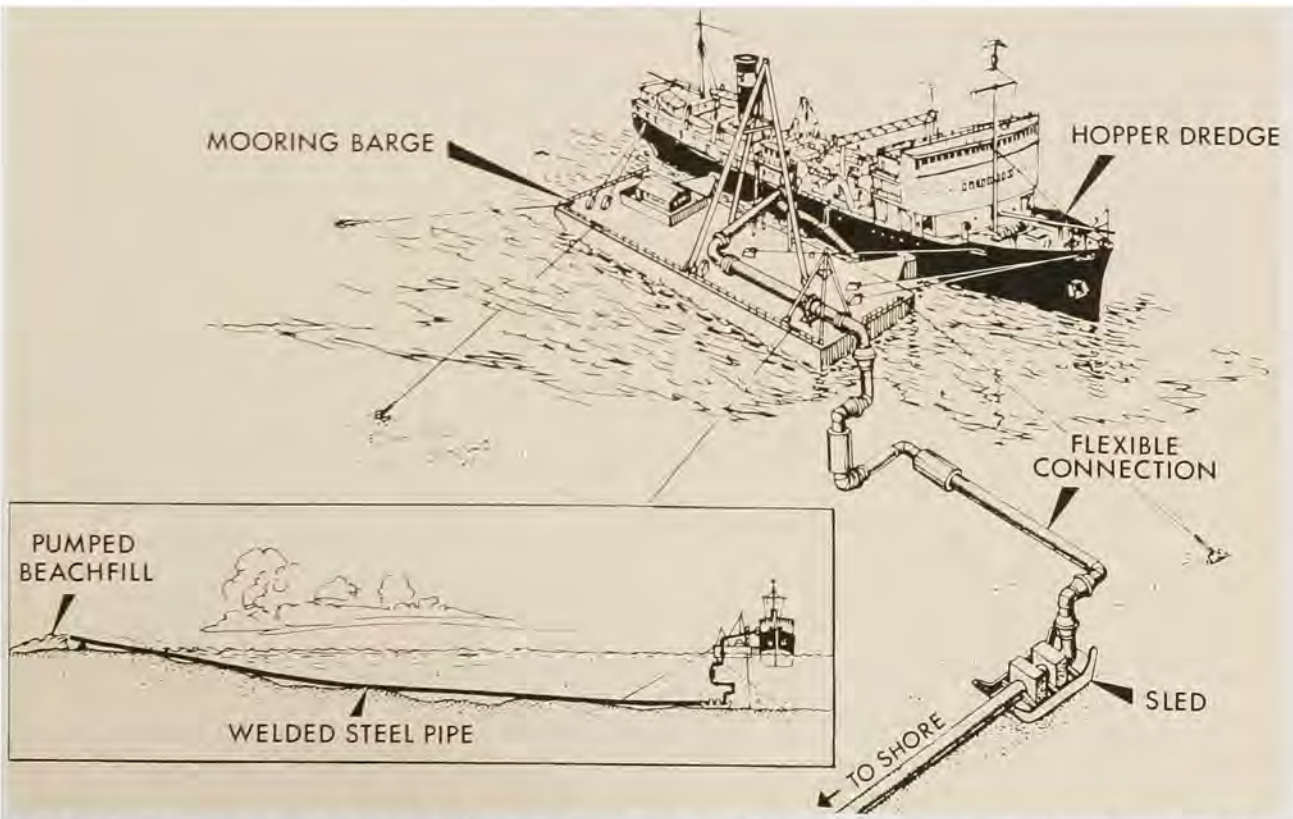
The practice of replenishing depleted beaches by hauling in sand from borrow areas is not an old one, but is undeniably effective and is gaining currency. Transport methods to economically replace the dump truck and provide a greater volume of suitable quality sandfill are under study in the District. The capability to transport sand hydraulically through pipelines, employing powerful dredge pumps is well proven. The combination being sought will include accessible borrow areas, acceptable material and a pumping system that is flexible and economical. Bottom material taken from the lagoons and thorofares inside the barrier islands proved convenient and satisfactory while it lasted. As of 1971, usable beachfill was becoming scarce; much of the potential borrow material contained refuse or pollutants, or could not be removed without risking destruction of marine life spawning grounds. Large deposits of fine white sand have been located offshore in ocean depths of 30 to 50 feet; some of this sand found its way to a Jersey beach in the Spring of 1966 by way of a unique experiment conducted by the District's Operations Division at Sea Girt.

Beach nourishment was in the minds of District planners when they devised the direct pumpout system for Delaware River channel maintenance dredging in 1963 ("Dredging the Delaware," p.184). The basic tools of the system were employed in the Sea Girt experi-

Beach nourishment at Sea Girt.

ment - seagoing hopper dredge, mooring barge, pipeline and tug - with significant modifications. The pipeline and its deployment through ocean waves to surf-beaten strand presented problems essentially different from those of a delivery system used in relatively placid estuarine waters. Instead of the floating pipeline of the river system, a 2,000 foot-long welded steel pipeline, 28 inches in diameter was laid on the ocean floor, extending off- shore to a 40-foot depth, there to link up with the mooring barge by means of a flexible connection assembly. Initially, it was intended to tow the pipeline by flotation and sink it into position. That plan was scuttled after the first attempt was frustrated by skittish weather, and the rig was towed out along the bottom.

The mooring barge (MB-2) was readied for sea duty by the addition of wave-measuring instrumentation and heavy timber bulkheading around the deck house. Ten anchors, weighing between 2,500 and 8,000 pounds held MB-2 in her mooring, and Corps Tug San Luis II stood by in case the barge should encounter difficulty with heavy seas. Hopper Dredge Goethals made her dredge runs over a heavy deposit of white sand just south of Asbury Park (about 15 miles, round trip) dragging up a 5,500 cubic yard load on each



The Sea Girt experiment employed the basic tools of the Direct Pumpout Dredging technique. Essentially different was the design of a discharge pipeline to withstand the stresses of ocean current and wave action. Instead of the floating discharge line used in more tranquil waters, a continuous welded steel pipe, flexibly adjoined to the mooring barge, was installed on the ocean floor.

The flexible connection, folded and ready to be towed into the Atlantic, "looked like the work of a drunken plumber," according to an observer; it was fabricated especially for the experiment. Other elements of the operation, except the 2,000-foot discharge pipe, were regular units of the Corps' floating plant.

trip. After 24 loads, a 1,000-foot length of beach was elevated five feet and the waterline was pushed nearly 200 feet seaward.

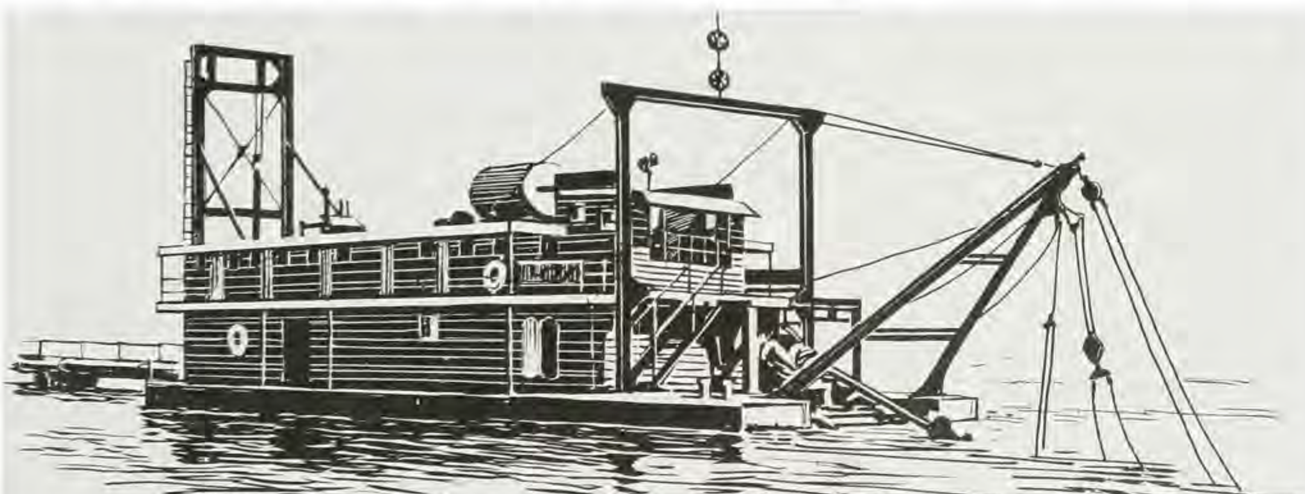
The experiment proved the feasibility of delivering a large volume of select material by pumping through a hydraulic discharge system. It did not prove that beach nourishment was inexpensive. The plant performed without significant difficulty in seas with wave heights of four to five feet. Higher waves twisted the flexible connection beyond tolerable limits and made berthing of the dredge extremely precarious. The operation was a preliminary step in a maintenance program which, realistically appraised, must be regarded as continuing and permanent. Since the sand beach is a basic factor in the resort seashore economy, its preservation appears to be an elementary fact of life.

To date, a generally effective technique for beach stabilization has not been evolved. Establishment of dumped off-shore feeder beaches, ostensible depots for the natural transport system of the littoral drift, has been ineffective. It is apparent that where beach sand is needed, there it must be placed by man's efforts. One scheme, under study in 1971, is to dump selected material in established offshore spoil areas, where submerged pumping installations would pick up and deliver sand to the beaches through flexible discharge lines. Essentially automated, such a scheme if feasible could make beach nourishment economically tolerable.

District studies, continuing through 1971 and carried out in coordination with other Federal agencies and with agencies of the State of New Jersey sought formulation of "a comprehensive plan to meet the long-term needs of the Atlantic Coast of New Jersey." The studies were divided into four sections, each covering a physiographic segment of the Atlantic coastline. The groupings predicate integral relationships between beaches and inlets. Priorities for recommended improvement projects will be designated to accord with State of New Jersey criteria. Programs which the District Engineer will recommend are designed to benefit navigation, curtail beach erosion, nourish beaches, restore and stabilize dunes and provide some measure of storm protection. To these ends construction of new structures will be recommended and many existing structures will be rehabilitated.

The preservation of a shoreline for coastal New Jersey will benefit the economic life of the entire community. It is therefore incumbent upon the community to carry out a consistent and major role in determining and funding the appropriate solutions. What seems particularly important is the kind of collabortion which makes possible a broad, integrated plan. Pre-authorization costs (surveys; studies; reports) are borne by the Federal Government; costs for authorized projects are shared between local interests (municipalities, counties, states) and the United States. Federal participation is apportioned up to 70 percent. Much well-intended effort has been expended to preserve the coastline, from early privately-funded works to public works programs such as those enacted by the Works Progress Administration (WPA, 1935), the Accelerated Public Works program (APW, 1963) and many others undertaken by the State of New Jersey and the Corps of Engineers.

Faced by the distinctly local problem of a shifting shoreline, we must first gain more knowledge of sand migration patterns—how much material is transported and what it is like; how much material is eroded away, why it is eroded and what becomes of it. In search for the place of origin of littoral drift, careful investigation of the composition of beaches and comparison of beach particles with those of contiguous streams, bays and near-shore bottoms was made. No external feeder source could be authenticated—the only significant natural source of littoral material appears to be the beach itself.



THE DAMS AND RECREATION

The adjunction of parks, campsites and other recreational facilities to essentially utilitarian dam and reservoir projects does not indicate a deviation from the basic Corps mission but rather an extension of it. It would be far simpler for engineers to concentrate on the functional aspects of their impounding systems than to complicate their plans with provisions for public use water-related recreation. Considerable versatility is required of a system proposing to satisfy the objectives of a multiple-purpose reservoir.[1] Impounding and releasing schedules for water supply and flood protection are variable because of seasonal (and adventitious) factors which regulate them. The fluctuation of pool levels is inevitable and possesses a special significance for a reservoir which is also recreation lake.

Multiple-purpose reservoir projects are not new; the increased emphasis on recreative use of public land is a product of growing concern for the steady absorption of natural open spaces by urban and industrial expansion and a resultant sense of urgency to preserve accessible green space. Adding such lands to those reserved for reservoir operation has peculiar merit: the regions are ideal both for natural preserve and recreational development; water-related recreational facilities are clearly available; and vast tracts of land may be acquired for public use, feasible only under a Federally-funded program.

Recreation features in the plans for all Reservoir projects comprising the Comprehensive Basin Plan of the Delaware River Watershed. Jadwin Dam is an exception; operational since 1959, it is intended solely for flood control and does not impound a pool. Prompton Dam on Lackawaxen River above Honesdale was completed in July 1960; it was authorized under Public Law 858-80-2 of 1948 as a flood control structure. The Flood Control Act of 1962 authorized modifications which gave Prompton impoundment capability, with control tower and gates, an impervious lining in the upstream valley and a new spillway width of 250 feet, increased from its original 50-feet width. In its renewed version, Prompton became a recreation site with facilities for boating, swimming, fishing and picnicking; a change house, comfort station and 750-car parking lot were added near the dam. The authorization provided for acquisition of an additional 1,325 acres, extending the site up the Lackawaxen Valley five miles above the dam and more than doubling the recreational area. This relatively small facility, operated and maintained by the Pennsylvania Department of Environmental Resources, is likely to experience capacity patronage of 156,000 visitors annually within a decade.

Francis E. Walter Dam spans the Lehigh River a half mile below its confluence with Bear Creek. From there the Lehigh flows swiftly and tortuously for 75 miles to join the Delaware at Easton. Even before its completion and dedication in June 1961, the dam rendered valuable service in flood control. The lake behind the dam has been popular with anglers from the days of its initial impoundment; waters above and below the lake are annually stocked with rainbow and brown trout and indigenous small mouthed bass are usually found in abundance. The full development of Bear Creek State Park has awaited the further determination of the project's storage function; the Flood Control

General Edgar Jadwin Dam

Prompton Dam and Lake

Francis E. Walter Dam and Lake

Act of 1962 authorized enlargement of the dam and reservoir and expansion of the recreational features. In addition to its usual water-related features, there will be trails for nature study and hiking and hunting will be permitted in season according to State game laws. Overnight facilities will not be provided and motor boats will be excluded from the rather restricted lake area.

Beltzville Dam is the District's most recently completed flood control project. Constructed across Pohopoco Creek four miles west of its juncture with the Lehigh River, the rolled earth embankment holds back a lake five miles long with a capacity of 13 billion gallons. The flood storage potential of Beltzville is significant in a region characterized by flash floods; alleviation of the risk of flood damage is assured for towns on the Lehigh from Bowmanstown through Allentown and Bethlehem to Easton. Pine Run empties into Beltzville Lake about a mile above the dam; here, the Pine Run Cove recreation area offers wooded picnic groves, boating and swimming. hiking trails lead to the Overlook and Exhibit Center and to dig sites where relics of the Devonian Sea are exposed in fossiliferous outcroppings. Carbon County's last covered bridge, salvaged from flooded Pohopoco Creek, will be retired from vehicular traffic duty in this scenic area. A mile farther up and across the lake is the site of Trinity Gorge recreation area, to be developed later for day use.

Up near the head of the lake and bisected by Wild Creek is the site of the proposed Twinflower area, to be developed for day and night use; plans call for installation of permanent campsites, boat launching ramps and fishing facilities. The combined recreational capacities of the three Beltzville areas is estimated at 635,000 visitors annually—a modest but valuable contribution to the tremendous recreational needs of an expanding Megalopolis.

The vast recreational resources available to the Delaware Water Gap National Recreation Area (DWGNRA) offer the best prospect for solving the metropolitan region's recreation problems. DWGNRA is a redesignation of the project originally conceptualized as the Tocks Island National Recreation Area (TINRA). The National Park Service was given responsibility for planning, development and management of the project by Congressional authorization under Public Law 89-158, 89th

Congress, approved 1 September 1965. The motivating core of the concept was the projected 37-mile long Tocks Island Lake, its storage waters behind Tocks Island Dam to extend up the Delaware River Valley to Port Jervis, New York, through a region of spectacular scenic beauty. The dam-to-be remains the single main stem control structure envisioned in the Delaware Watershed Comprehensive Basin Plan and was authorized by the Flood Control Act of 1962. The Tocks Island complex of nearly 100,000 acres will seek to carry out the entire range of functions constituting the multiple-purpose water control program of the Corps of Engineers. Basic to the mission are the flood control and water supply functions of the potential 105 billion gallon impoundment. A proposed hydroelectric plant would have an average annual production capacity of 307 million kilowatt-hours and the possibility of an additional pumped storage facility to more than treble that output. The 100-mile lake shoreline will challenge Park Service planners to provide a dozen or more controlled areas with varied water access features. A prodigious variety of geographic features on both the New Jersey and Pennsylvania sides of the 72,000 acre park offer unlimited possibilities to the outdoor sportsman and an abundance of wildlife to enrapture the naturalist. Recreational development within DWGNRA's boundaries, including hunting in season, is expected to provide for the four-seasonal needs of ten million annual visitors.

Tocks Island Dam will be managed by the Corps of Engineers as a key unit in the basin system of water control installations, in coordination with National Park Service recreational facilities on or contiguous to the lake.

Approximate apportionment of visitor sources for Delaware Water Gap National Recreation Area. The proposed recreation preserve is expected to accommodate 10.5 million annual visitors.

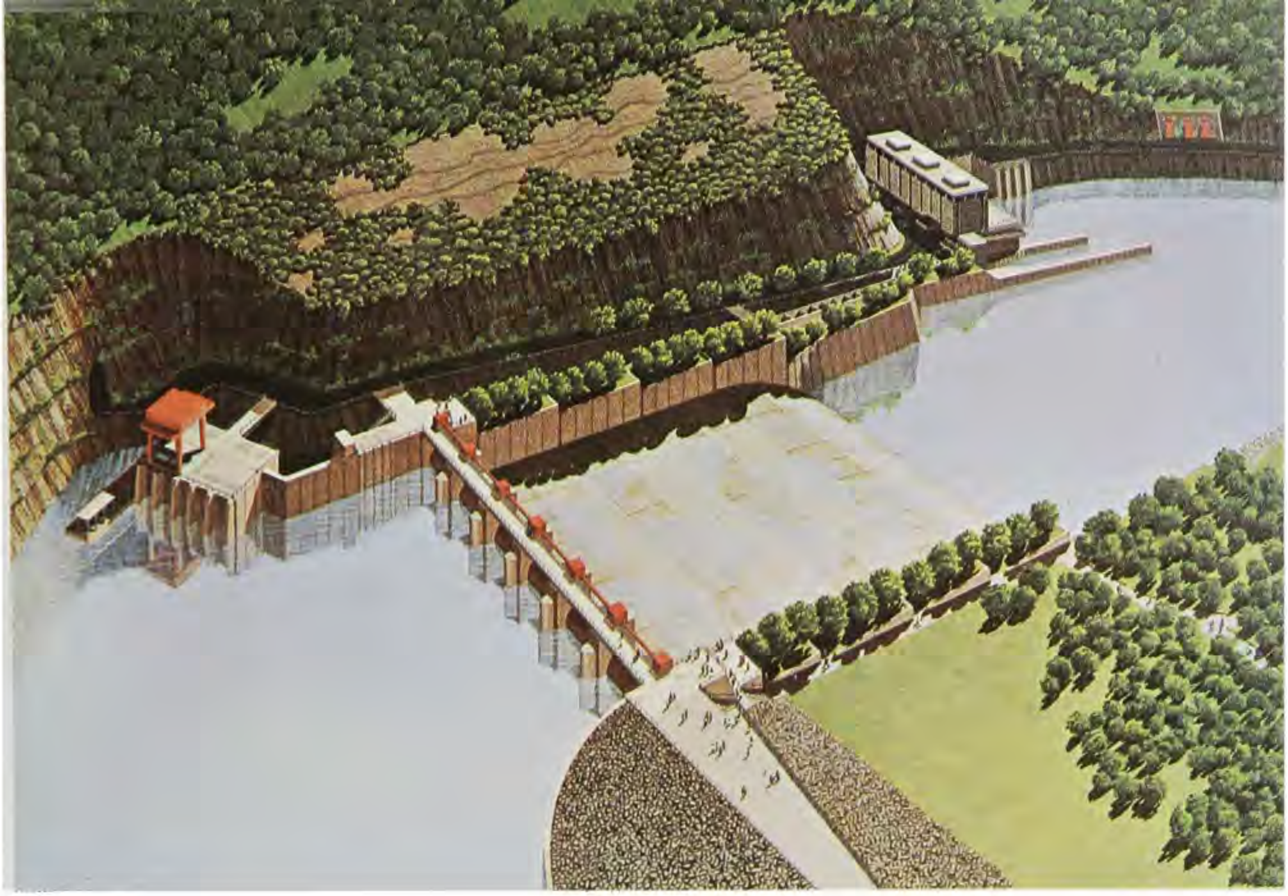
Beltzville Dam and Lake

Water quality control and enhancement of the environment as a fish habitat are high in priority on the developmental agenda; rather than adopt the procedure usually mandated for National Parks: to preserve wholly the integrity of the natural scene an effort will be made to develop the area for "green land" recreation.

The Delaware Water Gap National Recreation Area is ideally located to serve the population of the Northeast Corridor. The map on page 217 shows a hypothetical visitor distribution for an estimated annual capacity of ten-and-a-half million pleasure-seekers. Planners feel that recreation facilities in the area are lagging far behind requirements, that even DWGNRA is too little—too late and will be over-exploited long before it will be serviceable. The site lies within 100 miles of 15 percent of the nation's population; this segment will exceed 47 million persons by the year 2010. Recreation sites planned in conjunction with dams of the Comprehensive Basin Plan (11 major projects; 8 secondary projects) loom importantly as potential oases for relief from encroaching urbanization.

Completion dates for Tocks Island Dam, variously announced from time to time, are in suspense, pending determination of a number of questions concerning the impact of the project on the ecology and the human environment. Conservationists, critics of the project and perennial detractors of the Corps have generated a welter of issues aimed at Tocks Island as the focal point of a timely polemic. Out of the profusion of argument and criticism has emerged considerable material of positive value. The time of the conservationist has come and he will be heard. His theories and concepts are frequently incomplete or inconsistent, but his heart is pure. Though the immediate objectives and the methodologies of the Corps and its critics vary, their ultimate goals were identical: to seek the optimum means for survival.

Survival may seem an archaically basic goal to many accustomed to thinking of the present as complete, millenial and invulnerable; but the danger signs are there. Having come full cycle in the hour of technology, we may soon face the imperative of revising a hard-won and cherished life style to make it viable. The Corps with its long record of practical concern for the Nation's survival will likely be the most effective instrument for the practical actualization of the "new conserva-



Tocks Island Dam and Lake

tion." According to General Richard H. Groves, Deputy Director of the Civil Works Division, Corps of Engineers:

> *"While the pressures which have developed cannot be ignored, they must be kept in perspective. The program keeps growing. The program is tied to people, and the people double every forty years . . . . we build on the notion that people want an ever-increasing standard of living, and (that) is tied to water programs. If you conserve undeveloped areas, you're not going to be able to do it. If you double the population and they double their standard of living, you have to keep going. It's not as simple as the people who take an extreme view say."*

Conservation of wilderness areas and historic sites is crucial to the preservation of a national heritage but increasingly difficult to accomplish. In the densely populated District area with its rich historical background, the choice between preservation and economic development is made almost daily. Rural areas are no less affected. It has been said that the most painful price paid for the benefits derived from reservoirs is the sacrifice of valuable land. Another less tangible toll is levied by the disruption of life in the valleys where the new lake waters collect. The loss of home and familiar surroundings are most poignantly felt by the aged and by residents deeply rooted in the area. The value of a heritage lost, of the immersion of the unique essence of the past is not assessable and cannot be computed in the property settlement. While Corps negotiators (who are people after all, and not compulsive dam-builders) make every effort to obtain equitable reimbursement for displaced property owners, these are still agonizing decisions for all concerned. For some, it is the end of a cherished way of life; yet for others it is an opportunity to liquidate an encumbering past, to relocate and start afresh in newer, more stimulating surroundings.

The fresh-water lakes stored behind the dams and their vast adjacent land tracts spearhead a national effort to preserve our natural heritage. Work programs must keep pace with debates, so that essential water control measures are provided and our arguments are not concluded by inundations.

Epilogue

THE MILITARY—CIVIL MISSION

According to an old maxim: "if you want a job done, give it to a busy man." The implied theory is that the busy man possesses the necessary skill, experience and tools to do them all well. The Corps of Engineers has been the Nation's "busy man" for nearly two centuries-and the jobs keep pouring in. What was once a specialty shop with a distinctly military cast, has become so diversified that it now encompasses almost every function of design, building and repair demanded by the Nation in war or peace. A list of the Corps' achievements would fill books and will not be recounted here; many were of epochal importance, but the most important may be those still to be done.

Today, there are those who would limit the Corps' operations, others who would circumscribe many of its diverse functions and some who would abolish it. While there is little novelty in the forms of opposition to Corps projects and policies, there is particular virulence in recent criticism. The adamant "now-not later" slogan of the instant reformists cries out for the summary reversal of established life modes and the immediate creation of a world of utopian purity. Other voices express a more reflective and realistic concern for the continuity of life coupled with the desire to reform what needs reforming.

A by-product of life, American-style, is an ever-compounding complexity engendering in its turn a continuous series of crises. The higher standard of living toward which Americans have aspired has always been characterized in terms of something more, larger and faster. The desire for a slower, simpler existence has had little currency until recent years. The historic mission of the Corps has been to provide whatever Americans needed, even when it involved a choice of drastic alternatives. Since the beginnings of wagon roads, on through the development of canals, railroads, turnpikes and airways, Americans have enjoyed the gains they so avidly sought. The consequent system, with its cumulative glut of products, services and wastes, has produced a situation which now demands choices of unprecedented importance. At minimum, they are concerned with salvaging a quality of life; ultimately, they treat the mere matter of survival.

A large number of Americans will opt for the future with all its frightening complexity, just as many Americans chose to enjoy the benefits made possible by past engineering achievements of the Corps. While recent popular attitudes contain elements of a nostalgic yearning to return to the unrecoverable life modes of simpler times, it is probable that few would voluntarily renounce the conveniences of modern living, even as a pathway to a safe environment; still fewer are aware of the long, painful process by which those conveniences were evolved.

The mission of the Army Corps of Engineers was first spelled out by General Washington's Chief Engineer at Valley Forge in 1778. General DuPortail proposed to his superior an "absolutely indispensable establishment," with specific recommendations for its form, function and deployment. In some basics form and function are little changed.

Now, as then, it is essentially an officers' corps, the mass of its ranks filled by soldier-citizen specialists. DuPortails' sappers were selected from the ranks, the choice made of the most vigorous soldiers and the preference given to carpenters and masons. For them "the pay ought to be greater than that of the ordinary foot soldier, because the service is exceedingly hard." For the selection of officers, "choice should be made of young men well bred, intelligent and fond of instruction."

Troops were apprenticed to old-world masters in the arts of fortification and military maneuvers, "to be instructed in everything that relates to the construction of field works—how to dispose of the earth—to cut the slopes—face with turf or sods—make fascines—cut and fix palisades." These were the skills required for the time and situation; there was an enemy to be frustrated, and a neophyte army to be protected while it acquired some military proficiency. With the issue resolved and America sovereign, other skills were added to the Corps repertoire. In 1802, the new Military Academy at West Point undertook the establishment of an American school of engineers.

National works of internal improvement had, at first, to be carried out by the one existing entity qualified to accomplish complex engineering assignments—the Engineer Department of the Army. The skills inherent to the devising of breastworks, revetments and *chevaux-de-frise* were readily transposed to techniques of harbor, breakwater and road construction. The "new engineer" began to emerge from the Military Academy in the 1820's; under Sylvanus Thayer's revolutionized curricula, West Pointers were equipped equally well as military and civil engineers. The new engineer still planned forts and strategic gun emplacements; he also undertook the design of bridges and lighthouses, the building of canals, the improvement of river channels and exploration of the western lands, mapping their geophysical features and classifying their flora and fauna.

In war, Engineer contingents were assigned support functions in liaison with every branch of the military, except the Signal Corps, in every theatre of operations. A parallel peacetime function sent engineer emergency relief wherever natural disasters occurred. The deployment of a bewildering variety of material and equipment in vast quantities, the logistical support of complex and diffuse operations—whether for disaster relief or combat—became standard procedure. Inevitably, it fell to the Army Engineers to mount the defenses against floods and to assume responsibility for husbanding the Nation's water resources.

Much has been said and written about "turning around" the Corps' mission, to put it on course with the "new conservation;" the context is usually in terms of diverting the pell-mell career of a destructive juggernaut. In fact, the reorientation of Corps objectives occurs continually within a broad and flexible organization. Turning the mission around presents no problem of Corps intractability, but rather one of determining, realistically, from which programs Americans will derive the most benefits. Once a program is established, the unequaled advantages of the Corps' method become apparent: chain of command implementation, thorough design studies, non-political advertising and strict adherence to Army contract regulations. Among the Federal Agencies, the Army Engineers are notorious for "going by the book" in the administration of contracts and for tightfistedness in the expenditure of public monies. Well-known cases of cost overruns on

Corps projects are constantly exploited by Corps detractors, who consistently omit any reference to the equally well-known causes of those overruns. Original cost estimates for public works projects are vulnerable from the moment the projects are made public. Lengthy public hearings, rehearings and cumulative construction delays usually lead to an escalation of costs, due to rising prices of materials and services, exploitative inflation of real estate values and extended administrative overhead. Public awareness of an improvement project tends, perversely, to augment the price the public will eventually have to pay. On the other hand, Engineer files contain countless records of projects completed with balances on hand, attesting to adroit administration and consistently high performance in the application of engineering techniques.

A new brand of engineer for the new times is emerging from the Military Academy, from the Engineer School and from colleges and universities throughout the country. He is not only the young Corps officer, but the civilian staff specialist in the gestation levels of the Districts. His training has included all the traditional formulas and equations, plus a challenge to enter unexplored areas and to formulate yet undefined equations. Old line members of career civil staffs see in their midst new colleagues with new labels—agronomist, biologist, landscape architect, environmentalist, sociologist, ichthyologist, botanist—and remember when engineering was done, by and large, by engineers, who took a problem, defined it, designed it, built it and made it work. Old line, basic engineering has not been rejected by the "new look" department, but its horizons are wider, its research deeper and its techniques subtler. The net change is in a broadened social awareness (an ingredient said to be lacking in traditional engineering) and a reemphasis on responsibility for the status of the natural environment.

The basis and pattern of the Corps' civil mission are well established; the organizational structure is neither superior to nor very different from efficient organizations in the business-industry world. Its unique feature is to be found at the top—the Corps of Engineers command structure, staffed by officers superbly trained and imbued with the idea of fidelity to public trust. That idea pervades the functioning careers of 41,600 professionals who constitute the civilian work force of the Corps' organization. The high caliber of the civil staff is maintained through selective recruiting, the Junior Engineer in Training (JET) program and the education and advancement program. The latter aims to raise professional performance levels within the organization while enhancing individual opportunities for career advancement, by providing refresher and degree courses at universities and colleges and participation in government and business-industry symposia. The ranks of the officer corps are still being replenished by "young men well bred, intelligent and fond of instruction."

The Corps is vast, but not monolithic; it is sensitive and flexible and deals realistically with today's complexities. Having absorbed all the earned praise, prestige and criticism of its 196 years, the Corps is still here; we might occasionally congratulate ourselves that it is. None of us has had to experience a time when it was not.

A LOOK AHEAD

With the Nation, the Philadelphia District faces the problems and challenges of the 1970's. Undoubtedly, many are directly attributable to the increasing demands of an increasing population. The controversy generated by conflicting choices the District must make has found its paradigm in the Tocks Island Lake project, the solution to which will establish landmark decisions concerning man's responsibility to his environment. A formula must be created to resolve the basic conflict between man, the consumer and land, the supplier. The water-related problems of the Philadelphia area are the concern of the Philadelphia Engineer District. These problems are extensive and permeate every area of community life. The destinies of the river Ports and their effect on the economic life of the entire watershed may depend largely on the development of expanded facilities to accommodate new maritime delivery systems. Engineers of the District will be increasingly involved in studies treating the Delaware River channel, the development of new dredging systems and the feasibility of deepwater unloading terminals.

Projected reservoirs at Blue Marsh, Trexler, Maiden Creek and Tocks Island will attempt to satisfy the region's long range demands for water and electric power. The whole spectrum of water resources utilization will be explored in developing these impoundments; adjacent land tracts will be set aside for public use recreation areas. Integral elements of the dam designs will assure greater security against flooding; other built-in controls will regulate the quality of the water released. All feasible measures will be taken to insure the continued propagation of indigenous fish and wildlife.

The problems engendered by an increasing concentration of population are unlikely to diminish in the forseeable future. A reversal of current growth trends through demographic patterning may not be effected for many years; the dilemma of human waste disposal demands immediate solutions. In 1971, the Chief of Engineers initiated a crash program for the study and recommendation of environmentally compatible systems of sewage disposal. (The Philadelphia Districts' Marine Design Division already had installed sewage treatment equipment aboard units of the Districts' floating plant). The Corps of Engineers is engaged in a renewed mission of environment repair; in the ecological revolution, this may be the pivotal mandate for a nation at the crossroads in its choice of lifestyles. In a program with such broad implications, the Districts' participation is inevitable.

Clearly, the Corps must expand its interaction with people at many levels of interest and concern. Articulate public interest groups, local governments, concerned citizens and those with specific problems to be solved must be heard and their opinions evaluated. The District's involvement with the community implies collaboration with other agencies concerned with the public welfare.

The frontiers of modern America are not to be found at far-flung outposts; they are in our congested midst. The outposts, cleared with axe and long rifle, have all been absorbed, and we scarcely can move without nudging our neighbors. The frontiersmen of today are the planners, serious men with grave responsibilities, whose moves are deliberate and prayerfully precise, for the balance is delicate. A chain reaction is begun by the initial operation of a dam's construction. From site excavation to impoundment, each phase of construction exacts its full measure from the environment. After the scarification, the brush burning and the stream diversion have been compensated by landscaping, vector control and fishways, the planners must address themselves to the consequences of reservoir operation. Periodic drawdowns expose many miles of shoreline, requiring studies to determine their potential for the propagation of health-manacing or nuisance vectors. Scarified areas, the unwatered strand, and the dam itself require treatment to repair aesthetic damage. Provisions for the hosts of visitors drawn to the recreation areas must be sufficient to insure their long term usefulness to the public, with appropriate safeguards against the degradation of the "greenlands" environment.

Americans get what they want. The future missions of the District and the Corps will be designed, as were those of the past, to satisfy the demands of the American People. Eternally in quest of a "higher standards" of living, America at age 195 has attained affluence and, in reflection, a desire to conserve and improve the quality of life. Corps planners are sensitive to the growing public awareness of our rich national heritage, and of the desire to preserve the artifacts of earlier, less complicated eras as vestiges of our innocence.

Exhibit centers at the new reservoir sites will house displays which illustrate regional geology and reservoir function along with local lore and legend. Fossil exhibits and classified collections of local historical and archaeological merit will be given prominent display. Such a center has been installed at Beltzville Lake in Carbon County. A unique example of 19th Century technology, the Gruber Wagon Works, will be removed from its original location at Mount Pleasant, Berks County and installed, virtually intact, in the exhibit area at Blue Marsh Lake. Well-preserved 18th Century houses, especially the historic Van Campen dwellings, are earmarked for salvage and relocation from the area to be inundated by Tocks Island Lake. The Chesapeake and Delaware Canal Museum at Chesapeake City, Maryland contains the historical record of one of the Nation's most significant early transportation systems. It is situated in a building housing the 120 year old pumping plant, which the Corps of Engineers has preserved since 1919. Scores of historical and archaeological sites in the District area have been inventoried and tested in a program which has been underway since 1960. Other buildings of historic interest or significant architectural value have been thoroughly documented, measured, diagrammed, sketched and photographed in a program of cultural preservation which will be continued through the seventies and beyond.

APPENDIX I

DISTRICT ENGINEERS
1866—1973

Lt. Col. C. S. Stewart	1866-1871
Lt. Col. J. N. Kurtz	1871-1877
Col. J. N. Macomb	1877-1882
Lt. Col. G. Weitzell	1882-1884
Maj. W. H. Heuer	1884-1885
Lt. Col. H. M. Robert	1885-1890
Maj. C. W. Raymond	1890-1901
Col. J. A. Smith	1901-1902
Lt. Col. C. W. Raymond	1902-1903
Maj. J. C. Sanford	1903-1908
Maj. C.A.F. Flagler	1905-1907
Maj. Herbert Deakyne	1908-1912
Lt. Col. Joseph E. Kuhn	1912-1913
Col. George A. Zinn	1913-1916
Maj. J. C. Oakes	1916-1917
Col. Mark Brooke	1917-1918
L. D. Shuman C.E.	1918-1919
Col. W. B. Ladue	1919-1921
Maj. L. E. Lyon	1921-1922
Col. Earl I. Brown	1922-1923
Col. F. C. Boggs	1923-1928
Lt. Col. G. B. Pillsbury	1928-1930
Col. Earl I. Brown	1930-1933
Col. J. A. Woodruff	1933-1934
Lt. Col. John C. H. Lee	1934-1938
Maj. C. W. Burlin	1938-1940
Col. H. B. Vaughan, Jr.	1940-1943
Col. A. H. Burton	1943-1944
Col. Clarence Renshaw	1944-1945
Col. Frederic F. Frech	1945-1949
Col. Earl E. Gesler	1949-1950
Col. Ralph E. Cruse	1950-1952
Col. Walter Krueger, Jr.	1952-1954
Col. R. J. Fleming, Jr.	1954-1955
Col. A. F. Clark, Jr.	1955-1957
Col. W. F. Powers	1957-1959
Col. T. H. Setliffe	1959-1963
Col. E. P. Yates	1963-1966
Col. W. W. Watkin, Jr.	1966-1968
Col. J. A. Johnson	1968-1971
Col. C. D. Strider	1971-1973

APPENDIX II

PEREGRINATIONS OF A DISTRICT

Alone among small nations, SMOM, the Sovereign Military Order of Malta, has recognized the close connection between mobility and survival. When threatened by enemies domestic or foreign, the country simply picked up and moved. From its founding (as the Order of the Hospital of Saint John of Jerusalem) in Jerusalem in 1113 A. D., the nation moved to Acre (1197), Krak (1271), Margat (1285); thence to Cyprus (1291) and Rhodes (1309) where it remained until its expulsion in 1523. Without a base for seven years, the Order was granted a refuge at Malta in 1530, where (ever grateful) it remained until its expulsion from there in 1798. From Malta to Messina to Rome, where it currently occupies the second floor of a downtown office building, SMOM has been a poor pilgrim ever in search of a home.

Apropos the Philadelphia District: it too has been a wanderer. Since its founding in 1866, the District has called over a dozen places home, or tried to. From its first office, in a renovated private dwelling at 209 South Sixth Street, the District began its hegira from one Philadelphia address to another. It first moved to 1125 Girard Street; then to Fifteenth and Arch Streets; next to the Witherspoon Building, 1319-1321 Walnut Street, where it remained through World War I and into the 1920's (at the same time leasing office space for Military Procurement at 607 Manhattan Life Building, Fourth and Walnut Streets); the mid-20's found the District headquartered at the Schaff Building, 1505 Race Street, but not for long. By 1930, it had shifted to the Gimbel Building, 35 South Ninth Street, from whence it again moved in 1935 to the sixth, ninth, and tenth floors of the Custom House, Second and Chestnut Streets. World War II arrived and with it came the movers. In March 1942, the District moved again, this time to 1400 Penn Mutual Building, near the corner of Sixth and Walnut Streets, the site of its original home, where it remained until 1946.

In that year, by now accustomed to short runs, the District moved to 121 North Broad Street, and again (for the Supply Division) to 1420 Walnut Street in February 1951; to 5000 Wissahickon Avenue in June 1954; and back to the Philadelphia Custom House in August 1961, where happily, it has remained ever since. *Esperez, voyageurs du monde!*, which freely translated means there may be hope for the wanderers of the world.

U.S. Custom House, Philadelphia.

APPENDIX III

THE WATERWAYS EXPERIMENT STATION

Hydraulic laboratories were operating on a small scale throughout Europe in the early years of the twentieth century, expanding rapidly in the period following the First World War. In the United States, interest at the national level was stimulated in 1928, following the 1927 Mississippi River Valley floods. A bill to authorize establishment of a hydraulic laboratory in the Bureau of Standards in Washington, D.C. was passed by the Senate and reported to the House; hearings before the Committee on Rivers and Harbors were scheduled for 26 and 27 April 1928.

Testimony by Chief of Engineers General Edgar Jadwin and his staff at R & H hearings extending through February 1929, effectively blue-printed the type of experimental installation which would best fulfill the national need. General Jadwin suggested construction of a spacious field laboratory, sited in close proximity to the major problem area—preferably on the Mississippi River—where laboratory personnel could readily contact the field forces doing the actual river work. In accordance with provisions of the Mississippi River Flood Control Act of 1928, planning was begun for a laboratory building at Memphis, Tennessee, as directed by General Jadwin on 18 June 1929.

Before plans could be completed, orders were issued to relocate the project to Vicksburg, Mississippi. On 14 February, 1930 the Secretary of War approved purchase of 147 acres of land, five miles southeast of Vicksburg. Here was established a unique organization known as the Waterways Experiment Station (WES) of the Corps of Engineers. The name itself reflected the desire to preserve an identity distinct from the more general functions of the Hydraulic Laboratory of the Bureau of Standards.

Beginning with rudimentary facilities, a low budget and a young, unprejudiced staff, the station undertook and successfully completed the design and construction of models for large river studies at a time when the practical value of scale model experimentation was regarded with extreme skepticism. The station's project schedule increased rapidly. In addition to the original model studies of estuaries, facilities were added to conduct research in harbor development and channel stabilization, hydraulics, soils and foundations, concrete, nuclear weapons effects, erosion control, environmental effects, geology, terrain analysis, soil dynamics and rock mechanics. The Vicksburg installation sprawled outward, to eventually cover 595 acres. In 1942, 800 acres of land were acquired near Clinton, Mississippi for the Mississippi Basin Model Division; the initial construction was by German war prisoners. There in 1946, the Concrete Division was installed.

At its inception in 1929, WES was administered under the presidency of the Mississippi River Commission. In August, 1949 it came under the specific direction of the Office of the Chief of Engineers. The organization consists of an executive office with an advisory administrative staff and a technical staff of five divisions: Hydraulics; soils; concrete; mobility and environmental; and nuclear weapons effects. In addition, there are two support divisions: technical services and construction services.

WES is probably the largest institution of its kind in the world; at first concerned primarily with solving flood control problems for the Corps and other Federal Agencies, it has expanded its agenda to carry out a great variety of studies and investigations for other agencies, industries and societies, world-wide. The original function of WES and still among its major activities was the model studies program; scale models of river systems and projected related structures (dams, bridges, harbor installations) were constructed and their behavior, mechanical functions and environmental effects studied and recorded. Philadelphia District projects for which WES has developed essential model study programs:

Study or Investigation	Report Date	Report No.
1. Plans for the Elimination of Shoaling in the Delaware River's entrance to the Chesapeake and Delaware Canal-(2 parts)	June 1936 July 1940	TM 93-1 TM 93-3
2. Plans for Elimination of Shoaling in Wilmington Harbor, Del.	Aug 1942	TM 194-1
3. Plans for Elimination of Shoaling in Absecon Inlet, N.J.	Sep 1943	TM 204-1
4. Plans for Elimination of Shoaling in Deepwater Pt. Range, Del. River	May 1947	TM 2-231
5. Plans for Elimination of Shoaling in New Castle Finns Pt. Rges., Del. River	Aug 1948	TM 2-259
6. Flood Control Project for Allentown, Pa.	Dec 1953	TM 2-376
7. Delaware River Model Study		TM 2-337
a. Report No. 1-Hydraulic and Salinity Verification	May 1956	TM 2-337
b. Report No. 2-Salinity Tests of Existing Channel	June 1954	TM 2-337
c. Report No. 3-Effects of Proposed Channel Enlargement Between Philadelphia and Trenton	Jan 1952	TM 2-337
d. Report No. 3-APP A-Tests of Alternate Alignments of Specific Reaches and Closure of Burlington Island Back Channel	Jan 1959	TM 2-337
e. Report No. 4-Dike Rehabilitation	May 1964	TM 2-337
8. Effects of Salt Water Barriers Across the Delaware River	Sep 1959	MP 2-358
9. Results of Hydraulic and Shoaling Studies in Marcus Hook—Schuylkill Reach of Delaware River	Mar 1967	MP 2-887
10. Outlet Works for Beltzville Dam. Pohopoco Creek, Pa.	Dec 1969	TRH-69-18
11. Spillway and Outlet Works, Tocks Island Dam, Delaware River	Jul 1970	H-70-10
12. Tests of Proposed Improvements of Barnegat Inlet, N.J. (1969-71)	Report being prepared	
13. Tests of Effects of Enlargements to the Chesapeake and Delaware Canal (Investigations in both Physical and Mathematical Models)	Underway	
14. Salinity Intrusion Tests in Delaware River Model During Extreme Drought Conditions of 1965	No report prepared.	

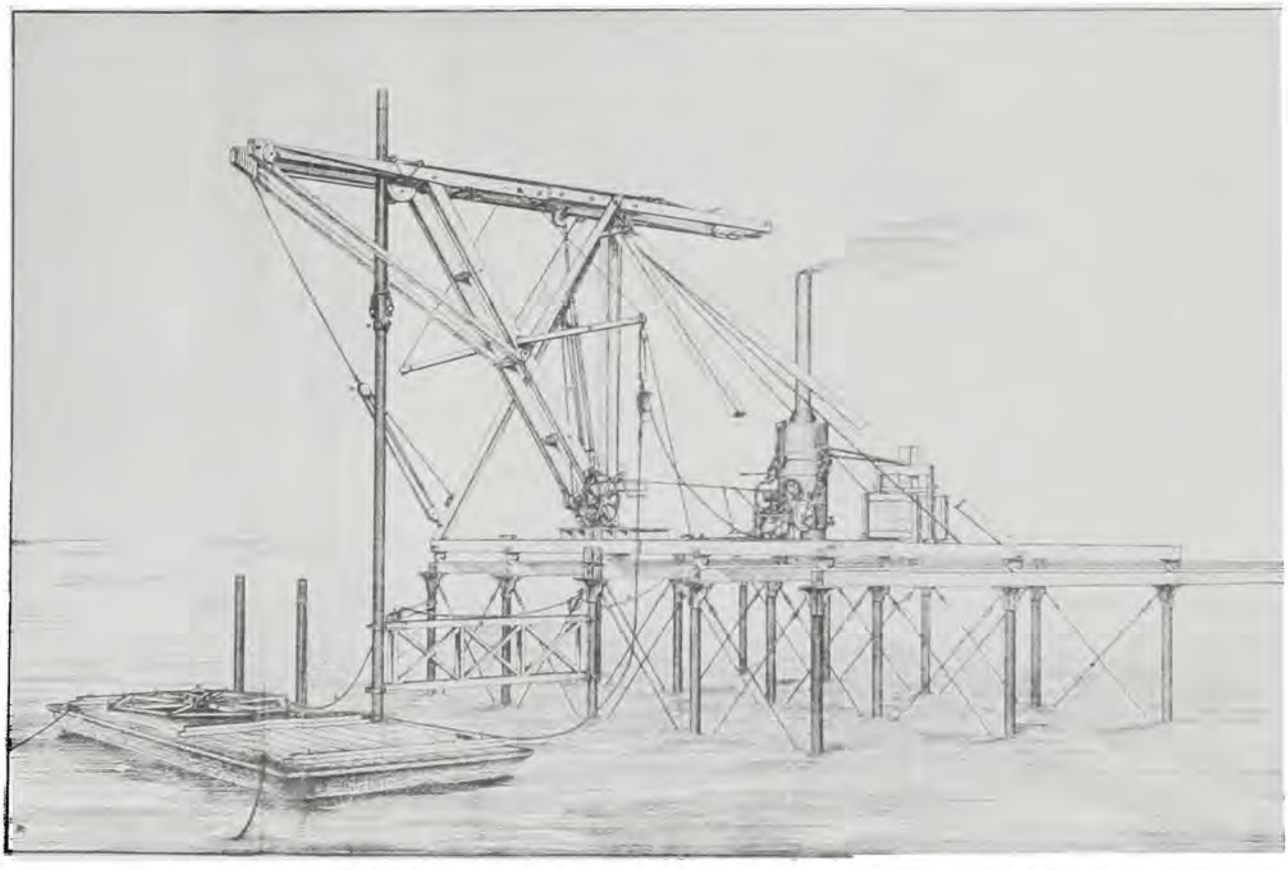
Notes—Studies 1, 2, 4 & 5 were accomplished in the sectional model of Delaware River, extending from below Artificial Island to above Wilmington, Del. Studies 7, 8, 9, 13 & 14 were accomplished in the Delaware Estuary Model, extending from the Capes to Trenton, N.J.

APPENDIX IV

THE IRON PIER

The Lewes-Henlopen area possessed natural characteristics potentially amenable to the development of a transportation center of economic importance. That it did not so evolve is but one of many instances of shifting economic fortune that characterized the protean Nineteenth Century. The curving shore of the strait embraced the waters of Breakwater Harbor, which, thanks to a rugged entrance through the Delaware Capes, was frequently filled by hundreds of trading vessels of all classes from ships to skiffs, seeking shelter there.

By 1870, vessels were using Lewes as a port of call although port facilities were extremely limited: besides the moles of the breakwater, a single pier extended offshore to a depth of 16 feet, on which the Junction and Breakwater Railroad rolled its vehicles right to the water's edge. The Iron Pier, or United States Pier, was projected to augment the area's port facilities as well as to implement Government operations at the Cape Henlopen reservation. Evidence of this purpose can be found in the terms of the act authorizing Iron Pier, dated 15 July 1870, and granting "use of the pier



The method of driving screw piles for the Iron Pier in 1877 and 1878 was illustrated for the Annual Report by Mr. A. Stierle, Captain Ludlow's Assistant Engineer.

for railroad purposes" to the Junction and Breakwater Railroad.

Construction was begun at the site in 1871, with the first pile driven in April 1872. The authorization called for "a substantial pier of stone or iron;" the project plan specified the installation of wrought iron screw pile shafts and a superstructure of yellow pine timber as offering the greatest strength and the least interference with the natural currents of the harbor[1]. The pier extended offshore 1700 feet to a water depth of 22-feet. From the start of work, appropriations were made annually, except in 1877, until the pier's completion in 1880. After eight years of construction, it was deemed necessary to replace a large amount of timber in the superstructure, the expenditure for which was included in the final cost figure of $358,339.40. The repairs were completed in 1882.

In his report of 1896, the District Engineer requested revocation by Congress of the right granting the railroad use of the pier, since that right had been waived the previous 16 years. During the construction of Iron Pier, railroad development had advanced phenomenally; the freight equipment of the 1890's was now too heavy for the structure to support. In the same report the District Engineer recommended the appointment of a harbor master and establishment of clear regulations governing use of the pier and adjacent Breakwater Harbor. These steps were clearly needed, especially during the confusion created by heavy ice floes in the bay, when the harbor became crowded with shipping and an excessive number of vessels sought shelter below the Iron Pier.

Iron Pier was provisionally transferred by Congress to the Marine Hospital Service in 1890 and became an important adjunct of the United States Quarantine System, which had established a station at the Cape Henlopen reservation in 1884. A cholera threat in 1892 occasioned the initiation of a rigid inspection system for all vessels entering the harbor from foreign ports; Philadelphia had become an important port of entry for immigrants and many Philadelphians feared a repetition of historic epidemics which had swept the city before[2]. Iron Pier and the breakwater station could not provide all the needed services and, in 1893 an additional boarding and disinfecting station was opened at the northern end of Reedy Island, on the site of the old ice harbor.

Iron Pier is interesting as a kind of landmark along the route of an evolving American technology. An example of a national trend which sought generally to replace wood with metal, its initial construction was laboriously undertaken by man and mule power; not until 1877 was steam applied to the work. In 1872, the first year of the pile driving, successful experiments were made with water jets to assist in forcing pile shafts into the river bottom. In that same year, the Engineer Department instituted the eight-hour work day.

APPENDIX V

AN EMERGENCY DEFENSE PLAN FOR FORT DELAWARE

Concern for the safety of the young Republic's first capital city, Philadelphia, prompted the initial efforts to fortify Pea Patch Island in 1814. Great Britain, inspirer of earlier fears, was still suspect as a potential invader in 1855, when the above plan was submitted confidentially to the Engineer Department. Fort Delaware was in its seventh year of construction, several years short of completion, by the most optimistic expectations. The scarp wall had attained but one-third of its full height; the casemate piers had not yet reached the springing line of the arches. Major Sanders' alternative emergency plan called for arming the island as a channel defense while using the incomplete fortress as a last ditch citadel to defend the island itself. Sanders' notes on the face of the drawing explain the scheme:

"This sketch, prepared in compliance with confidential instructions from the Engineer Dept. of the fourth of April 1855, exhibits two distinct projects for the position of the exterior and advanced batteries for the defense of the Pea Patch Island and for the command of the approaches to it and of the contiguous channels, either of which projects could be carried out at a very short notice if circumstances should make it necessary.

The line of batteries encircling the island and just within the ditch, being more effectually protected by the cover of the dike is the one preferred by Major Sanders. It would mount in barbette 218 guns. The line a-b-c giving 31 guns looking directly down

Brig. Gen. James St. Clair Morton
—Courtesy of Mr. Leland Johnson

> *the bay, is common to both projects—but in the second project the rest of the guns of the fort would be replaced by the lines l-m and n-o with full traversing circles so as to allow the guns to fire on either channel. The second project would require only half the number of guns of the first.*
>
> *Fort Delaware proper, in either case, as the works may stand at the time, to be converted by temporary arrangements into a citadel for the more immediate defense of the island."*

Line l-m was to deploy 17 guns; line n-o, 60 guns. Neither this plan, nor any like it was ever made operational; enemy warships never came within range of Fort Delaware's batteries.

This drawing was made by Major Sanders' assistant, the controversial James St. Clair Morton, then a lieutenant. Morton achieved recognition as an authority on military fortification and notoriety for suggesting that the curriculum at West Point, including the work of the vaunted Professor Mahan, was more petrified than progressive. He was promoted to Brigadier General after the Battle of Stones River in 1863 and was killed in action before Petersburg in 1864.

NOTES

To Build a Nation

[1]At first practical and eclectic, partaking of selected practices and theories of the Europeans, American engineering began in the 1830's to assert a native character through construction of the transportation systems and development of the techniques which would become the tools of the industrial revolution. The American method stands out uniquely by the colossal scale of its works and by its pursuit of techniques to improve the general life style proliferated through mass production.

[2]Formally established by Congress in 1779; commanded by General Louis LeBegue DuPortail.

[3]Etienne Rochefontaine, who had served under DuPortail 1778-1783.

[4]Jonathan Williams, Joseph G. Swift, Walker K. Armistead, Alexander Macomb, Charles Gratiot, Joseph G. Totten and *John J. Abert (*Chief, Corps of Topographical Engineers).

Insignia of the Corps

[1]R. B. Buzzaird; Insignia of the Corps of Engineers, the Military Engineer March-April 1950 and January-February 1958.

The Delaware Breakwater and Ice Breaker

[1]Construction authorized by Act of Congress, approved 23 May 1828.

[2]" . . . . . .And I entirely concur in the opinion expressed in your letter of the 22nd of December last, that the more contracts we have the better we shall be served." QMG to Maj. Geo. Bender, QM, Phila.

[3]William Strickland—(1787-1854) Architect-Engineer. Founder and first president of the American Institute of Architects. Designed: First U. S. Mint, Phila.; Restoration, Independence Hall. Phila. (1828); Merchant's Exchange, Phila., Walnut & Dock Sts (1832-34); Merchant's Bank (now Norwegian Seaman's Church) Phila. 3d South of Market, originally Mechanic's Bank; St. Paul's, Phila. (rebuilt) So. 4th Street; Capitol Building, Nashville, Tenn.

[4]Samuel S. Southard, Secretary of the Navy; President John Quincy Adams

[5]Maj. Gen. Thomas S. Jesup, QMG.

[6]"It is due to candor to inform you that, valuable as your services unquestionably have been, I have never since the first years' operations considered them necessary. There are many officers of the Department fully qualified to direct every operation at the work, with compensation not much exceeding one half that which you have received." ($3,500 per annum) QMG to Wm. Strickland, Esq.—Letter dated 24 July 1834.

[7]QMG to Henry Myers, Esq., Chester, Pennsylvania.

[8]Hon. Lewis Cass.

[9]Letter to Maj. Bender, Quartermaster at Philadelphia, 4 May 1830.

[10]Report of Major J. G. Barnard, Corps of Engineers, 1853.

[11]Major Delafield, Corps of Engineers, proposed closure in 1836.

[12]8 October 1853—Chief of Engineers Annual Report.

The Chesapeake and Delaware Canal

[1]"What they did not understand they conquered by diligent study, unwearied zeal and sound common sense;" Desmond Fitzgerald, President, ASCE.

[2]Albert Gallatin, born in 1761, Geneva, Switzerland. Came to America in 1780; appointed Secretary of the Treasury by Thomas Jefferson in 1801.

[3]C & D: Surface width 66 ft., bottom width, 36 ft., depth, 10 ft. Erie: Surface width 42 ft., bottom width, 28 ft., depth, 4 ft. (later enlarged)

[4]Greville Bathe in "An Engineer's Miscellany," quoting Mr. Toward Nevison Loraine, C & D Canal Engineer, 1900-1927.

[5]Highest annual number of passages through the Old Lock Canal was 16,394.

[6]Samuel Vaughan Merrick started Southwark Foundry in 1836 at Washington and Federal Streets in Philadelphia. Originally a foundry for castings, it developed into a first class machine works; was among first to use the Nasmythe steam hammer. Work force averaged 350 to 500.

Ice Harbors

[1]The purpose of the ice piers, to make a safe and secure harbor for vessels against running ice, should be considered in the light of conditions prevailing in the early 1800's. A majority of the vessels plying the Delaware prior to the Civil War had wooden hulls; early navigation was wind-powered. Before a proper channel was made, large vessels under sail needed the high water of two tides and the right wind to run up to Philadelphia from the bay. Harbors of refuge equipped with ice piers along the route were welcome indeed. Running ice could strain and crack wooden hulls, could sweep vessels off course and cause them to founder.

[2]Legend on a Plan of the Harbor of New Castle, Delaware, 23 June 1854.

[3]Richard Delafield; became Major general; Chief of Engineers, 1864-1866.

The Upriver Canals

[1]Incorporated 2 April 1811 as the Union Canal Company of Pennsylvania. The name signified the union of two predecessor companies established for the same route: Schuylkill and Susquehanna, chartered 1791 and Delaware and Schuylkill, chartered 1792.

[2]The Union Canal was finally built between 1821 and 1827.

[3]"This company was declared to be hopelessly insolvent in March, 1855, in a legal report filed in a Philadelphia court, which recommended that it should be sold at Sheriff's sale"—Ringwalt's transportation systems in the United States.

[4]Hydraulically operated sluice gates, an invention of Josiah White, were dubbed "Bear Traps." The name is said to have originated in the facetious reply of a dam builder to a curious native who asked what he was building.

[5]Asa Packer 1805-1879. Born, Mystic, Conn. was a carpenter in New York City; made a fortune building canal boats and locks and investing in railroads; was Carson County Judge 1843-1848, member House of Representatives (Pa.) 1841-1842 and member, House of Representatives (National) 1853-1857. Founded and endowed Lehigh University.

[6]Delaware Division, Pennsylvania State Canals.

[7]Most active and meritorious in supporting the Canal's preservation has been the Delaware Valley Protective Association.

[8]Highest was the Pennsylvania Main Line (Mixed System). Its Portage Railroad between Hollidaysburg and Johnstown rose 2,291 feet to traverse the Allegheny divide. Second highest was the Delaware and Hudson—El. 972.5 feet at Honesdale, Pa.

Rebuilding Fort Delaware

[1]The National Road was begun in 1811; its original route was between Cumberland, Md. and Vandalia, Ill. The first federally supported interstate highway system, its construction was suspended due to extension of long line railroads. Also known as the Cumberland Road and the Great National Pike.

[2]Major General Joseph G. Totten, Chief Engineer 1838-1863; became first "Chief of Engineers" when Corps of Engineers and Topographical Engineers consolidated, 3 March 1863.

[3]Jean Victor Poncelet, 1788-1867 born Metz, France; General of the French Army and mathematician; author of "Traité Des Propriétés Projectives Des Figures;" considered a founder of modern geometry.

[4]Considerable doubt still remained as to the feasibility of erecting a heavy masonry structure on the Pea Patch mud bar. Many persons in and out of government remembered the unfortunate and expensive result of the first Fort Delaware project.

[5]Thomas Lincoln Casey, graduated Number One, Class of 1852, West Point; became Brigadier General; was Chief of Engineers 1888-1895.

[6]The Leiper Quarries on Crum and Ridley Creeks in Pennsylvania were owned and operated by the Leiper Family since about 1790. These quarries supplied much of the stone for the Delaware Breakwater and great quantities of curbstone, paving and building stone for the city of Philadelphia.

[7]Four piles were covered with a typical grillage platform; stone was piled on to equal a proportionate wall bearing load. After a year it was observed that the oak pile heads had penetrated an inch into the white pine grillage logs.

[8]William Price Craighill; became Brig. General; was Chief of Engineers 1895-1897.

[9]John Newton, a Virginian who stood for the Union. Served as a combat commander during the Civil War, returning to the Corps in 1866. Was Chief of Engineers (Major General) 1884-1886.

Steam and the New Techniques

[1]Jean Baptiste Marestier, *Memoir sur les Bateaux a Vapeur des Etats-Unis D'Amerique* (Paris 1824), passim.

[2]The qualifications of the prototype wood spans developed by Town, Burr, Long and others were well established by 1850. Initial attempts were made to meet the new load requirements by introduction of iron supplementally in the form of braces and tie rods, but the bulky timbers soon gave way to slimmer, all-metal structures.

Early Dredging

[1]"Mud," the common term for Delaware River dredging spoil, is altogether too vague an appelation to afford an adequate description of the material in question. The predominant ingredients, identified in the disposal areas, are organic clay and silt, sand, peat and gravel. For hydraulic dredging, mud is differentiated from sand, as it contains appreciable quantities of carbon dioxide and methane and must be treated as a solid-water-gas mixture.

[2]Years later, with power equipment, the "agitation" method was used. It consisted of pumping into the dredge's hoppers during flood tide, then pumping overboard to disperse the buoyant silt on the ebb tide.

[3]Other Board Members were Lt. Col. W. F. Raynolds, Lt. Col. N. Michler and Capt. William Ludlow.

Haven Within the Capes

[1]"The form and dimensions of the old (Delaware) breakwater were principally based upon a study of the long flat slopes of the Cherbourg breakwater, at that time (1828) the only practical example of an extensive random stone offshore breakwater. The stone was not deposited to the best advantage, as the methods of unloading then available were not such as to render an accurate emplacement possible."—Lt. Col. C. W. Raymond.

Early River and Harbor Works

[1]It is not evident that appropriations were made pendant to this act.

[2]Length of the River is about 310 miles; its drainage area is approximately 12,765 square miles.

[3]Annual Report of the Chief of Engineers, FY 1873.

[4]The act was amended in 1826 to stipulate "two inches" in substitution of "one inch."

[5]United States Assistant Engineer in Philadelphia.

[6]The tide attains maximum height of six feet at Bombay Hook, assumed mouth of the Delaware River.

[7]Major C. W. Raymond, Corps of Engineers, Phila., Pa., 5 Jan. 1898 to Brig. Gen. John M. Wilson, Chief of Engineers; Annual Report FY 1898.

[8]Grievances of Delaware's riparian owners concerned the possibility that channel training dikes might obstruct inflow of the flood tide.

The United States Buys a Canal

[1]In his report a year later Col. Craighill noted an unexpended balance of $2,500.

[2]Resolution adopted by the Board of Public Works, State of Maryland, in Baltimore Nov. 15, 1906.

[3]Col. W. M. Black, Col. Frederick V. Abbot, Lt. Col. J. C. Sanford, Lt. Col. Mason M. Patrick and Maj. R. R. Raymond.

[4]The canal was purchased August 13, 1919 for $2,514,000 as authorized by HD 196-63-1.

The Inland Waterway

[1]Completed in 1825—Mount Carbon to Philadelphia, 108 miles.

[2]Succeeded in 1895 by Mayor Charles F. Warwick.

[3]Thomas Martindale, L. Y. Schermerhorn, George W. Kendrick, Jr., Edwin S. Cramp, Daniel Baugh, John Wanamaker, Elias P. Smithers, W. W. Foulkrod, Hamilton Disston and Edward Morrell.

[4]Editorial, "Carts, Boats and Rails," 30 Oct. 1911.

[5]Statement of Hon. J. Hampton Moore; Public hearing at Custom House, Philadelphia, 14 July 1937 before a special board of Army Engineers.

[6]Senate Document 139, 79th Congress.

[7]A continuous navigation route, mostly sheltered, extending 2,900 miles from Boston, Massachusetts to the Rio Grande in Texas.

[8]A Soils Research Installation of the Corps of Engineers. When the Ithaca Section was discontinued, key personnel were transferred to the Wilmington and Philadelphia Engineer Districts and there developed the basic principles of the new science of Soils Mechanics.

[9]In engineering jargon, ascending or descending grade pitch is treated in proportions, as one on five. That is: for every five feet of horizontal extension, a one on five grade descends (or ascends) one foot, e.g.

The Good Defense

[1]Brig. Gen. A. Humphries, "Historical Sketch of the Corps of Engineers," *Occasional Papers*, No. 16, (Washington Barracks, D.C., 1876), passim.

[2]A letter dated 28 April 1776 suggests an ugly rift developing between Gridley and Washington, concerning the construction of the defences at Boston. The general writes:

> *"Who am I to blame for this shameful neglect but you, sir, who was to have them executed. It is not an agreeable task to be put under the necessity of putting any gentlemen in mind of his duty, but it is what I owe the public. I expect and desire, sir, that you will exert yourself in completing the works with all possible dispatch, and do not lay me under the disagreeable necessity of writing you again on this subject."*

[3]Brig. Gen. Edward Burr, "Historical Sketch of the Corps of Engineers, United States Army 1775-1865," *Occasional Papers*, No. 71, (Fort Belvoir, July 1939), passim.

[4]J. Bennett Nolan, *The Schuylkill*, (New Brunswick, 1951), p. 215.

[5]W. F. Heavey, "The Corps in the Days of the Revolution," *Military Engineer*, XXXI, No. 180, (December 1939), p. 410.

[6]When the Philadelphia District was assigned the mission of rebuilding the fortifications at Valley Forge in 1915, it did so by comparing du Portail's map with the so-called "Spy Map" made by a Tory in British pay and submitted to Sir William Howe, British commander in Philadelphia.

[7]Capt. Francois G. Ollivier, *Le Corps du Genie Aux Etats-Unis d'Amerique Pendant la Guerre de l'Independence, Revue du Genie Militaire*, LI, #2 (Paris 1922), pp. 514-542.

[8]Earl I. Brown, *Historic Fort Mifflin*, (Philadelphia 1932), pp. 1-9.

[9]Nolan, *The Schuylkill*, passim.

[10]Humphries, *Historical Sketch*, p. 5.

[11]Major Pierre L'Enfant, *American State Papers, Military History*, I (Washington 1832-1861), pp. 82-89; see also the report by Thomas Jefferson, "On Forts," in the same volume, pp. 192-197.

[12]The attack on the American frigate Chesapeake by the British frigate Leopard in June 1807, raised the national temperature. The British had removed and impressed 4 sailors from the Chesapeake, alleging them to be British seamen. Impressment and the emotions it roused were to be a major cause of the War of 1812.

[13]"Survey of the Works at Fort Delaware, And Proceedings of a Court-Martial on Major Babcock," *American State Papers*, 18th Congress, No. 264-communicated to the House of Representatives, 19 January 1825.

[14]J. St. George Joyce, ed., *The story of Philadelphia* (Philadelphia 1919), pp. 206-209.

[15]George Washington Cullum, "American Engineers of the War of 1812-15," *Campaigns of the War of 1812-1815* (New York 1879). passim.

[16]Brown, *Fort Mifflin*, p. 12.

[17]W. Emerson Wilson, *Fort Delaware* (Newark, Del. 1957), p. 16.

[18]U. S. Congress, *House Miscellaneous Document, No. 17*, 37th Congress, 2nd session, Vol. 1 (2 December 1861), pp. 1-2.

[19]Frank H. Taylor, *Philadelphia in the Civil War* (Philadelphia 1913), passim.

[20]Emmanuel Raymond Lewis, *Seacoast Fortification of the United States* (Washington, D.C. 1970), passim.

[21]*Annual Reports of the Chief of Engineers* (Washington 1903; 1904; 1905), passim.

[22]*Annual Reports of the Chief of Engineers* (Washington 1879), pp. 237-242.

[23]D. D. Heap, *Engineer Department U. S. Army at the International Exhibition 1876* (Washington 1884), p. 299.

[24]Wilson, *Fort Delaware*, p. 29.

[25]Gen. Johnson Hagood, *The Services of Supply, A Memoir of the Great War* (Boston 1927), passim.

[26]Lenore Fine and Jesse A. Remington, *United States Army in World War II. The Technical Services, The Corps of Engineers: Construction in the United States.* Washington, D.C. 1972, pp. 3-41.

[27]Francis A. Collins, *The Fighting Engineers* (New York 1918), pp. 191-193.

[28]Fine, *Construction*, p. 466.

[29]*The Binnacle (The Binnacle* was an in-house publication of the Philadelphia Engineer District and provided excellent source material for the 1940's), Vol. III, #2, (1942), passim.

[30]"Resume of Accomplishments of Philadelphia Engineer District as of January 1944"—forwarded to OCE 14 January 1944.

[31]"Ibid," p. 4.

[32]*The Binnacle* (October 1941), Vol. II, No. 10, pp. 18-19.

[33]*The Binnacle*, passim.

[34]Much of the information dealing with military construction from the Second World War through the termination of the District's mission in that context, on 1 July 1960, has been obtained through interviews with past and present District employees.

[35]*The Binnacle* (August 1947), Vol. 9, No. 8, pp. 7-8.

[36]U. S. Army Corps of Engineers, *McGuire-Dix Area* (Philadelphia 1960), passim.

[37]*History of Project at Birdsboro Ordnance Depot, Birdsboro, Pa.* (Philadelphia 1956), passim.

[38]Records of the Philadelphia Engineer District.

[39]Records of the Philadelphia Engineer District.

[40]Records of the Philadelphia Engineer District.

[41]*Capehart Family Housing, Fort Dix, N. J.* (Philadelphia 1960), passim.

[42]Records of the Philadelphia Engineer District.

A Wagon Provided For the Purpose

[1]*Pennsylvania Magazine*, Vol XXXIX, No. 3, 1915, pp. 375-76.

[2]Cullum, *American Engineers*, pp. 20-4.

[3]Bvt. Capt. Gustavus W. Smith, "Company A, Corps of Engineers, U. S. A., in the Mexican War, 1846-48," *Occasional Papers*, No. 16 (Washington Barracks, D. C., 1904), p. 109.

[4]J. Mayhew Wainwright, Assistant Secretary of War, "Lecture on Mass Procurement," delivered at the Army War College, G-4, Course No. 10, (Washington, D. C., 20 January 1904), p. 109.

[5]Ibid., pp. 22-23.

[6]Isaac F. Marcosson, S.O.S., *America's Miracle in France*, (New York,1919), passim.

[7]Hagood, *Memoir*, passim.

[8]Much of the material relating to World War I and in general to the period 1917 to 1939 has been extracted from the official records and correspondence files of the Philadelphia Engineer District.

[9]Wainwright, p. 25.

[10]*Directory of Field Agencies Engaged in Procurement Planning*, (Washington, 1923), pp. 12-14.

[11]*The Binnacle*, Vol. 1 (July, 1940).

[12]*The Binnacle*, Vol. 5 (November, 1944).

[13]*The Binnacle*, Vol. 6 (August, 1945).

[14]Letter from the Office of the Chief of Engineers to the Division Engineer, North Atlantic Division.

[15]Blanche D. Coll, Jean E. Keith, and Herbert H. Rosenthal. *United States Army in World War II. The Technical Services. The Corps of Engineers: Troops and Equipment* (Washington, D.C., 1958), pp 177-78.

[16]Presentation by Chief, Marine Design Division, September 1971, p. 15.

[17]Four (4) new 300/700 YD militarized hopper dredges were built by the Philadelphia District: The *Lyman*, *Barth*, *Davison*, and *Hyde*. The five older dredges which were completely militarized at the District were the *Rossel*, *Marshall*, *Harding*, *Hains*, and *Hoffman*.

[18]*The Binnacle* Vol. 6 (September, 1945).

[19]An interesting attempt at expediting the flow of supplies, the Industrial Mobilization Planning Program was doomed to failure, since its officers did not possess letter contracting authority, and the firms contacted were frequently undercut in open competitive bidding, invalidating the program's effectiveness.

[20]The treatment of the Military Supply Programs during and after the Korean Conflict is largely based on District records and on interviews with District personnel who participated in these programs.

[21]Colonel E. P. Yates, "USAHOME," *The Military Engineer*, November-December 1965, p. 414.

Dredging the Delaware

[1]Approximate annual inflow of solids from the uplands: 2,166,000 tons; (U. S. Geological Survey report: "Sedimentation Processes in Estuaries," 1965.).

[2]State of Pennsylvania dredging project authorized under Pennsylvania Assembly Act 441, the Desilting Act, 1945. The Federal Government aided the project financially.

[3]A consortium of eleven major oil companies, organized as the Delaware Bay Transportation Company.

[4]"The terminal would consist of a marginal wharf, located about six miles offshore near Big Stone Beach, Delaware, to accommodate 250,000 DWT tankers."—(Long Range Spoil Disposal Study, Substudy 6, page 9-a).

Marine Design—Unique Mission

[1]Authorized in ER 10-1-3, Appendix XX.

The Valley Report

[1]The "308 surveys," defined in the report of the Chief of Engineers, published as House Document 308, 69th Congress, 2nd Session, 1927.

[2]House Document 179, 73rd Congress, 2nd Session; one of eight basin studies made under the "308" authorizations.

[3]Essentially, a process of free discussion and quiet thinking which does not admit the authority of a majority; all decisions are made on the basis of unanimity, reached by a process which considers the opinion of every person. The Committee retained the procedure throughout its term of service.

[4]Renamed Francis E. Walter Dam 8 July 1963 to honor the Pennsylvania Congressman whose considerable efforts aided the enactment of legislation authorizing the Lehigh River Basin Flood Control Plan.

[5]President Dwight D. Eisenhower to secretary Wilbur M. Brucker; the White House, Washington; 22 October 1956.

Big Storms—Big Floods

[1]Major General F. P. Koisch, Corps of Engineers; Director of Civil Works Division, Office of the Chief of Engineers.

The Dams and Recreation

[1]"Reservoir" and "Lake" are terms used interchangeably to designate the pool created by the impoundment of a dam. As of 1970, the officially assigned term for Corps of Engineers projects is "Lake."

Appendix IV—Iron Pier

[1]Engineer Major Hartman Bache was an early proponent of wrought iron screw piles for offshore foundation structures. His plan for an ice harbor at Reedy Island was rejected for budgetary considerations in 1852, but the Lighthouse Board adopted his innovation for many of their structures in the Delaware Bay and Chesapeake Bay areas.

[2]In 1793, Philadelphia's population of 40,000 was reduced ten percent by yellow fever. The disease reached epidemic proportions again in 1802 and 1820, and cholera was rampant in Philadelphia in 1832.

GLOSSARY

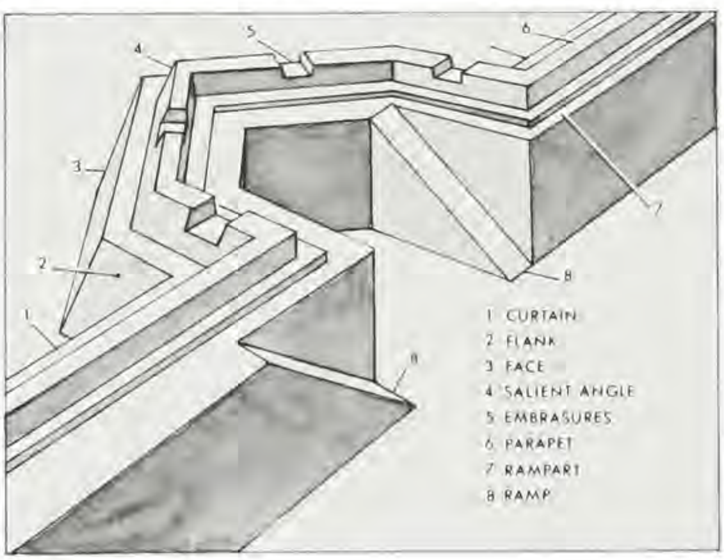
AAA—"Triple A" priority rating; during World War II, this was the highest priority designation which a project could be given.

APPLICATEUR—French term for the craftsman expert in the laying of "mastic" or asphaltic tar to protect and waterproof fortifications. Both the term and the artisan were much in use in 19th century America.

APRON—The extensive paved part of an airport located immediately adjacent to the terminal area or hangars and used for loading, unloading and parking aircraft.

ASPHALTIC CONCRETE—Graded aggregate (gravel-sized particles of crushed stone) bonded together into a solid mass by the addition of asphaltic cement. It is a durable, skid resistant, and economical surfacing material.

BASCULE—Drawbridge, usually of two leaves which open upward by hinging at the shoreward ends.



BASTION—An element of fortification that remained dominant for about 300 years before becoming obsolete in the 19th century. A projecting work consisting of two flanks and two faces terminating in a salient angle, it permitted defensive fire in front of neighboring bastions and along the curtain connecting them.

BATTERY—The basic tactical and administrative artillery unit, usually consisting of from two to six pieces, with the necessary personnel, transportation, communication, and equipment.

BERM—A relatively narrow, horizontal or gently sloping man-made bench or shelf, generally part-way up a slope.

BOW THRUSTER—A device to assist in maneuvering and docking a vessel; a power-driven propeller located in a transverse tube at the forward end of a ship, to provide lateral thrust at that point.

C.A.A.—Civil Aeronautics Authority—Established under the Civil Aeronautics Act of 1938 as an independent agency under an Administrator authorized to encourage development of civil aeronautics and air commerce and establishment of civil airways, landing areas, and other air navigation aids and facilities; transferred to Federal Aviation Agency by act of Congress, 23 August 1958.

CANTONMENT—A group of more or less temporary structures for housing troops.

"CAPEHART ACT" HOUSING—Armed services housing program under which almost 100,000 units of government-owned, government-built military family housing were under construction by the end of 1958; with an average cost of $16,500 per unit (at a legislated cost limit range of from $12,000 for enlisted mens' quarters to $20,000 for a general's house). Designed as both supplement and successor to the Wherry Act, Capehart Housing answered many of the objections raised to the earlier program.

CASEMATE—A fortified, usually masonry position or chamber, in which cannon or other guns could be placed to fire through embrasures. (From the Italian *casa matta*—"mad house.")

CHEVAUX-DE-FRISE—("Frisian horses")—obstacles composed of barbed wire or iron spikes attached to a wooden frame, used to block enemy advancement.

COLD-DRAWN EXTRUSION—A process whereby metal is drawn through a die and shaped, without prior heating.

"COPPERHEAD"—A political epithet applied to Northerners who sympathized with the Confederacy during the Civil War; so called because of an alleged resemblence to the venomous copperhead snake, which does not rattle and strikes from concealment.

C.O.R.—A Contracting Officer's Representative was given the authority to act on behalf of the contracting officer in all matters pertaining to the fulfillment of that contract, except changes in contract specifications, or actions which would result in the default or termination of the contract. Each engineer district was granted C.O.R. inspection responsibility for all contracts with firms located within district limits.

COST-PLUS-FIXED FEE CONTRACT—Essentially a contract for service, in which the contractor was reimbursed for all legitimate expenses except home office overhead, executive salaries, and interest on borrowed money; for his services, he was paid a fee, determined at the time of negotiation, based on the original estimate of cost, and not subject to alteration except in the case of a major change in the scope of the project. It was imployed most frequently on projects where urgency, rather than cost economy, was an overriding factor.

C.Q.M.—Constructing Quarter Master—That semi-autonomous branch of the Quartermaster Corps responsible for the greater part of the military construction mission in the 1920's and '30's.

CULM—Coal dust and dirt; waste from anthracite coal mines.

DISAPPEARING CARRIAGE—A carriage for heavy coast guns on which the gun is raised above the parapet for firing and upon discharge is lowered automatically behind the parapet for protection.

DISPOSAL AREA—A tract of land or water enclosed by dikes or bulkheads for deposit of spoil material. Area is equipped with drains to aid settling and compaction of the solids.

DREDGE—Any of various machines equipped with scooping or suction devices used in deepening harbors and waterways and in underwater mining; or a boat or barge equipped with such a machine.

DWT—Dead Weight Tons.

EN BARBETTE—A mound of earth or specially protected platform on which guns were mounted to fire over a parapet.

ENGINEER UTILITY ITEMS—These items of engineer equipment, procured by and for the use of engineer troops, included pumps; electric power generator sets; knocked-down metal and fabric storage tanks; industrial gas-generating equipment; water purification units; fire-fighting equipment and refrigeration equipment.

E.S.C.O.—The Engineer Supply Control Office, in St. Louis, served as a coordinating point, and central clearing house for all military engineer supply requisitions, during and after the Korean conflict.

ESTUARY—That part of river where its currents are met and affected by tidal action; a tidal channel.

FASCINE—Bundle of sticks used in reinforcing fortifications.

FLOOD—A condition arising from excessive accumulation of water in streams and other bodies of water, causing them to overflow and inundate flood plains and adjacent areas.

FLOOD PLAIN—The land adjoining a stream of other body of water that is subject to flooding from overbank flow.

FROG—A device on intersecting railroad tracks that permits wheels to cross the junction.

INCLINED PLANE—A boat railway used in supplement of locks to surmount extreme heights on the early canals. Various versions of cable-drawn rail cars transported the canal boats between water levels.

INDUSTRIAL MOBILIZATION PLANNING PROGRAM—A program begun in the late 1940's to contact essential industries and prepare lists of potential suppliers of engineer utility items, in the event of a national mobilization ("M" day).

ITEM PLANT MANUAL—A manual designed to instruct and guide government inspectors in the proper manner of examining those factories which were parties to government contracts. They were only to be used to train the inspectors, not to conduct actual inspections.

LIGHTERING—A procedure in which a large cargo vessel unable to navigate in shallow water, transfers part or all of its cargo to smaller vessels (lighters), which in turn convey the cargo ashore. VLCC (Very Large Crude Carrier) supertankers often have to lighter in American harbors, which lack the minimum depths necessary to handle the giant ships.

MASTIC—Asphaltic tar used as a protective coating on cement or masonry construction.

MEGALOPOLIS—The East Coast's rapidly developing super-city; urban-industrial saturation of the land belt between Washington, D. C. and Boston, Mass.

PARAPET—An earthen or stone embankment protecting soldiers from enemy fire.

PLANE OF REST—A horizontal plane below which the action of the sea is assumed to be so small that it may be ignored. (In studies of the old Delaware breakwater assumed at 12 feet below mean low water).

PONTON—In military usage, a float, often in the form of a boat, used to provide buoyancy for the superstructure and imposed loads of a float bridge; not to be confused with *pontoon*, a completely inclosed, water-tight, often pneumatic structure attached to an aircraft to give it buoyancy and stability when in contact with water.

PROCUREMENT—Includes purchasing, renting, leasing, or otherwise obtaining supplies or services. It also includes all functions that pertain to the obtaining of supplies and services, including description (but not determination) of requirements, selection and solicitation of sources, preparation and award of contract, and all phases of contract administration.

REDOUBT—A small, often temporary defensive fortification; or a reinforcing earthwork or breastwork within a permanent rampart.

RIFT—A shallow area in a waterway; probably dialectal variant of reef—a ridge of rocks, sand or coral that rises to or near the surface of a body of water.

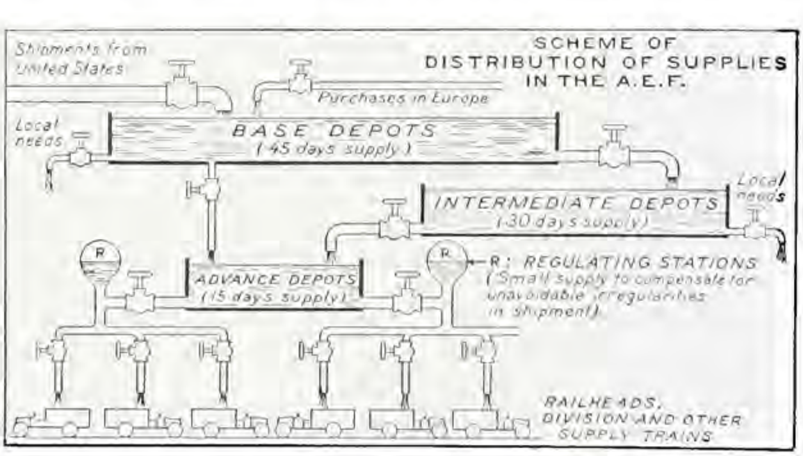
RIPRAP—A protective shell of random stone laid on the slopes of dikes, dams and channels to prevent erosion due to water motion. Generally installed on compacted surfaces, it may be hand-placed or machine-dumped and employs pieces of unfinished stone in the general weight range of one pound to about 10 tons.

RUBBER DREDGING SLEEVE—Rubber hose used to connect lengths of metal pipe from dredge to shore; an item procured Corps-wide by the Philadelphia Engineer District.

SAPPERS—Military engineers engaged in the digging of "saps" or tunnels to undermine enemy fortifications, preliminary to the placing of explosive charges by "miners" or demolition experts. At Valley Forge, General DuPortail suggested that the sappers . . . should be instructed in everything that relates to the Construction of Field works—how to dispose of the Earth—to cut the Slopes—face with Turf or Sods—make fascines—arrange them properly—cut and fix Palisades &ca."

SCARP—A nearly vertical, sometimes walled side of a ditch below the parapet of a fortification.

SLOPE OF STABILITY—Angle of a structure, which, through the action of the elements, has attained a "permanent" position.



S.O.S. (Services of Supply)—An acronym for the masthead organization under which all supply units of the A.E.F. in World War I were grouped.

Originally known as the Line of Communications, it included all supply activities and installations up to the Zone of Operations. The appended diagram from General Pershing's war memoirs illustrates the system in operation.

SPOIL—Refuse material removed from a stream bed or other excavation.

STRAND—Land bordering a body of water, especially the area between tide marks.

SUPPLY—In an engineer context, supply means all property except land or interest in land. It includes public works, buildings, and facilities; ships, floating equipment, and vessels of every character, type, and description, together with parts, and accessories thereto; aircraft and aircraft parts, accessories, and equipment; machine tools; and the alteration or installation of any of the foregoing.

TECHNICAL MANUAL—A manual which sets forth the maintenance and operating procedures of the equipment procured.

THOROFARE—On local navigation charts, a regional designation for the narrow winding courses the natural channel takes through the marshland reaches behind the barrier beaches of the New Jersey coast.

UNIT INTEGRITY—A military training concept in which a particular unit lives, messes and works as a separate functional organism; designed to develop *esprit de corps* or group responsibility among members of that unit.

VECTOR—An organism that carries disease-causing agents from one host to another.

VITRIFIED CLAY—Clay which has been exposed to intense heat, resulting in a compacted, glassy ceramic surface; used in making clay pipe.

"WHERRY ACT" HOUSING—The title VIII housing program, Public Law 221 of the 81st Congress, was designed to assist in relieving the acute shortage and urgent need for family housing which existed at or in areas adjacent to military installations. They were privately funded, and rented to military personnel at what was ultimately determined to be too high a level to attract the military on a voluntary basis. Furthermore, they were found to be generally below the standards of public quarters built with appropriated funds. Purchase by the military was recommended in 1956.

SELECTED BIBLIOGRAPHY

Any attempt to write history must ultimately concern itself with the matter of making the proper choices, of extruding from an unsifted morass of records, files, published and unpublished documents, the thread of a coherent, viable narrative. This volume has been culled from a broad range of sources, including extensive interviews with past and present personnel of the Philadelphia Engineer District; District files and records; the facilities of the Federal Records Centers in Philadelphia and throughout the Nation; the Library Company; the Historical Society of Pennsylvania; the National Archives, Library of Congress, and the Office of the Chief of Engineers in Washington; the Engineer Museum and Library at Fort Belvoir, Virginia; the libraries and collections of a number of public and private institutions in the Philadelphia area; and a wide variety of published materials, including books, monographs, articles and essays. The following list offers a brief accounting of published works consulted by the authors in the preparation of this history. Works of general information, such as dictionaries, encyclopedias, and standard general histories have been omitted.

Arthur, Robert. "Early Coast Fortification," *The Military Engineer, LIII,* #354 (1961), 279-281.

Barnard, J. G. "Biography of the Late Bvt. Major General Joseph G. Totten, Chief Engineer, United States Army," *Occasional Papers,* No. 16. Washington, 1904.

Bathe, Greville. *An Engineer's Miscellany*. Philadelphia, 1938.

Binnacle, The. Philadelphia, 1940-56.

Brandt, Francis B. *The Majestic Delaware,* Philadelphia, 1929.

Brewington, M. V. *Chesapeake Bay, A Pictorial Maritime History*. New York, 1956.

Brown, Earl I. *Historic Fort Mifflin*. Philadelphia, 1932.

Brumbaugh, G. Edwin. *Fort Mifflin, on Historic Mud Island in the Delaware River*. Philadelphia, 1959.

Burr, Edward. "Historical Sketch of the Corps of Engineers, U. S. Army," *Occasional Papers*, No. 71. Washington, 1939.

Buzzaird, Raleigh B. "America's First Chief Engineer," *The Military Engineer* XXXIX, #266 (1947), 505-510.

. "Insignia of the Corps of Engineers," *The Military Engineer*, L, #333 (1958), 25-29.

"Washington's Favorite Engineer," *The Military Engineer*' XL, #269 (1948), 115-118.

"Washington's Last Chief Engineer," *The Military*

Engineer, XLV, #304 (1953), 118-122.

. "Washington's Most Brilliant Engineer," *The Military Engineer*, XLI, #283 (1949), 358-365.

Chief of Engineers, United States Army. *Annual Reports of the Chief of Engineers*. Washington, 1879, 1903, 1904, 1905.

Chief of Engineers, United States Army. *Historical Report of the Chief Engineers, A.E.F.* Washington, 1919.

Coggins, Jack. *Arms and Equipment of the Civil War*. New York, 1962.

Coll, Blanche D., Jean E. Keith and Herbert H. Rosenthal. *United States Army in World War II. The Technical Services. The Corps of Engineers: Troops and Equipment*. Washington, 1958.

Collins, Francis A. *The Fighting Engineers*. New York, 1918.

Commanger, Henry S. and Richard B. Morris, eds. *The Spirit of '76*. New York, 1967.

Commonwealth of Pennsylvania. *Water Resources Inventory Report, Part III*. Harrisburg, 1917.

Corps of Engineers Museum. *Geneses of the Corps of Engineers*. Fort Belvoir, 1966.

Crowell, Benedict and Robert F. Wilson. *How America Went to War*. New Haven, 1921. 6 vols.

Cullum, George W. "American Engineers of the War of 1812-15," *Campaigns of the War of 1812-15*. New York, 1879.

Biographical Register of the Officers and Graduates of the U. S. Military Academy. *Boston, 1891-1930. 7 vols.*

Dawes, Charles G. *A Journal of the Great War*. Boston, 1921. 2 vols.

Directory of Field Agencies Engaged in Procurement Planning. Washington, 1923.

Ellis, Robert R. "Richard Gridley: First Chief Engineer of the Army," *The Military Engineer*, LV, #365; #366; #367 (1963), 157-160; 265-268; 344-347.

Fine, Lenore and Jesse A. Remington. *United States Army in World War II. The Technical Services. The Corps of Engineers: Construction in the United States*. Washington, 1972.

Fitzpatrick, John C., ed. *The Writings of George Washington from the Original MS Sources, 1745-1799*. Washington, 1931-1944. 39 vols.

Ford, Washington C. and others, eds. *Journals of the Continental Congress*. Washington, 1904-1937. 34 vols.

Ford, Worthington C. *Defenses of Philadelphia in 1777*. Brooklyn, 1897.

Four Times Panama: A Century of Dredging the American Way, 1867-1967. 100th Anniversary publication of the American Dredging Company. Philadelphia, 1967.

Freedley, Edwin Troxell. *Philadelphia and its Manufactures.* Philadelphia, 1859.

Geib, Geo. A. "A Graphical History of Engineer Organizations," *The Military Engineer*, XIII, #69 (1921), 282-284.

Haferkorn, Henry E. "List of Publications printed by The Battalion Press and by the Engineer School Press," *Occasional Papers*, No. 43. Washington, 1910.

Hagood, Johnson. *The Services of Supply, A Memoir of the Great War.* Boston, 1927.

Harlow, Alvin S. *Old Towpaths.* New York and London, 1926.

Heap, D. D. *Engineer Department U. S. Army at the International Exhibition 1876.* Washington, 1884.

Heavey, W. F. "The Corps in the Days of the Revolution," *The Military Engineer*, XXXI, #180 (1939), 410-415.

Hill, Forest G. *Roads, Rails and Waterways: The Army Engineers and Early Transportation.* Norman, 1957.

Homans, Benjamin, ed. *Military and Naval Magazine of the United States.* Washington, 1833-1835. 6 vols.

Hoyt, William G. and Walter B. Langbein. *Floods.* Princeton, 1955.

Huddy, William M., ed. *The Military Magazine and Record of the Volunteers of the City and County of Philadelphia.* Philadelphia, 1839-1842. 3 vols.

Hudson Coal Company. *The Story of Anthracite.* New York, 1932.

Humphries, A. A. "Historical Sketch of the Corps of Engineers," *Occasional Papers*, No. 16. Washington, 1904. 1-54.

Hurley, Edwin N. *The Bridge to France.* Philadelphia, 1927.

Huston, John. *Hydraulic Dredging.* Cambridge, 1970.

Ingersoll, Charles J. *Historical Sketch of the Second War Between the United States of America and Great Britain.* Philadelphia, 1845-52. 3 vols.

Jackson, Joseph. *Early Philadelphia Architects and Engineers.* Philadelphia, 1923.

Jacobs, David and Anthony E. Neville. *Bridges, Canals, and Tunnels.* Washington, 1968.

Johnson, Leland R. "19th Century Engineering: Part I, The Contest of 1824; Part II, The Contract of 1824," *The Military Engineer*, LXV, #425; #426 (1973), 166-171; 252-257.

Joyce, J. St. George, ed. *The Story of Philadelphia.* Philadelphia, 1919.

Kite, Elizabeth S. *Brigadier-General Louis LeBegue Du Portail*. Baltimore, 1933.

Leopold, L. B. and T. Maddock, Jr. *The Flood Control Controversy*. New York, 1954.

Lewis, Emmanuel R. *Seacoast Fortification of the United States*. Washington, 1970.

Linn, John B. and Wm. H. Egle, eds. "Plans for the Construction and Raising of the *Chevaux De Frize* in the Delaware River, 1775-1784," *Pennsylvania Archives*, Second Series, I (1879), 749-773.

Marcosson, Isaac F. *SOS, America's Miracle in France*. New York, 1919.

Marestier, Jean Baptiste. *Memoir on Steamboats of the United States of America*. Paris, 1824. Reprinted by the Marine Historical Ass'n. Inc. Mystic, 1957.

Martin, Roscoe C. and others. *River Basin Administration and the Delaware*. Syracuse, 1960.

Marx, Wesley. *The Frail Ocean*. New York, 1967.

McCloskey, Joseph F. "History of Military Road Construction," *The Military Engineer* XLI, #283 (1949), 353-356.

Menzies, Elizabeth G. C. *Before the Waters*. New Brunswick, 1966.

Miller, Benjamin L. *Lehigh County Pennsylvania, Geology and Geography*. Harrisburg, 1941.

Northampton County Pennsylvania, Geology and Geography. Harrisburg, 1939.

Miller, John P. *Pricing of Military Procurements*. New Haven, 1949.

Morton, James St. Clair. *Memoir of the Life and Services of Captain and Brevet Major John Sanders*. Pittsburgh, 1861.

Nolan, J. Bennett. *The Schuylkill*. New Brunswick, 1951.

Ollivier, Francois G. "Le Corps du Genie Aus Etats—Unis d'Amerique Pendant la Guerre de l'Independence," *Revue du Genie Militaire*, LI (1922), #2, 514-542.

Pennsylvania Arts and Sciences Guidebook. Philadelphia, 1935.

Pennsylvania Magazine, XXXIX, No. 3 (1915), 375-76.

Pershing, John J. *My Experiences in the World War*. New York, 1931. 2 vols.

Poore, Benjamin P. *A Descriptive Catalogue of the Government Publications of the United States*, 1774-1881. Washington, 1885.

Rees, Thomas H. and G. A. Youngberg. "History of Engineer Troops in the United States Army, 1775-1901," *Occasional Papers*, No. 37. Washington, 1910.

Report of the Canal Commission of Philadelphia as Transmitted to the Select and Common Councils of the City of Philadelphia. Philadelphia, 1895.

Ringwalt, J. L. *Transportation Systems in the United States*. Philadelphia, 1888.

Risch, Erna. *Quartermaster Corps: Supply and Services*. Washington, 1951.

Roe, Charles H. "The Building of Fort Delaware," *The Military Engineer*, XXI, #118 (1929), 350-354.

Roscoe, Theodore and Fred Freeman. *Picture History of the U. S. Navy*. New York, 1956.

Sanders, John. *Military Resources of the West*. Washington, 1845.

Scheffauer, F. C., ed. *The Hopper Dredge*. Washington, 1954.

Simon, F. Lester. *Dredging Engineering*. New York and London, 1920.

Smith, Gustavus W. "Company A, Corps of Engineers, U.S.A., in the Mexican War, 1846-48," *Occasional Papers*, No. 16. Washington, 1904. 66-111.

Spaulding, Oliver L. *The United States Army in War and Peace*. New York, 1937.

Taylor, Frank H. *Hand Book of the Lower Delaware River, The*. Philadelphia, 1895.

Philadelphia in the Civil War. Philadelphia, 1913.

Thompson, Gilbert. "The Engineer Battalion in the Civil War," *Occasional Papers*, No. 44. Washington, 1910

Trevelyan, Sir George O. *The American Revolution*. London, 1899-1907. 4 vols.

Turtle, Thomas. "History of the Engineer Battalion," *Essayons Papers*, Vol. 1, No. 8. Washington, 1868.

U. S. Army Corps of Engineers. *Capehart Family Housing, Fort Dix, N. J.* Philadelphia, 1960.

U. S. Army Corps of Engineers. *History and Traditions of the Corps of Engineers*. Ft. Belvoir, 1953.

U. S. Army Corps of Engineers. *History of Birdsboro Ordnance Depot, Birdsboro, Pa.* Philadelphia, 1956.

U. S. Army Corps of Engineers. *Long Range Spoil Disposal Study, Part I through Part VII*. Philadelphia, 1969.

U. S. Army Corps of Engineers. *McGuire-Dix Area*. Philadelphia, 1960.

U. S. Army Corps of Engineers. *Report on Operation Five High*. New York, 1963.

U. S. Army Corps of Engineers. "Stations of the Regular Army, 1846-1937," *Occasional Papers*, No. 70. Washington, 1938.

U. S. Army Corps of Engineers. *The Sump Rehandler Dredging Technique*. Philadelphia, 1957.

U. S. Army Corps of Engineers. *Water Resources Development by the U. S. Army Corps of Engineers in New Jersey*. New York, 1967.

U. S. Congress. House of Representatives. *Chesapeake and Delaware Canal.* 53rd Congress, 3rd Session. House Executive Document No. 102. Washington, 1894.

U. S. Congress. House of Representatives. *Delaware River Basin Report.* 87th Congress, 2nd Session. House Document No. 522. Washington, 2 April 1962.

U. S. Congress. House of Representatives. *Intracoastal Waterway: Final Report on Sections From New York Bay to Delaware River, and Thence to Chesapeake Bay*. 63rd Congress, 1st Session. House Document No. 196. Washington, 1913.

U. S. Congress. House of Representatives. *Report on Intracoastal Waterway—Boston, Mass. to Beaufort, N. C. Section*. 62nd Congress, 2nd Session. House Document No. 391. Washington, 1912.

U. S. Congress. The Senate. *Proposed Acquisition of Chesapeake and Delaware Canal.* 64th Congress, 1st Session. Senate Document No. 14. Washington, 1915

U. S. Congress. The Senate. *Waterway to Connect Waters of Chesapeake and Delaware Bays.* 59th Congress, 2nd Session. Senate Document No. 215. Washington, 1907.

U. S. Congress. "Survey of the Works at Fort Delaware, and Proceedings of a Court-Martial on Major Babcock," *American State Papers, Class V: Military Affairs* Vol. 2. 18th Congress, 2nd Session. House Document No. 264. Washington, 1825.

United States Government. *American State Papers*. Washington, 1832-1861. 38 vols. *Class V: Military Affairs*, 1789-1838. 7 vols.

United States Government. *Annals of Congress*, 1789-1824. Washington, 1825-37. 42 vols.

United States Government. *House Miscellaneous Documents*, No. 17, 37th Congress. Vol. 1.

United States Government. *Journal of the Executive Proceedings of the Senate of the U. S., 1789-1901*. Washington, 1909. 34 vols.

United States Government Printing Office. *Checklist of U. S. Documents, 1789-1909*. Washington, 1911.

Vandiver, Frank E., ed. *The Civil War Diary of General Josiah Gorgas.* University, Alabama, 1947.

Vauban, Sebastien Le Prestre de. *A Manual of Siegecraft and Fortification.* Transl. by George A. Rothrock. Ann Arbor, 1968.

Vauban, Sebastien Le Prestre. *Memoire pour servir d'instruction dans la conduite des sieges et dans la defense des places*. Leiden, 1740.
Maniere de fortifier de M. de Vauban. Amsterdam, 1689.

Vauban, Sebastien Le Prestre. *Maniere de fortifier de M. de Vauban.* Amsterdam, 1689.

Veit, Richard F. *The Old Canals of New Jersey*. Little Falls, 1963.

Weldes, Harry E. *The Delaware*. New York, 1940.

Wilson, Mitchell. *American Science and Invention*. New York, 1954.

Wilson, W. Emerson. *Fort Delaware*. Newark, Del., 1957.

Winslow, Eben E. "Notes on Seacoast Fortification Construction," *Occasional Papers*, No. 61. Washington, 1920.

Yates, E. P. "USAHOME," *The Military Engineer*, (November-December 1965), 414.

Young, John Russel. *Memorial History of the City of Philadelphia (1681-1895)*. New York, 1895.

INDEX

Lt. Col. C. S. Stewart
1866-1871

Lt. Col. J. N. Kurtz
1871-1877

Col. J. N. Macomb
1877-1882

Lt. Col. G. Weitzell
1882-1884

Maj. J. C. Sanford
1903-1908

Maj. C.A.F. Flagler
1905-1907

Maj. Herbert Deakyne
1908-1912

Lt. Col. Joseph E. Kuhn
1912-1913

Col. W. B. Ladue
1919-1921

Maj. L. E. Lyon
1921-1922

Col. F. C. Boggs
1923-1928

Lt. Col. G. B. Pillsbury
1928-1930

Col. H. B. Vaughan, Jr.
1940-1943

Col. A. H. Burton
1943-1944

Col. Clarence Renshaw
1944-1945

Col. Frederic F. Frech
1945-1949

Col. A. F. Clark, Jr.
1955-1957

Col. W. F. Powers
1957-1959

Col. T. H. Setliffe
1959-1963

Col. E. P. Yates
1963-1966

Maj. W.H. Heuer
1884-1885

Lt. Col. H. M. Robert
1885-1890

Maj C. W. Raymond
1890-1901
1902-1903

Col. J. A. Smith
1901-1902

Col. George A. Zinn
1913-1916

Maj. J. C. Oakes
1916-1917

Col. Mark Brooke
1917-1918

L. D. Shuman C. E.
1918-1919

Col. Earl I. Brown
1922-1923
1930-1933

Col. J. A. Woodruff
1933-1934

Lt. Col. John C. H. Lee
1934-1938

Maj C. W. Burlin
1938-1940

Col. Earl E. Gesler
1949-1950

Col. Ralph E. Cruse
1950-1952

Col. Walter Krueger, Jr.
1952-1954

Col. R. J. Fleming, Jr.
1954-1955

Col. W. W. Watkin, Jr.
1966-1968

Col. J. A. Johnson
1968-1971

Col. C. D. Strider
1971-1973

Col. C. A. Selleck, Jr.
1973-