Number, nationality, and tonnage of vessels.

Steamers, barks, &c.	1877.		1878.	
	No.	Tons.	No.	Tons.
Steamers:				
American	164	146,482	120	86,445
Barks:				
American	2	907	1	442
Norwegian	78	25,493	87	27,870
German	42	15,976	51	18,402
British	22	7,851	45	16,645
Swedish	11	3,787	6	2,090
Spanish	5	1,823	9	3,150
Russian	1	330	2	664
Danish	2	613	----	----
Brigs:				
American	15	3,823	8	2,385
Norwegian	23	6,237	31	5,663
German	13	3,289	15	3,823
British	35	10,819	39	11,958
Swedish	4	1,081	4	1,076
Spanish	6	1,491	6	1,745
Dutch	2	279	2	394
Italian	1	370	----	----
Danish	----	----	1	223
Schooners:				
American	137	30,750	123	25,277
British	4	633	9	864
Norwegian	----	----	1	354
Total American steamers	164	146,482	120	86,445
Total American sailing-vessels	154	35,480	132	28,094
Total foreign sailing-vessels	249	80,072	308	95,921

F 15.

SURVEY OF BARS AT ENTRANCE TO ANNAPOLIS HARBOR, MARYLAND.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., January 8, 1879.

GENERAL: The law of June 18, 1878, required a "survey of the bars at the entrance of Annapolis Harbor, Maryland, with a view to the accommodation of deep-draught vessels at low-tide." The survey was made in September, 1878, by Mr. Seager, an assistant from this office. He also prepared the map, a copy of which is herewith.

A careful study of this locality has, at my request, been made by Capt. J. W. Cuyler, Corps of Engineers, who, with Mr. Seager's aid, has prepared an estimate of the cost of connecting the deep water of the bay with the deep water of the Severn River, and thus permitting "vessels of deep draught" to pass over "the bars at the entrance" and come into the "harbor of Annapolis."

Captain Cuyler has submitted a report, dated January 4, 1879, a copy of which is herewith. The estimate is based upon the understanding that "deep-draught vessels" would find a channel 24 feet deep at mean low-tide sufficient for their accommodation. The average rise of the tide is about 1 foot, which would make the channel about 25 feet deep at mean high-water. It is supposed the channel would be used only by steamers or by sailing-vessels towed by tugs. The channel estimated for is 150 feet in width, which may be considered the minimum that would suffice.

The average depth of dredging to make such a channel as has been described would be about 4 feet, and the cost about $55,000.

It is probable the channel would not remain permanently open unless

a system of jetties or other works were constructed to increase the volume of flow through it, or to intercept matter in motion which would otherwise fall into the dredged channel and reproduce the bars which it is proposed now to remove in part.

A determination of the best location and method of construction for such auxiliary works requires a longer time and more money in observations of the directions, force, and transporting power of the various currents of the locality than it has been possible up to this time to give. Such works would be quite expensive. A first step in the direction indicated would probably be a work for shore protection at Greenberry Point. Captain Cuyler submits an approximate estimate of $17,000 for beginning work of this character.

If reliance be placed altogether upon dredging to keep open the excavated channel, observation of the rapidity of its filling can alone determine with accuracy the annual cost of redredging. It is supposed the expenditure of $10,000 per annum would suffice.

Efforts have been made to procure information as to the importance of the improvement of the entrance to Annapolis Harbor, as is usual. I can learn but little on the subject. In this connection reference may be made to the following papers herewith:

Extract from a letter to me from Rear-Admiral Rodgers, Superintendent of the Naval Academy, dated October 7, 1876.
Letter of the city counselor of Annapolis to the admiral, dated March 19, 1876.
Reply of the admiral, dated March 21, 1876.
Extract from report of Capt. C. B. Phillips, Corps of Engineers, dated October 30, 1876.

Very respectfully, your obdt. servt.,

WM. P. CRAIGHILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF CAPT. JAMES W. CUYLER, CORPS OF ENGINEERS.

BALTIMORE, MD., *January* 4, 1879.

COLONEL: Pursuant to your verbal directions, I have respectfully to submit the following report, based upon that clause in the act of Congress approved June 18, 1878—the last river and harbor act—directing examination and survey of "the bars at the entrance of Anapolis Harbor, Maryland, with a view to the accommodation of deep-draught vessels at low tide."

The field-work of the survey was put in charge of Assistant John L. Seager, of your office, by you, and was successfully executed by Mr. Seager, with a small party, between September 9 to 26, inclusive, 1878. To Mr. Seager, who also worked up all the field-notes, &c., I am entirely indebted for valuable and skillful co-operation in the preparation of this report.

The accompanying map covers the entire area necessary for the object had in view, and exhibits, in detail, the present condition between the 24-foot curve *outside* in Chesapeake Bay, which depth is taken as the appropriate one for the "accommodation of deep-draught vessels at low-tide," and the deep water—ranging from 24 feet to 36 feet—inside in the Severn River just below and abreast of the United States Naval Academy. The plane of reference of the survey is that of mean low-water, as deduced from observations made during its progress, there not being found at Annapolis any authenticated bench or mark for the determination of this or any other plane of reference. Comparison and inquiry, however, demonstrate that the plane, as taken, is practically that of mean low-water, the mean tidal range being found to be 0.92 feet, or 0.02 feet greater than that given by the Coast Survey charts, whose observations for this purpose extended continuously over a period of thirteen months in 1844 and 1845.

Between the outside and inside limits above described—a distance of 15,300 feet (2.94

miles) measured, as vessels now come in, on a line nearly straight, having but two small deflection-angles in it—the entire water-area is embraced between the 15-foot curves next either shore. From the 24-foot curve outside, the bottom of this present channel-area shoals up very gradually to the 20-foot curve in 3,000 feet.

From this latter curve the channel-area extends in 5,090 feet, with a mean depth upon it of 18½ feet, with bottom very uniform; passing this inwards, another area is attained, embraced between the 24-foot and 20-foot curves, and reaching up some 5,270 feet, to well inside of Greenberry Point, the northerly headland of harbor entrance, and abreast of Horn Point, the southerly headland. Passing farther in, another area of comparative shoalness is met with, having an average depth of 18½ feet, and, at a distance of 2,100 feet, passing into the deep natural channel of the Severn with a depth of 22 feet, thence deepening in 3,000 feet farther up—to abreast of the Naval Academy—to 24 feet and greater depths. From this it will be seen that the two areas of comparative shoalness—depth, 18½ feet—above described constitute the "bars at the entrance to Annapolis Harbor," 5,090 feet (outer) and 2,100 feet (inner) wide, respectively.

Both these so-called "bars" are drift and wave bars, formed by the littoral currents and the action of the waves in those storms to which their respective exposures lay them open. From the position of each, relative to its adjacent point of the harbor entrance proper, the method of formation becomes evident. The outer "bar" stretches south-southeasterly, with its crest, or line of least depths, but a little to the outside of the prolongation of Greenberry Point, the northerly point of the harbor entrance. The general direction of the main shore-line of the bay, from Tally's Point down, stretches similarly, but falling away more to the westward. There is thus left a wide expanse of water entirely exposed to the south and southeast storms—from the position of Annapolis, high up the bay—the most violent and disturbing of the storms; north and northeast storms striking full against Greenberry Point, and even the shore north of it, wash out the soft and light soil composing the land here and carry it in suspension until a certain proportion of it is brought back and deposited on the "bar" by the opposing and predominating southerly storms. Inquiry and examination show Greenberry Point itself—a headland about 18 feet in height, composed of light clay soil, with bluff face—to be washing away quite markedly, the light-house keeper here reporting that during his residence in charge, of nine years, the point has washed away about 100 feet. Data are lacking to show the exact amount of abrasion, or its rate of progress, but that there is considerable, inspection indicates unmistakably. The bottom, too, over this "bar," soft (excepting of course, detached oyster-beds) and of clayey sand, with rare beds of hard sand, goes to further confirm this fact.

By a similar process is formed the inner shoal area, situated relative to the southwesterly harbor entrance point—Horn's Point—as is the outer to Greenberry Point; only, as this area stretches east-northeasterly from "Horn's" and is open to gales from this quarter which from the extent of bay swept over cannot have the force or disturbing effect of storms to the southward, what might be termed the width of this area—2,100 feet—is less than that of the outer shoal—5,090 feet. On this side, too, of the water the shore is generally low. Horn's Point being the mere end of a low inland ridge, lower and of less extent than Greenberry Point, there is not the same quantity of material offered for abrasion. There are, too, probably more "flats" on this side, the 15-foot curve being farther out than on the northerly side by reason of the shore from Horn's to Tally's Point, where is taken up the general trend of Chesapeake Bay shore-line on west side, lying in a curve normal to the north and east storms, and gathering the storm deposits in its hollow.

The channel into the Severn is of that class maintained by the flood-tide. It possesses the typical flat seaward slope, with the quick dip into deep water (comparative, of course, in this particular case) on the inside belonging to this class of channels; the ebb-tide, passing out between Greenberry and Horn Points a distance straight between of 4,900 feet, is at once dispersed over the open expanse of the bay, and has no scouring effect whatever. The Severn, though with an unusually deep channel, really ends its navigable waters at Round Bay, a deep and wide interior basin 5½ miles (about) above the mouth proper, so that its volume of discharge is less than what might be supposed; the discharging waters, emptying at once into a wide open area, exercise no scouring action, finding their way into the deep waters of the main bay as nearly directly as the interposition of the shoal areas formed by the storms, as above described, will allow of. Neither does the river discharge any freshet waters; its drainage area is too limited, and its channel of soft mud, edged by banks and points of hard sand with little water on them, showing no change, as proved by the Coast Survey maps, running back to 1846. These same charts show, also, but slight and slowly-progressing changes on the outside of the harbor proper; almost a condition of permanence, in point of fact. If the analysis of existing conditions, then, as above given, be correct, considering the present demands of commerce on this harbor, the method to be pursued to attain the object held in view would seem to me to be that of dredging. It is believed the character of this would be favorable, and for the reasons above quoted but small periodical repairs would be required for a channel once so made; 24 feet would of

course be the depth throughout, and for all present needs 150 feet in width at bottom with side slopes of 1½ or 1 would suffice. On the map such a channel has been outlined by Assistant Seager, the principles governing its laying down having been, firstly, to give as direct an outlet as possible to the waters of the Severn into the deep water of the bay; secondly, to take advantage of all deep "pockets" in this general line for economy's sake; and, thirdly, to so locate the outer end of the channel on the 24-foot curve, outside, as to admit of an easy and convenient entrance into it by vessels, both going up or down Chesapeake Bay; it thus differs somewhat from the course now followed by vessels using this harbor, though the length of artificial channel measured on mid-line is practically lengthened thereby to 16,560 feet (linear) of dredging. But four deflection-angles are made in this channel, all easy (the outer 22°, the next inner 18°, the third 04°, the fourth 25°), with widths of from 260 feet to 300 feet to give free room for changing direction. The mean depth of cutting, aggregating the several sections, it is estimated would be 3.94 feet, allowing 0.50 foot for the filling in behind bucket (a liberal allownce in so slight a cutting).

	Cubic yards.
Total estimated excavation	406,000
Cost, at 13 cents per yard	$52,780

With the dredging of the proposed channel should go on works for the protection from further abrasion of Greenberry Point, to stop the filling in, across from it, of the made channel, and, later on, of Horn Point. Further and more detailed examination would be requisite to determine whether these works should be in the nature of a solid pile and square timber revetment, encircling Greenberry Point, after the manner of a sea-wall, or in that of a series of light shore groins, or deflectors, running out to about 6 feet of water, and inclined to the shore-line, down the bay, with a view of intercepting the littoral currents, close in, and causing them to drop their suspended matter and make beach. Such groins should extend up the bay shore at least 1,500 feet above the point. The cost of the first class of structure, in this position, would be about $28 per foot (running); that of the second, about $8.50; more running feet, though, considerably, of the second class would have to be built than of the first; an approximate estimate—all that can now be given—is then given to begin such work with, of $16,800, an equivalent of 600 feet linear of protection of the first class.

It is not considered advisable to recommend the adoption of any other system of improvement, such, for example, as jetties, to confine the volume of the in and outward flow to produce scour, certainly at least to begin with. Jetties, to be effective here, would require a location involving great extent, and, from the exposure, much solidity in construction, so giving a large first cost. It is questionable, also, whether, if properly placed, jetties might not seriously interfere with the facilities now enjoyed by, and which would be required to a greater extent still, in case of an improvement being made here by, navigation.

I have the honor, sir, to remain, very respectfully, your obedient servant,

JAMES W. CUYLER,
Corps of Engineers.

Col. W. P. CRAIGHILL,
United States Corps of Engineers.

EXTRACT FROM LETTER OF REAR-ADMIRAL C. R. P. RODGERS, UNITED STATES NAVY.

UNITED STATES NAVAL ACADEMY,
Annapolis, Md., October 7, 1876.

MY DEAR SIR: * * * I send you herewith a copy of the correspondence between the city authorities of Annapolis and myself in regard to the proposed deepening of the channel. At present we have no serious difficulty in bringing our practice-ships into the harbor at high-water, but it would be a convenience to us were the channel deepened.

* * * * * * *

I am, very respectfully, your obedient servant,

C. R. P. RODGERS,
Rear-Admiral, Superintendent.

Maj. WM. P. CRAIGHILL,
United States Corps of Engineers.

LETTER OF THE CITY COUNSELOR OF ANNAPOLIS TO REAR-ADMIRAL C. R. P. RODGERS, UNITED STATES NAVY.

ANNAPOLIS, *March* 19, 1876.

SIR: The authorities of this city, and our citizens generally, are very much interested in a movement recently started to deepen the harbor of Annapolis and improve the access to it, by cutting through the bars interfering with the approach of the heavier class of shipping. We hope and think that such an improvement would, besides assisting Annapolis, prove an incidental advantage to the great interests of the government located here. If you be of this opinion also, and would not object to expressing it as briefly or as fully as you desire, that we may put in possession of it our present Representative in Congress from this district, Hon. Eli J. Henkle, for the information of the House Committee on Appropriations, you will oblige the authorities of the city.

Requesting an answer,

I am, sir, with great respect, your obedient servant,

WM. T. IGLEHART,
City Counselor.

Rear-Admiral C. R. P. RODGERS, U. S. N.,
Superintendent Naval Academy.

LETTER FROM REAR-ADMIRAL C. R. P. RODGERS, UNITED STATES NAVY, TO CITY COUNSELOR OF ANNAPOLIS.

UNITED STATES NAVAL ACADEMY,
Annapolis, Md., March 21, 1876.

SIR: I have the honor to acknowledge the receipt of your letter of the 19th instant, and I beg to say in reply that I should esteem it not only advantageous to Annapolis, but, under certain circumstances, advantageous to the general government, if the channel to our inner harbor could be deepened. There are neither rocks nor wrecks to interfere with dredging. At present the usual depth of water on the bar is 19 feet at low-water; the average rise of the tide is about 1 foot; the maximum rise about 2½ feet. From the best information I possess, the Coast Survey chart, made several years since, is still correct in all essential points, though some of the flats have grown in extent. Our larger ships must wait for a very favorable tide to cross the bar; the largest cannot now enter at all.

At all times Annapolis has been the most easy and favorable point at which large ships could repair to be near Washington.

Ships of war of various powers have often sought anchorage here for that purpose, as it is abundantly set forth in our historical records; and in the late civil war its strategic value to the capital of the United States was conspicuously apparent.

I have not studied the cost or the methods of deepening the channel nor its commercial value, but I shall be sincerely glad if the project shall be proved feasible and carried into effect.

I am, sir, very respectfully, your obedient servant,

C. R. P. RODGERS,
Rear-Admiral, Superintendent.

Hon. WILLIAM T. IGLEHART,
City Counselor, Annapolis, Md.

EXTRACT FROM REPORT OF CAPT. CHARLES B. PHILLIPS, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., October 30, 1876.

MAJOR: I have the honor to report that, in accordance with instructions received from you, I visited the harbor and city of Annapolis, Md., on the 25th instant, for the purpose of collecting data to assist in reporting upon "the necessity and cost of an examination and survey of the harbor at Annapolis, Md., and an estimate of the cost of the removal of the bars at the entrance thereto," and in stating "whether the general interests of commerce will be subserved by such examination or survey."

I was accompanied on my reconnaissance of the harbor by Captain Kerwan, master of the Baltimore and Annapolis steamboat, who was detailed for the service by Captain Ensign, president of the Maryland Steamboat Company. To both of these gentlemen I am much indebted for their co-operation.

* * * * * * *

Upon inquiry, I find three classes of shipping interested in the navigation of the water approaches to Annapolis: 1st. Vessels (mainly of light draught) running regularly to and from the port, and carrying on the local commerce of the city. 2d. Coasting and oyster vessels, which use the harbor solely as a point of refuge from ice and inclement weather. 3d. Deep-draught United States Navy vessels.

It is not likely, in the event of an improvement of this harbor, that any plan would be adopted by the government which would be of the slightest benefit to the vessels of the class first mentioned; that is to say, this class of shipping has already an ample depth of water for its needs, and it could only be benefited by giving the channel greater width by cutting off a few points of shoals which now interfere somewhat with sailing-vessels. The latter plan would hardly be adopted in a channel which, though not wide, is by no means circuitous.

For the same reasons, vessels of the second class mentioned would derive no benefit from any probable plan of improvement, if we except deep-draught coasters, which might occasionally seek refuge at this port in case a greater depth of water existed.

The party most interested in the improvement of the harbor appears to me, then, to be the United States Government, in behalf of its deep-draught Navy vessels.

Admiral Rodgers, Superintendent of the United States Naval Academy, in his letter of March 21 last, to the authorities and citizens generally of Annapolis, sets forth the advantages likely to accrue to the government in the event of an increased depth at the entrance to the harbor.

From this letter, and from a conversation which I had with the admiral on the subject, I ascertain as follows: The practice-ships at this station are unable to enter the harbor at low-water, but experience no great difficulty in passing in and out at high-water. It is seldom, however, that they are required to leave the harbor. Our largest Navy vessels cannot enter the harbor under any circumstances.

On account of its proximity to Washington, it is believed that the port would be largely used by the Navy if a sufficient depth of water existed to accommodate the largest vessels. The admiral also cites the late civil war as demonstrating the strategic value of the port of Annapolis.

In view of all of the above, I cannot say that the general interests of commerce would be subserved to any considerable extent by an examination or survey of the harbor in question.

The interests of the United States Government in behalf of its Navy, however, are such, in connection with this port, that I should deem it a very judicious measure on its part to cause such a survey to be made.

I am, major, very respectfully, your obedient servant,

CHAS. B. PHILLIPS,
Captain of Engineers.

Maj. W. P. CRAIGHILL,
Corps of Engineers, U. S. A.

F 16.

EXAMINATION OF WEST BRANCH OF PATAPSCO RIVER, FROM LIGHT STREET BRIDGE TO THE HEAD OF TIDE-WATER.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., January 20, 1879.

GENERAL: In the act of June 18, 1878, directions were given for the making of an examination or survey of the "West Branch of the Patapsco River, from Light street bridge to the head of tide-water, and an estimate of the cost of making the same navigable for canal-boats."

Only a small sum could be allotted for this examination, which (under the general supervision of Captain Cuyler) was made in November, 1878, by Mr. John L. Seager, an assistant engineer from this office, who also prepared the map and has aided with the estimates and report.

The subject of the improvement has, at my request, been carefully studied by Capt. J. W. Cuyler, Corps of Engineers. A copy of his report, dated January 18, 1879, is forwarded herewith. He has given a detailed description of the portion of the river surveyed, which need not be repeated.

It was supposed that this survey was ordered in the interest of the Chesapeake and Ohio Canal, with a view to a change of terminus to Baltimore, and the estimates therefore assume a depth (6 feet) for the improved river such as would suffice for boats to be probably used on that canal if extended to Baltimore. By resorting to the simple process of dredging, a suitable channel could be very soon made, but it would soon disappear by the deposition in it of the large quantity of sediment carried by the stream. It is to be expected that greater stability of channel would be obtained by contraction of the water-way and confinement of the water to a channel of a width less than the natural width, and varying according to the circumstances, which should be carefully taken into account if a definite determination should be attempted. An approximate location of this channel is indicated on the map. Captain Cuyler's estimate for dredging, diking, embanking, &c., amounts to $173,000, which, by adopting a cheaper method, might, he thinks, be reduced to $100,000. I doubt the availability of the cheaper method, and think his larger estimate should be increased by not less than 20 per cent., which would bring it to $207,600.

The characteristics of this stream are such, that it is even doubtful whether the channel thus made, at an expense of more than $200,000, would be permanent. Before undertaking such a work the whole subject should be thoroughly studied. To do this has not been possible with the means provided by Congress up to this time. It is very probable that, upon full investigation, it may be found to be better to make an independent canal, to be fed by water from the Patapsco above the upper limits of this survey, rather than attempt to render the stream navigable.

No attempt has been made to estimate the compensation which would be demanded by riparian owners or others who have been understood to have claims, under patents from the State, to certain portions of the flats now under water, the value of which would probably be affected by any proper improvement of the Western Branch.

As one indication of the importance attached by the legislature of the State of Maryland to the improvement of this portion of the Patapsco River, a copy is inclosed of an act approved April 11, 1874, the object of which was to incorporate the "Maryland Canal Company."

It is stated in the law that, in order to secure to Baltimore a portion of the large and increasing trade of the Chesapeake and Ohio Canal, a branch thereof is necessary, and the importance is pointed out of a connection by canal from the head of navigation on the Eastern Branch of the Potomac River to the head of navigation on the Patapsco River. The company is authorized "to use such portions of the Patapsco River as the company shall deem best."

The growth of the commerce of the city of Baltimore, leaving out of consideration a possible extension of the Chesapeake and Ohio Canal, has been such in the past few years as to increase the importance of the occupation of those portions of the Western Branch near the city. This state of affairs will doubtless continue.

A paper is also appended, dated January 20, 1879, prepared by Mr. W. R. Hutton, the engineer of the Chesapeake and Ohio Canal.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF CAPT. JAMES W. CUYLER, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., January 18, 1879.

MAJOR: Pursuant to your verbal directions, I have respectfully to submit the following report, based upon that clause in the last river and harbor bill, act of Congress approved June 18, 1878, directing an examination and survey of the "West Branch of Patapsco River, from Light street bridge to head of tide-water, and an estimate of the cost of making the same navigable for canal-boats."

The field-work of the survey was successfully executed by Assistant J. L. Seager, of your office, with a small party, between November 4 and 30, inclusive. The late season, with attendant cold and inclement weather and continued westerly winds, driving the water out of the river and rendering boat navigation nigh impracticable, combined to make the work severe and tedious to all engaged in it.

The plane of reference of the survey is that of mean low-water, as deduced from half-hourly readings of a tide-gauge established at Light street bridge (where this branch may be said to pass into the main Patapsco channel) during the 18½ days of its actual duration. Lack of time and means prevented the establishment of a second tide-gauge at the other end of the line of survey (head of tide-water), to be read with synchronous readings to the one at Light street bridge, *as also* the running of a line of levels to head of tide-water, to determine the surface-slope of the stream and its approximate discharge, both field operations highly needful, *if not essential*, to the correct determination of the questions involved.

The survey-observations work out a mean tidal range of 1.10 feet (13¼ inches), as against a mean range of 1.16 feet given by Coast Survey map made in 1876-'77, for advisory board on harbor-lines of Baltimore harbor, a map based upon extended and nice field-work; but the determining tide-gauge for this latter survey was kept, as is recorded, at Henderson's wharf, Fell's Point, a point quite remote and otherwise situated where it is believed certain local conditions affected the difference now found. Similarly, a departure from this same Coast Survey map is now found in that portion of this survey just at the mouth of the West Branch, a short distance around and above Light street bridge, where, over this area and that more to the southwestward along the bridge, there is now found less water by 0.7 foot (about) than the Coast Survey map shows.

This difference in the direction of shoaling not having a direct practical bearing, so far as the objects of the present survey are concerned, however, for these objects the deduced plane of reference may be taken as practically correct.

The length of line of present survey is 6.97 miles, measured form Light street bridge along midline of meanderings of river, following its main direct channel, and ending just above crossing of Washington Turnpike Bridge about the head of tide-water; for, though the swell of the tide can be observed as far as the foot of the dam, some 150 feet above the viaduct of the Baltimore and Ohio Railroad, or about 1,500 feet above the end of the survey, extreme shoalness of the water and lack of time prevented the extension hereto of the line of survey. Not even, indeed, though, as far up as the end of the survey line is the inflowing wave of flood tide, observable; the point where this is perceptible will be noted further on in this report, and the tidal swell observed as far up as it is, is due, it is submitted, to the damming-up of the waters here by the inflow of the flood-tide wave below.

The data afforded by the survey point to the existence of a water-slope of about 0.3 foot in its line, nearly if not all of which would be found in the upper one-fourth of the line, a perceptible downward current being noted for some distance *below* even the terminus of the line. As, moreover, canal-boats would have to enter the river from canal no higher than the mouth of Deep Run, 1,115 feet below actual end of survey, and, as inquiry shows, this mouth is the proposed canal outlet, the requirements as to carrying the survey up to the head of tide-water are practically complied with, it is believed.

The map of survey, also made by Assistant Seager, to whom I have again to express indebtedness for essential and skillful co-operation in the preparation of this report, accompanies this. It is as full as the circumstances would allow of making it. To better describe the stretch of river it covers, I have divided it into six sections, distinguished by mean widths, depths, and general natural features, as summarized below.

Section No. 1.—Extends from above Washington Turnpike Bridge to mouth of Deep Run, 3,575 feet; mean width, 97 feet; no depth to exceed 2 feet; average 1 foot (scant), with many places where but 0.4, 0.3, 0.2 foot show; bed well defined, banks, 5 to 10 feet above water-surface, present most unfavorable features for improvement. As the location of the canal outlet is at Deep Run mouth, this section, for all the practical purposes of this examination, may be here dismissed from any further consideration.

Section No. 2.—Extends down from section 1 (lower end) 2,220 feet, to Baltimore and

Potomac Railroad bridge, crossing stream about 50 feet above water, and thence on 1,910 feet, a total length of 4,165 feet; mean width, 132 feet; stretches, or "pockets," of some length embraced by the 3-foot curve first appear in this section. These reaches run in width from 40 to 60 feet; lie now in mid-stream, now close to banks, and have 3 to 4 feet water in them. They are separated, though, by longer stretches of shoals or sand bars, with but from 1 foot to 0.6 foot water on them; the bed is much broken in on by bare bars or spits of sand. On northerly side several sloughs or bayous intervene between main channel and real north shore. This bank is low, subject to overflow, while on southerly bank more clearly-defined high lands border the stream, a current moving ever down-stream perceptible throughout; does not present favorable features for improving; occupies a sharp bend in course of river.

Section No. 3.—Extends down from section 2, 8,380 feet; mean width, 205 feet. The stream in this section passes into what may be termed more a tidal river, with corresponding attributes; generally it occupies the arc of a circular curve, with large radius of curvature—not under 3,000 feet—connected with section No. 2 by a short, sharp reverse curve. The area embraced between the 3-foot and 6-foot curves runs nearly continuously the length of the section, excepting the upper 2,000 feet, where "pockets" only of this depth are met, as in section No. 2. The bars intervening between the deep-water reaches (3 feet and over) are short, having 1.5 to 2.5 feet water on them. The widths embraced by 3-foot curve run from 60 to 100 feet; at lower end of section this deep area occupies nearly entire bed, while above it there are found, as might have been expected, lying in next to northerly or concave bank, short stretches, embraced between 6-foot and 9-foot curve. Two thousand feet below end of section 2 is the point where, as noticed before in this report, the up-flow of the flood-tide seems to end, and what may be termed the limit of present navigation, an oar-barge being "poled" up on high water to a dock here, below which no current down stream could be noted; 500 feet above lower end of this section is another dock, to which a small steamer periodically ascends: ridges, entirely defined, skirt both shores a short distance back from river edge; banks well defined, and no large tracts exposed to overflow.

Section 4.—Extends down from section 3 6,920 feet to just below Switzer's Bridge; mean width, 280 feet. The river marks itself more as such in this section. Its course still occupies the other branch of the circular curve described for section 3. The deep water (3 to 6 feet) occupies nearly the whole bed, save where stream widens to 400 feet, when interspersed shoals have 2.5 feet on them. The banks slope regularly to the 3-foot curve. About Switzer's Bridge the 6, 9, and 12 foot curves appear, the two former for reaches of some extent. For lower half section, a large swamp or low land, cut by sloughs and drainage courses, lines the southerly shore, and on north shore a wider expanse of low ground appears, the banks being not so well defined here and the stream widening to the 400 feet width above noted.

Section 5.—Extends down from section 4 8,400 feet; mean width, 345 feet; course lies in a sharp reverse curve below Switzer's, connecting with a long, straight reach; resembles more a river mouth in this section; low land or swamp lines the south bank for over 200 feet back, while on north side, in the lower straight reach noted above, the bank is a mere swamp of sedge, 1,700 feet across at widest, intersected by small blind "guts"; on northern edge of this swamp is another channel of the river (or, better, an indent from the main Patapsco) from 180 to 400 feet across to the main northern shore, with from 2 feet to 0.4 foot of water spread irregularly over it, connected by a "gut" with upper end of section; a 4-foot channel 160 feet wide extends whole length on concave bank or parallel to shores in straight reach; a regular slope from this depth up to edge of bank above water, long reaches, embraced between 6-foot and 9-foot curves, appear, and one reach of 860 feet, with 12 feet and over of water in it.

Section 6.—Extends from end of section 5 to Light-street Bridge, 5,350 feet; the river in this ceases to be a river, being an indent or arm from the main Patapsco, the distance between actual north and south shores being 3,400 feet; the 4-foot channel of section 5 passing out into this wide open area is speedily lost, and the whole area is a shoal with from 1 to 2 feet water on it, save at northern lower corner around the "draw" of the bridge—situate diagonally to the end of section 5—where the 3-foot, 6-foot, and 9-foot and 12-foot curves show concentrically, for distances of 1,800 feet, 1,200 feet, 760 feet, and 460 feet from bridge at its northerly end.

Passing from the above particular description to a general study of the river, the following features manifest themselves:

Whenever the river widens, whether with defined banks or with edgings of low land overflowed by freshets, there invariably appear the shoals (under 3-foot curves) as far up as the lower end of section No. 2. The limits horizontally of this widening, inducing shoaling, vary, of course, with position in the river; wherever the waterway is contracted within these limits, invariably scour takes place, at points markedly. At Switzer's Bridge is a case in point, where not only does the natural water-way contract, but the piers and auxiliary pile-work of the bridge further diminish the sectional

area. As a result the 9-foot and 12-foot curves show at once and abruptly. The upper end of straight reach, lower half of section 5, is another example. Indeed, so marked is this tendency that a study of the map shows deep "pockets" wherever points of land or tongues of sand-spits project out, or even where old pile-work or artificial works take up space in the normal section. Also, when sloughs or "guts" divert water from main channel, shoals appear. This is perhaps most notable in section 2, though here all the natural features are so diminished that analogies from the lower sections scarce apply. For this reason, then, it would seem to me best, so far as the improvement of the river is concerned, to bring in the canal 1,500 feet below lower end of section 2, if it were possible to do so. From the map, such a location for inlet of canal would seem practicable.

The soundings, water-marks on banks, and all other indications, point to the material of this valley as being of a very unstable character. The bare bars are of fine brown sand; the bottom is of this sand and of soft mud. Both readily transported, and in all likelihood a survey another year, or even another time of year, would show notable changes in the extent, in some cases, of the location of the 3-foot curves the natural mean depth of the river. The downward current noticed at upper end can be seen to be abrading the bolder south shore. This material is carried down but a little way and dropped, thus the local loss being compensated for in small limits as to distance. Data are not available to determine the height, duration, recurrence, or effects upon the regimen of floods or freshets. It is only known generally that the usual spring freshets rise about 4 feet at narrow upper end, and are not of long duration. Toward the mouth the rise is probably under 4 feet, as considerable ground can be overflowed hereabout. Rises of from 0.5 foot to 1.5 feet are apt to occur, as due to local rains, at any time.

With these conditions existing, the method of improvement to be adopted, whereon to base the required estimate, presents itself. "Canal-boat" navigation is specified, as this river would be the outlet of the Chesapeake and Ohio Canal; the dimensions, &c., of that work would fix generally those of this contemplated improvement, a width of 60 feet at top, side slopes 2 base to 1 perpendicular, and 6 feet depth on miter-sills are the limits (exterior) of this canal.

To merely dredge out a channel in the river of the requisite dimensions, while the work would be simple and easy, would not meet the case. From the foregoing analysis, such a made deep channel could not be relied on to maintain itself for any series of years consecutively; it would be, at best, shifting and uncertain, and might be entirely destroyed at once.

The tidal range is too small, and the length of river to be influenced by this range too great relatively, to rely on this as an agent to maintain a stable channel, even if once made.

The plan then clearly suggested, from the statements given above, of narrowing the natural water-way to within such limits as to scour out and keep a 6-foot deep channel remains.

To effect this, spur-dikes, whether run out normal to shore lines or inclined up or down stream, would not, in my judgment, here apply. Even with rivers whose entire regimen is on a greater scale, such jetties, to be effective, must be located close together; otherwise, if wide basins are not made between adjacent jetties, where sediment is dropped and shoals or "lumps" formed thereby, with much of a current, there is a "swirl" between jetties, the effect of which is to cut out deeply along face near end, and, at end, of the lower jetty, undermining this, and also to make a counter-current running obliquely across stream from lower jetty end, which checks the main-current and makes accretion on the other side of bed and on that bank. In this case, with slope, volume of discharge, velocity, tidal range, all small, jetties, to prolong their beneficial effects for continuous "reaches," would have to be inconveniently close together.

The plan of canalization by lateral close dikes does not seem open, in this case, to the objections that can be urged against it in streams whose hydraulic factors are all larger. The ordinary difference between high and low stages is such that in keeping the top of the dikes 15 inches (or 18 inches) above mean low-water, the freshet waters can readily find escape in the overflowing of the bordering bottom-lands, and the river subside naturally into its made low-stage channel. The present velocity is such that, with the contraction required, no undue or irregular erosion of the bed by it can ensue. The natural widths afford ample margin to make the contraction within, with no excavation above water, save at upper end, where some dry bars and tongues of sand would have to be dredged out to give the requisite lines. The course of the stream allows the dikes to follow easy curves, passing imperceptibly from one to another without sharp reversals or direct impinging upon the banks by the waters. Four sharp curves, with radii of curvature from 405 feet to 185 feet, are necessitated at the upper end (section 2), below canal inlet as now located, because of the sharp curvature here of the natural water-way. Below these, the radii are from 2,000 feet to 3,000 feet—amply easy for all canal-boat navigation, especially as it is intended to use steam to tow these boats on the improved river. No great strength, involving cost, is demanded for the dikes. Wattle-work, in some cases, could be used, though sheet-piling should