42D CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { EX. DOC. No. 267.

LIGHT-HOUSE AT NEW HAVEN HARBOR.

LETTER

FROM

THE SECRETARY OF THE TREASURY,

IN ANSWER TO

A resolution of the House of March 20, 1872, relative to removing the light-house at New Haven Harbor to Southwest Ledge.

APRIL 18, 1872.—Referred to the Committee on Commerce and ordered to be printed.

TREASURY DEPARTMENT,
Washington, D. C., April 17, 1872.

SIR: In accordance with the resolution of the House of Representatives of 20th March last, upon motion of Hon. S. W. Kellogg, I have the honor to transmit a report of the Light-House Board relative to the expediency of removing the light-house at New Haven Harbor, Connecticut, from its present position to Southwest Ledge, together with the papers marked A, B, C, D, E, and F covered by, and referred to in, said report.

I am, very respectfully,

GEO. S. BOUTWELL,
Secretary.

Hon. J. G. BLAINE,
Speaker House of Representatives.

TREASURY DEPARTMENT,
OFFICE OF THE LIGHT-HOUSE BOARD,
Washington, April 16, 1872.

SIR: In answer to your letter of the 23d March, transmitting resolution of the House of Representatives relative to removing the light-house at New Haven Harbor to Southwest Ledge, I have the honor to say that the board has received from the local officers of the third light-house district, viz, Brevet Brigadier General I. C. Woodruff, engineer, and Commodore J. H. Strong, inspector, letters concerning the project, of which the inclosed are copies. Please also to find, herewith, a copy of a letter from General Warren, the engineer officer in charge of the improvement, under the War Department, of the rivers and harbors in that district, and a chart of New Haven Harbor. It will be seen from

these papers that Southwest Ledge lies in the middle of the main ship-channel into New Haven Harbor, and forms a great danger to navigation; that there are but seven feet six inches of water on the rock at mean low water; that the question is between a removal of the rock by the War Department and the erection by the board of a light and fog-signal to keep vessels from running upon it and other dangerous rocks in the vicinity. The main light at the entrance is now at Five-Mile Point, on the mainland on the east side of the harbor, and distant one mile from and inside of Southwest Ledge. It was established in 1805, and last refitted in 1855. There is no doubt but that a light in the channel on this ledge would serve the interests of navigation better than the present light, and that it and a fog-signal also placed on the rock would be of more benefit to commerce than the removal of the ledge, since vessels could always run for the light and keep clear of all the many dangers to navigation which, it will be observed, exist at the entrance to New Haven Harbor.

A light-house at Southwest Ledge would involve a very large expense on account of its submarine foundation, and the strength which would be required to resist the large fields of ice by which it would be assailed. The expense is estimated at $117,800.

The resolution of the House of Representatives is herewith returned, with the papers, of which the following is a list, and which it is hoped will furnish the information desired:

1st. Letter from the light-house engineer of the third district, marked A.

2d. Letter from the light-house inspector of the third district, marked B.

3d. Letter from General Warren, Corps of Engineers, who is charged, under the War Department, with the improvement of the harbors on Long Island Sound, marked C.

4th. Letter from the Secretary of War, in answer to a resolution of the House relative to the improvement of New Haven Harbor and Housatonic River, Connecticut, dated the 12th of February, 1872, being Executive Document No. 137, House of Representatives, Forty-second Congress, 2d session, marked D.

5th. Letter from the Secretary of War, in answer to a resolution of the House of March 20, relative to removing the light-house at New Haven Harbor, Connecticut, to Southwest Ledge, dated April 2, 1872, being Executive Document No. 237, House of Representatives, Forty-second Congress, 2d session, marked E.

6th. Chart of New Haven Harbor, marked F.

Very respectfully,

JOSEPH HENRY,
Chairman.

Hon. GEORGE S. BOUTWELL,
Secretary of the Treasury.

A.

OFFICE OF LIGHT-HOUSE ENGINEER THIRD DISTRICT,
Tompkinsville, Staten Island, N. Y., April 9, 1872.

SIR: In obedience to your instructions of the 25th ultimo, relative to the proposed transfer of the New Haven Harbor light from its present position to Southwest Ledge, near the entrance of the harbor, a resolution of inquiry having been introduced into the House of Representatives by the Hon. Mr. Kellogg as to its advisability, a copy

of which accompanies your letter of instructions, I beg leave to submit the following report:

The numerous ledges and isolated rocks at the entrance of this harbor render the approach thereto hazardous, and no system of range-lights could be devised to serve the purpose of marking each ledge or the channel-ways between them. The removal of the ledge, also alluded to in your letter of instructions as an alternative, would be attended with excessive cost, an estimate for which would be vague at the best, and the removal of other ledges and rocks would be equally necessary.

The only effectual and economical remedy would seem to be to erect a light on Southwest Ledge, the most prominent ledge in the channel-way, and to discontinue the present light.

The fog-bell at the present station does not fulfill its purposes as a reliable guide for entering, owing to its feebleness and its distance from the dangers. If it were placed on the Southwest Ledge, vessels could shape their course toward the signal and the harbor be made with certainty.

General G. K. Warren, Corps of Engineers, who has made, under the order of the Chief of Engineers, minute surveys at the entrance of the harbor with the view to its improvement, has kindly, on my application for them, furnished tracings of the entrance, showing the location of the ledges and contour of the Southwest Ledge; the latter is indispensable, as, without the information supplied thereby, it would be impossible to submit so promptly an accurate estimate of the cost of a suitable structure upon the ledge called for in your letter of instructions.

I beg leave to acknowledge herein the valuable assistance rendered me by General Warren by this contribution of the results of his surveys.

After a study of this subject, I am of the opinion that it is practicable to erect on Southwest Ledge a solid piece of granite, fifty feet in diameter, in an average depth of ten feet at mean low water. The entire height of the pier is proposed to be twenty-nine feet; surmounting the pier, a dwelling for keeper and assistant keeper, three stories in height, tower and lantern over dwelling. The focal plane of the light may be fixed at sixty-two feet above mean low water.

The lens of fourth order now in use at New Haven light is quite adequate for the locality, as the adjacent lights on Faulkner's Island and Stratford Points are distant about twelve miles on either side. A fog-signal of proper power should be adopted. The estimated cost of a structure of the kind described is, taking the bids for Race Rock light-house as a basis, $117,800.

I transmit herewith copies of the tracings of the entrance of the harbor, and of the contour of Southwest Ledge, which were furnished by General Warren, and a tracing of the proposed light-house on the ledge in elevation only.

Very respectfully, your obedient servant,

I. C. WOODRUFF,
Lieutenant Colonel of Engineers, Engineer Third Light-House District.

Prof. JOSEPH HENRY, LL. D.,
Chairman Light-House Board.

B.

OFFICE OF LIGHT-HOUSE INSPECTOR THIRD DISTRICT,
No. 16 *Broadway, New York, April* 8, 1872.

SIR: In compliance with instructions of the board, dated 25th ultimo, directing me to investigate and report as to the advisability of transferring the New Haven Harbor light to the southwest ledge, so called, near the entrance to said harbor, I visited, on the 2d instant, the present light-house and the Southwest Ledge, or site of the proposed transfer; and from personal observation, embracing, as I think, all the circumstances affecting the case, I have reached these conclusions—

1. At the first establishment of a light to guide into New Haven Harbor the Southwest Ledge would have been a preferrable location to the site of the present light-house.

2. The transfer of the light would involve the necessity of building a new light-house, and all the necessary adjuncts; in a word, to transfer means the erection of a new station, and the extinction of the old one.

3. The estimated cost of building a light-station for the exhibition of a fourth-order light on the so-called Southwest Ledge, where the bottom is of rock, 8 feet of water at low tide, and a rise and fall of from 4 to 5 feet, is $117,800.

The question of probable cost being one for the consideration of the engineer of the district, I submitted it to General Woodruff, who furnished me with the figures given, his estimate being as follows, viz, $117,800.

A light on the Southwest Ledge would be a better guide for vessels in the sound, and for entering the harbor, for small craft, using at night the passages east of the ledge, and would extend the range of the fog-signal.

Against these advantages is the heavy expense of the undertaking, which is a matter for the consideration of the board, to whom I respectfully submit it.

I have the honor to be, sir, your obedient servant,

J. H. STRONG,
Commodore U. S. N., Light-House Inspector 3d District.

Professor JOSEPH HENRY, LL.D.,
Chairman Light-House Board, Washington, D. C.

C.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, March 27, 1872.

SIR: I have the honor to submit the following report in regard to the expediency of removing the light-house at the entrance to New Haven Harbor, Connecticut from its present position to Southwest Ledge.

I would recommend that the change be made for the following reasons:

1. In approaching the harbor from the eastward the light is not visible until nearly abreast of it, being shut out by woods. In coming from the westward the light is so situated as to render its position very deceptive, making it appear nearer than it really is; many vessels ground on the west shore flats from this cause.

2. If the light-house was on the ledge, vessels could run for it until it was close aboard, then haul to the northward, pass to the westward of the light, and head up the harbor directly for the fired red light on long wharf, thus following the line of best water up the harbor, avoiding all rocks and shoals. The light-house would also serve as an excellent channel-mark, by day as well as by night. In consequence of the present position of the light, it is necessary to run by bearings and estimated distances, thus rendering dangerous the entrance to the harbor.

3. The woods in the vicinity of the present light-house so deaden the sound of the fog-bell that in those fogs accompanied by a southerly breeze it is impossible to hear the bell more than 600 or 700 feet, except when directly abreast—to the westward of the light. This would be obviated by placing the light-house upon the ledge, besides thus greatly improving the entrance to the harbor itself; the position of the light on Southwest Ledge would be about one mile farther out in the sound, and would furnish an excellent object for vessels passing along the sound to steer by and correct their position in thick weather. New Haven Harbor is much used as a harbor of refuge, and should the light-house be placed on Southwest Ledge, vessels whose captains were not acquainted with the harbor could readily find refuge.

The nearest lights are Falkland Island light, 12 miles to the eastward, and Stratford light, about 12 miles to westward. Every reason that occurs to me justifies the removal of the light-house to Southwest Ledge. Five-Mile Point should be reserved as a site for a fort. Southwest Ledge has now over it at mean low water 7.5 feet, and is composed of granitic rock. The contours of the rock on a scale of 10 feet to one inch are shown on a tracing I sent you with my report of December 23, 1871. (H. Ex. Doc. No. 137.) I return herewith the copy of the resolution sent me.

Yours, respectfully,

G. K. WARREN,
Major Engineers, and Brevet Major General, U. S. A.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers, U. S. A., Washington, D. C.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, March 28, 1872.

MAJOR: I have received your communication of the 26th in relation to the light-house at New Haven Harbor.

I inclose you a copy of my report concerning it, made to the Chief of Engineers yesterday.

All the maps are in the Chief Engineer's office at Washington.

I also inclose you a printed copy of my report on New Haven Harbor, giving the cost of removing the Southwest Ledge, and those ledges contiguous to it called B and C and Middle Rock. This estimate is given on page 3, and the amount is $88,700. This I consider a low estimate. I cannot estimate the cost of the light-house, because I do not know what kind of a light this should be, to be in harmony with the system already established. The water around the ledge is about 22 to 26 feet deep at mean low water, the bottom being hard sand. The ledge has over it at mean low water 7.5 feet. The areas of the horizontal curves, at different depths down to 17 feet, are given on page 9 of the printed report, in the columns nearest the bottom. The rock is granite.

From these data and the contour map you can readily estimate the cost of building such a light as the place requires. I wish, however, to be clearly understood as saying that the greater certainty and security in entering the harbor which would result from the changing of the light from Five-Mile Point to Southwest Ledge would justify the entire expenditure of doing it, independent of what might be saved in the removal of the ledges. These advantages are fully stated in my report to the Chief of Engineers, of which a manuscript copy is inclosed.

Yours respectfully,

G. K. WARREN,
Major of Engineers, Brevet Major General U. S. Army.

Major GEORGE H. ELLIOTT, *United States Engineers,*
Engineer Secretary Light-House Board, Washington, D. C.

D.

NEW HAVEN HARBOR AND HOUSATONIC RIVER.

Letter from the Secretary of War, in answer to a resolution of the House relative to the improvement of New Haven Harbor and Housatonic River, Connecticut.—February 14, 1872, referred to the Committee on Commerce and ordered to be printed.

WAR DEPARTMENT, *February 12, 1872.*

The Secretary of War has the honor to transmit to the House of Representatives, in response to a resolution calling for them, reports of Major G. K. Warren, United States Engineers, on the improvements of New Haven Harbor and Housatonic River, Connecticut, and accompanying papers, made since the last annual report of the Secretary of War, and dated, respectively, December 23, 1871, and January 20, 1872.

WM. W. BELKNAP,
Secretary of War.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 8, 1872.

SIR: In compliance with the following resolution of the House of Representatives, viz: "That the Secretary of War be requested to transmit to this House a copy of the reports of General G. K. Warren, the engineer in charge of the improvements of New Haven Harbor and Housatonic River, Connecticut, with the accompanying papers, that have been made to or filed in the Department since the last published report of the Secretary of War," I beg leave to transmit copies of the reports of General Warren on the improvements referred to, dated, respectively, December 23, 1871, and January 20, 1872.

The resolution is herewith returned.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

ENGINEER OFFICE UNITED STATES ARMY,
Newport, Rhode Island, December 23, 1871.

GENERAL: I have the honor to submit a report on the operations of improving the harbor of New Haven, Connecticut, during the season just closed.

The condition of these works at the date of my annual report, August 31, is given in your printed annual report of this year, pp. 85 and 768, 769, 770, 771. At that time a large part of the necessary surveys had been made and contracts entered into for removing the rocky ledges at the entrance and for dredging from Black Buoy No. 5 up

to the city wharves. As then stated, the contractors were at their work and making satisfactory progress.

Morris & Cummings, the contractors for the dredging, commenced work on the 10th of July, and completed their contract on the 31st of October. During this time they dredged from the channel and removed outside of the harbor 153,718 cubic yards of material, mostly a clayey mud. In my previous report I stated there were but 7½ feet in the channel at mean low water, but this was a mistake; there were about 9 feet at mean low water. The new channel was excavated so as to make 13 feet depth at mean low water, which is the depth on the bar opposite Fort Hale, and thus vessels of any draught that could cross this bar can proceed directly to the walls without lightering.

The dredged channel is 200 feet wide from the 13-foot curve up to Long Wharf, a distance of 3,125 feet. There the channel makes a bend, and was widened to 350 feet up to the canal dock, a distance of 750 feet; there to the steamboat dock, a distance of 2,125 feet, the channel was made 100 feet wide. The wharf-owners have since begun to dredge around their piers, thus still further adding facilities to commerce.

In my previous report I stated that I considered no more dredging was necessary, and I would now qualify it by saying no more in this part of the harbor. But there is a great demand for an increase of depth over the bar at Fort Hale, so that vessels of heavy draught arriving there may not have to wait for the tide in order to pass at once into the inner harbor. Once inside of this bar there is deep water and excellent anchorage, which latter feature is wanting outside of the bar. Many persons think that simple dredging is all that is required to secure this increased depth on the bar, which is composed of fine sand and has remained unchanged since the earliest surveys were made. I cannot agree with those who think so, as I believe there is an almost constant movement of this sand westward, across the mouth of the harbor, and that the present depth is merely the result of an equilibrium of the action of the waves on the one hand in moving the sand toward the shore, and the action of the tidal current on the other, sweeping it out again. If this equilibrium is disturbed by dredging a channel, the cut will be filled again in the same way as the drifting snows fill up a railroad cut. But there is this difference, that in excavating the channel we may increase the force of the tidal currents so that the cut will be kept open, and this, it is claimed, will be the case by those advocating the dredging.

There is enough reason in this to give dredging a trial, and it is the more justifiable as there does not seem to be any other more promising method to pursue. The distance between the curves of 16 feet depth at mean low water on the outside and inside of this bar or shoal is about 5,000 feet, and it will require an average cut 2 feet in depth to give a draught of 16 feet over it. It is estimated that a channel 200 feet wide would require the removal of about 75,000 cubic yards, at a cost of 35 cents per cubic yard, amounting to $26,250. I have limited the depth to 16 feet at mean low water, as that will afford nearly all the benefit now wanted, and to get a greater depth would require a very large amount of work.

It may be that jettees along the shore to arrest the motion of the sand may be of service in keeping open the dredged channel, and this will be considered in the future prosecution of the work. The channel already dredged between Black Buoy No. 5 and the wharves is in no danger of silting up again.

Mr. Sullivan, the contractor for removing the submerged ledges of rock, began work on the 1st of August on Luddington Rock, and continued at work until September 30, when he ceased, on account of the increasing inclemency of the season. In the two months he removed 126.8 cubic yards. He will resume work at this rock as early next season as the weather will permit. There remain 695 cubic yards to be removed.

The complete survey of the rocks at the entrance, which we made the past season, enables us now to present a definite project for their removal; and this differs considerably from anything heretofore reported on this subject.

The work was originally begun in 1852 and 1853 by Mr. Maillefert on Middle Rock, because it was thought that it furnished a favorable case for trying his method of surface-blasts. This method, however, failed, and under the contract the experimenter received no pay. The appropriation of $6,000 remained nearly all unexpended until 1867, when Mr. Townsend was employed by the day to operate with his drill and ordinary blasts upon it. From some cause, Mr. Townsend reported much success, and he claimed to have removed so much of the rock as to make 14 feet of water upon it, while before there were but 10 feet. Misled by this account, I, in 1870, employed him to work again upon Middle Rock. I soon became dissatisfied with the progress he was making, and began to distrust the accuracy of the statement of the success he had before reported. A survey of the rock revealed the fact that there were still only 10 feet of water on the rock, the same as it was at first. This disagreeable result was confirmed by a thorough and careful survey made again this summer. I did not resume work upon it.

It has been recommended to remove not only Middle Rock, but the Southwest Ledge also, and the two rocks between them, called B and C by Captain Dutton, and we have carefully surveyed them all. The amount of rock to come away before there will be 17 feet at mean low water on all these ledges just referred to is: Middle Rock, 818 cubic yards; Rock B, 141 cubic yards; Rock C, 624 cubic yards; Southwest Ledge, 1,964 cubic yards; all together 3,548 cubic yards, which, at $25 per yard, would cost $88,700. The distance from the Southwest Ledge to Middle Rock is 1,020 feet. It is thought by many that the entrance to the harbor would be benefited by erecting a light-house on the Southwest Ledge, which has 7½ feet of water on it at mean low water. In that case it is thought that Middle Rock, and the intermediate shoal points B and C, need not be removed.

The principal entrance to New Haven is not on the side of the Southwest Ledge (east side) on which Middle Rock stands, but on the west side, and in the midst of this west channel stands Luddington Rock, with a depth on it at mean low water of about 10 feet. Vessels beating out and in the harbor pass on both sides of it, and it is very much in the way. I therefore directed work to be begun upon it.

In the channel east of the Southwest Ledge there is, however, a dangerous rock, first located by our survey, but known by the fishermen as the Big Boil. This rock has but 7 feet on it at mean low water, and should be removed. The amount of rock above the 17-foot curve is about 587 cubic yards, which, at $25 per yard, would cost $14,675.

To finish the work in the harbor, which I think it advisable to do at the present time, (besides the light-house for Southwest Ledge,) will require as follows:

To complete the removal of Luddington Rock, 695 cubic yards, at $25 per yard	$17,375 00
To remove Big Boil Rock, 587 cubic yards, at $25	14,675 00
To dredge a channel 200 feet wide to a depth of 16 feet across the shoal near Fort Hale, 75,000 cubic yards, at 35 cents	26,250 00
For superintendence	3,700 00
Total	62,000 00

During the past year the expenditures have been as follows:

For surveys, making maps, and superintendence	$7,218 43
To Morris & Cummings, for dredging	26,150 33
To Eugene Sullivan, for work on Luddington Rock	3,107 36
Total	36,476 12

The amount appropriated by the act approved March 3, 1871, was	$40,000 00
On hand at the beginning of the year of former appropriation	9,093 04
Total	49,093 04

Leaving the balance of the last appropriation still unexpended, $12,616.92.

It therefore appears that the additional appropriation required will be about $50,000!

In my annual report I recommended an additional appropriation of $20,000 for the ensuing year, but this was made without taking into consideration the improvement of the depth on the shoal near Fort Hale.

Accompanying this report is a tracing from the unfinished map of the new survey, showing the dredging done during the past season; also a tracing showing the correct locations of the rocky ledges at the entrance to the harbor; also six tracings showing the contours of these rocks, and one sheet of sections of Luddington Rock; also a report of Mr. Mann, who has had charge of the survey and superintendence of the improvement, which contains much information not given in my report, and is a valuable record for future reference. The map of the harbor is being prepared, and is in an advanced stage.

Mr. Mann has been assisted all the time by Mr. C. R. Mather, and part of the time by Mr. H. N. Babcock. The energy, thoroughness, and completeness of the work commend these young men to all interested in their professional pursuits, and who desire to see a faithful execution of a public trust.

Very respectfully, your obedient servant,

G. K. WARREN,
Major of Engineers and Brevet Major General, U. S. A.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers, United States Army, Washington, D. C.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, December 23, 1871.

GENERAL: I have the honor to submit report of operations at New Haven Harbor, Connecticut, during the present year. In accordance with your instructions, I left Newport on March 16, accompanied by Mr. Charles R. Mather, civil engineer. Operations were commenced on March 17 by the locating of tide-gauges at Long Wharf and Chapel Street Bridge, the gauge at Chapel Street Bridge being placed on the east side of the guard-piling of the draw-pier of the bridge; the gauge at Long Wharf being placed in a corner between the freight-house at the end of the dock and the east end of the dock. Simultaneous tide observations were commenced at these points on March 18, being taken every ten minutes between high and low water, and every five minutes for thirty minutes before and after high and low water. These gauges were observed until March 31, when simultaneous observations were commenced at Chapel Street Bridge, Long Wharf, Fort Hale, and Five-Mile Point. Tables of these observations are annexed to this report. At Long Wharf, Fort Hale, and Five-Mile Point, box-gauges of the form shown in the annexed diagram were put up, this being rendered necessary by the prevalence of southwest winds, which make the water too rough for accurate reading upon a staff-gauge. The tide-gauge at Fort Hale was placed on the east side of the Chemical Works dock, and that at Five-Mile Point on the north side of a dock belonging to W. H. Clark, esq. Observations were taken at all four gauges until April 15. On the 14th, 15th, and 17th, levels were run to connect the planes of reference as marked on the different gauges, and bench-marks put in as follows.

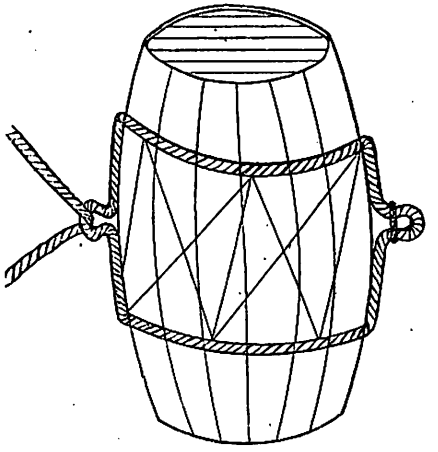
Bench-mark 1 consists of a copper bolt 6 inches long, ¾ inch diameter, and 1¼ inches across, the head leaded into a large circular stone on the southeast corner of a passage-way through the west end of Long Wharf, about 60 feet east of P. P. Avery's store. The stone is level with the roadway, the bench-mark being in the south side of the upper face. The head of the bolt is 10.233 feet above the plane of mean low water as determined at the tide station at Long Wharf.

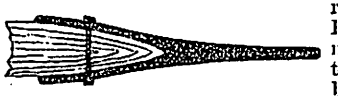
Bench-mark 2 consists of a copper bolt leaded in the northwest corner of the upper face of the northwest stone in the second course from the top of the east abutment of the draw-span of the Chapel Street Bridge; the stone forms a projecting corner, the bench-mark being inserted about 5 inches from its northwest corner on a line running southeast. The bench-mark is 9.631 feet above plane of mean low water as determined at the tide station at Chapel Street Bridge.

Bench-mark 3 is a copper bolt leaded in the upper face, at the southwest corner, of the west stone of the north side of the sluice-way at the southwest corner of Fort Hale, and on a line running northeast from corner of said stone. The bench-mark is 11.919 feet above the plane of mean low water as determined at the tidal station at Fort Hale, (at Chemical Works dock.)

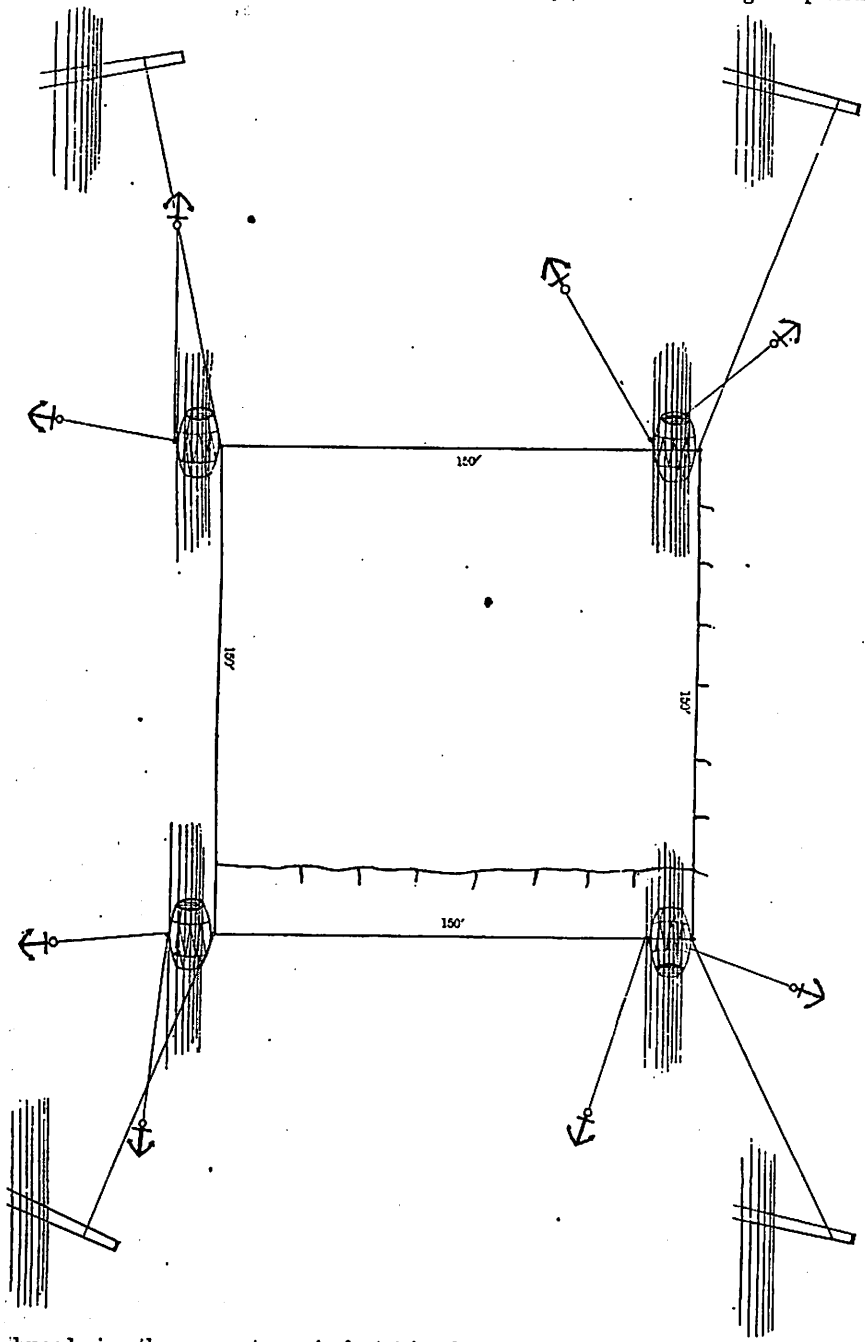
Bench-mark 4 is a copper bolt leaded into the second stone from the north edge of the southwest face of the water-table of the New Haven light-house; the bolt is about 4 inches from the upper edge of the stone, the head being flush with its face and notched thus ⊕. The horizontal notch is 20.866 feet above the plane of mean low water, as determined at the tidal station on dock belonging to W. H. Clark, esq. At the two last stations, as the observations extended over only half a lunation, mean low water was determined by subtracting one-half of the mean rise and fall of the tide, (spring, the observations extending over a period of high tides,) taken from United States Coast Survey records from the height of the mean sea-level. At the other stations the mean of the low waters for a lunation determined the plane of mean low water. I also found that the tide-gauge used during the survey of Middle Rock in 1870 was put up by Mr. R. M. Bache, of the United States Coast Survey, and observed for a month, and that his mean low water, as used by me in 1870, differed but 0.05 foot from that of 1871. On April 19 I examined the channel below Long Wharf, with the dredge shown in the diagram, for the purpose of determining the character of the bottom and the depth at mean low water. I found that the bottom consisted of soft mud, mixed occasionally with broken shells, but in no place was anything struck approaching the consistency of hard mud. Soundings commmencing at Long Wharf and extending to 13-foot curve, near Black Buoy No. 5, gave a mean depth of 9 feet at mean low water. No oyster-beds were struck, nor any considerable accumulation of shells, and the statement of pilots in regard to the existence of any well-defined bar between Long Wharf and Black Buoy No. 5 were conclusively shown to be erroneous. On the 17th, 18th, 19th, and 20th of April, primary triangulation stations, consisting of poles 25 feet long and 2 by 3 inches, having large red flags at top, and supporting tripods, were erected at the following prominent points in the harbor below the bridge: A, near east end of Tomlinson's Bridge; A, on Belle Dock; B, opposite Long Wharf on east shore; B, on end of Long Wharf; C, at Fort Hale; C, on Oyster Point; D, at light-house; D, on Sandy Point; E, on Brister's hill, on west side of harbor, back of Savin Rock. The base line A B was also measured and found to be 2,396.5 feet in length. On the 21st, 22d, and 24th, the angles of the primary triangulation were measured by the Troughton & Simms theodolite, reading to 10″, each angle being taken three times. The

variation of the sum of the angles of any triangle from 180° in no case exceeded 25″. These angles have been corrected by ordinary method, founded on method of least squares, and the sides of the triangles computed. The traversing of the shore-line was commenced on April 25, at north end of base, and was completed on May 6, being run to the light-house on the east shore, and to a point just below Savin Rock, on the west shore, and connected at every principal station with the primary triangulation. A limited topographical survey was made in connection with the traversing by Mr. Charles R. Mather, civil engineer. The total distance traveled was 52,000 feet; the stations were marked as follows: 1 A, 2 A, &c., running south from north end of base 1 B, 2 B, &c., from some point north and west. On May 8 a survey of the openings of the sea-wall at Fort Hale was made to determine the amount of repairs required. On May 9 preparations were made to commence sounding, and on the 16th it was begun at Tomlinson's Bridge, and concluded on May 20, extending to a point opposite the middle of Morris's Cove. About 2,600 soundings were located by two transits, the lines being run zigzag and taken so as to determine changes of level, the pole used in less than 20 feet of water being kept on the bottom most of the time. A system of signaling by red and white flags was adopted, and the numbers of soundings checked at the end of each line; in case of soundings being lost by instrument, which was very rarely, the line was re-run. While sounding, the gauge at Long Wharf was read every 15 minutes, and the soundings reduced to mean low water by these observations, the time being taken in the boat every 5 minutes. Several lines of soundings were located, radiating from Long Wharf, so as to determine the axis of the channel, which was found to coincide very nearly with a line from Long Wharf to Black Buoy No. 5. The soundings were completed to the entrance of the harbor in the fall. This will be referred to in its proper chronological order. On May 22, 23, 24, and 25, buoys, ropes, &c., for the surveys of the rocks at the entrance to the harbor were prepared and taken out to Middle Rock and placed in position for the survey of that rock. On the 27th a complete survey of Middle Rock was made, including those parts necessarily omitted in 1870, in the following manner: Four kerosene-oil barrels were strapped, as shown in the diagram, and provided with two 100-foot anchor warps each. These buoys were arranged in the form of a square, as in the diagram, (see next page,) and were connected by rope 150 feet long, passing through and fastened to an eye formed of the bight of the rope on the barrel inclosing an iron thimble. These ropes were marked at every 5 feet by strips of red bunting inserted between the strands. The angles of the square were laid off with a sextant and the buoys held in place by anchors, and also by being strung up to the span-buoys left after operations in 1870, so that any displacement was impossible. The survey was made about the time of slack water, as nothing could be done at the strength of the tide. The survey was commenced at the northeast end of the rock, the north side of the square being taken as the base from which all the lines were run, the bearing of the base being south 80° east, (mag.) Soundings were taken at every 5 feet along the lines running north and south, the sections being 10 feet apart. During the survey the gauge at Five-Mile Point was read, the soundings, 370 in number, being reduced to mean low water by these observations. The soundings were taken with a pole 31 feet long, having feet and half-feet branded upon it, as I have found that a painted pole is of little use in salt-water. The lower end of the pole consisted of an iron rod 6 feet long and ¾ inch diameter, fastened thus: By keeping this constantly on the bottom no prominent inequality can escape notice. I also sounded thoroughly around the rock, to ascertain if I had been mistaken in stating that there was no broken rock left there in 1867 by Mr. G. W. Townsend, but found that my former statement was entirely correct. A map of Middle Rock has been made on a scale of 5 feet to the inch, the contours being drawn at every foot, 12 and 18 foot contours heavy, and the line of proposed excavation (17 feet below mean low water) in blue. The map is different in some minor respects from those made from the survey of 1870, but is more correct, as in 1870 the water was very rough, while in 1871 it was almost a dead calm during the entire survey. I find the least depth of water on the rock to be 10.4 feet at mean low water in 1871,





and 10.0 in 1870. This difference is undoubtedly due to the difficulty of taking exact soundings in 1870. The survey of 1871 included that portion of the rock lying to the south, which was omitted in 1870. I give a comparison of the areas of the curves (below plane of mean low water) from the two surveys, these areas being completed



by reducing the curves to equivalent triangles and measuring their bases and altitudes. The difference of the areas of the lower corresponding curves results from

the introduction of the south part of the rock, which is quite flat, and which did not appear in the survey of 1870, but is entirely included in that of 1871.

Area.

Curve.	1870.	1871.
Feet.	*Square feet.*	*Square feet.*
11	358.88	573.64
12	1,282.66	1,168.11
13	2,243.5	2,468.062
14	3,315.5	3,826.827
15	3,647.5	4,930.900
16	4,894.0	5,851.552
17	6,036.89	6,804.9125

The volume has been computed by two methods: 1st. From horizontal sections at every foot of vertical height, (the areas being given above,) by the prismoidal formula. For instance, assuming 11 and 13 foot curves as upper and lower bases, and 12 foot as middle base, there results the volumes between the 11 and 13 foot curves, thus:

$$\text{Vol.} = \tfrac{2}{6}\left\{(11) \;\&\; 4\ (12) + (13)\right\}$$

and in like manner for the other curves, by this method. I find for the volume above the 17-foot curve 809.32. 2d. By vertical sections whose areas are determined directly from the reduced soundings, by the application of Simpson's rule, thus: subtract each reduced sounding from 17 feet, then the area of each vertical section will be as follows:

$$\text{Area} = \frac{\text{Distance between soundings}}{3}\,(\text{1st height} \;\&\; 4 \times \text{even heights} + 2 \times \text{odd heights} + \text{last height.})$$

In this way I find for the areas at the following distance from east end of base:

Section. *Feet.*	Area. *Sq. ft.*	Section. *Feet.*	Area. *Sq. ft.*
15	0.	70	316.8
20	76.6	80	319.3
30	225.2	90	204.6
40	241.3	100	115.2
50	364.2	110	12.8
60	371.6	115	0.

The volume was then computed from these areas by the prismoidal formula, and found to be 826.6 cubic yards. The most probable volume of the rock is then the mean of these results, or 817.96 cubic yards above the 17-foot curve, (below mean low water.) Comparing this with the result of the survey in 1871, and with that computed from Captain Dutton's areas from his survey in 1853, I have the following volumes:

	Cubic yards.
1853	768.36
1870	728.38
1871	817.96

The discrepancy may seem large, but the greater accuracy of this year's survey, and the more favorable conditions under which it was made, would lead me to adopt the volume deduced from it in any subsequent estimates, more especially as the volume given in Captain Dutton's report as deduced from his areas was really double the amount actually corresponding to the area, which, of course, does not tend to strengthen faith in the correctness of the areas themselves. The depth of water on the sand about Middle Rock is 22.5 feet at mean low water on the north side, and 23.6 feet on the south side. The survey in 1870 gave 22.3 and 23.3, this being additional proof of the general accuracy of the depths taken then, and further proof, if any be needed, that Mr. Townsend's plane of low water when 15 feet was found by him on the shoalest point of the rock must have had its origin in his imagination. All the rocks at the entrance to the harbor appear to have deeper water on the south than on the north side, probably due

to their checking the silt, &c., brought down by the strong ebb tide. During the week ending June 3 several attempts were made to survey Southwest Ledge, but without success, as southwest winds made it too rough for work. A heavy fog each day prevented other out-door work. On June 5 I surveyed Southwest Ledge by the checker-board method, the barrels being arranged as follows: The base, 365 feet long, and bearing north 33° east, made an angle with the side of the parallelogram of 85°, the side being 200 feet in length. The angles were measured with a sextant. The base and the side parallel were marked at the 10-foot points by red bunting tags, and a line marked at every 10 feet was stretched from one to the other, and moved along 10 feet at a time, so that soundings were taken at the corners of parallelograms 10 feet by 10 feet. The buoys were placed at slack water, and so arranged that the ebb tide ran in the direction of the lines of soundings. Each buoy was held by two anchors with long warps hauled taut, so that swaying was possible during the ebb. A boat was anchored at the middle of the base to prevent swaying and sagging. The soundings were taken by allowing the boat to drop down with the tide along the line stretched from the base to the side parallel with it. After crossing it, (the parallel side,) the line was secured to it and soundings taken as before. During the survey the gauge at Five-Mile Point was read, and the sounding reduced to mean low water from the observations. About 450 soundings were taken. When the survey was nearly completed it commenced to blow from the south-southeast, so that the last two lines of soundings were taken 20 feet apart. During the survey the spindle-socket which formerly held a large spindle was struck and located; it is about 1 foot across, and has over it at extreme low water not more than 3 feet of water; it should be removed, or the spindle replaced, as it is very dangerous to light-draught vessels. A map of Southwest Ledge has been made to a scale of 10 feet to the inch, contours drawn at every foot of vertical height, the same colors being adopted for the curves as in the map of Middle Rock. The least water over the ledge at mean low water is 7.5 feet. This is $\frac{1}{10}$ foot more water than is shown on the United States Coast Survey chart. The ledge is about 310 by 250 feet, the longer direction being northwest and southeast; it is very jagged, being full of crevices. I have computed the volume by vertical and horizontal sections, as in Middle Rock. By vertical sections I have taken sections at noted distances from north end of base. By Simpson's rule:

Section. *Feet.*	Area. *Sq. Feet.*	Section. *Feet.*	Area. *Sq. Feet.*
97	.0	190	592.6
100	2.0	200	502.6
110	37.9	210	485.6
120	92.8	220	304.7
130	165.0	230	277.0
140	336.8	240	219.4
150	473.6	250	143.5
160	514.0	260	58.3
170	518.9	270	29.6
180	635.9	280	1.0

Then by prismoidal formula for the volume above the 17-foot curve (below mean low water) is 1,997.36 cubic yards. By horizontal sections the following results are given for areas of curves below mean low water:

Curve. *Feet.*	Area. *Sq. Feet.*	Curve. *Feet.*	Area. *Sq. Feet.*
8	149.64	13	6,116.88
9	585.90	14	7,845.45
10	1,195.20	15	9,843.92
11	2,848.25	16	12,086.87
12	4.364.58	17	15,062.14

Then by prismoidal formula the volume = 1,931.44 cubic yards, or, taking the mean of the two results, 1,964.40 cubic yards, for the volume of the ledge above the 17-foot curve, (below mean low water.) Until June 14 the time was occupied in dragging for the rock known as Luddington's Rock, the position of which was not marked by any buoy, and, as I afterward found, was incorrectly located on the United States Coast Survey map. On the 14th I found Luddington's Rock, also two rocks between Southwest Ledge and Middle Rock, known as Tortoise and Ragged Rocks, B and C in Captain Dutton's report, and a rock not marked on any chart, known as the Big Boil, (named from the tide-rip over it at certain stages of the tide,) lying about one-fourth mile south-southwest of Quixe's Ledge spindle, and having over it about seven feet at mean low water. I found ranges for all these rocks, so that I could drop a lead on them without any previous soundings, and marked the Big Boil with a small barrel-buoy, as the tide ran so swiftly there that it was somewhat difficult to strike the shoalest water on it. I was somewhat surprised to find less than 10 feet at low water on Luddington's Rock, instead of 12.5, as shown on the charts. Big Boil Rock lies directly in the entrance to the eastern channel of the harbor, and is a very formidable obstruction; B and C have over them at mean low water about 13 and 11.5 feet respectively. Luddington's Rock is a large rock, at least 150 by 100 feet, instead of a small peaked rock, as I was informed last year by the harbor pilots. I also sounded on Old Head Reef, about half-way between Quixe's Ledge and Adam's Fall, finding on it about 9 feet at low water; as the Coast Survey map gives 6, I presume I did not strike the highest point. As it is not in the channel, I did not spend any more time on it, the only object being to know where it was. The following ranges were noted for Luddington's Rock: Quixe's Ledge spindle is on range with the south edge of the only large white house on the "South End;" the north edge of two brown cottages on the beach, just north of Savin Rock, is on range with the spire of the southernmost of the two churches in West Haven; these cottages being at the high water are readily distinguished, as they are the only ones so situated. The Big Boil is on range of Quixe's Ledge spindle with bluff at mouth of Morris Creek, and on the range of the end of the woods on Morgan's Point, with the west edge of white house behind them to the north.

On June 16 I surveyed Luddington's Rock by checker-board method, the base-line being 225 feet long, and bearing north; the side-lines were 200 feet long, and were inclined to the base at an angle of 61° 30′, this angle being taken with the sextant. The side-lines were as nearly as possible in the direction of tidal current, so that the sounding-boat could drop down with it. The sections were 10 feet apart, soundings being taken every 5 feet along them, beginning at the northwest corner of the parallelogram, the sections running from northwest to southeast, while the axis of the rock was from northeast to southwest. The base was prevented from sagging by a boat anchored at its middle. Three hundred soundings were taken, being reduced to mean low water by observations at Five-Mile Point. A map has been made of Luddington's Rock, on a scale of 5 feet to 1 inch, contours 1 foot apart; 12-foot contour heavy; 16-foot contour, line of proposed excavation. The rock is about 150 by 100 feet, the longer axis northeast and southwest. The rock is very jagged, rising in some places quite abruptly, and affords excellent opportunities for face or surface blasts. There is on the highest point 9.8 feet at mean low water, and on the surrounding sand 16 to 17 feet at mean low water. The rock consists of two portions, connected by a narrow ridge; this ridge is not shown on the map, as its existence was first discovered by the diver; I afterward examined it myself, and found it to be quite small.

Luddington's Rock is a much better locality to work in than Middle Rock, as the velocity of the tide is less, thus making it smoother in the southwest winds. The volume of the rock has been computed by horizontal and vertical sections, as follows:

1. By horizontal sections:

Curves.	Area of larger part, sq. feet.	Area of small part, sq. feet.	Curves.	Area of larger part, sq. feet.	Area of small part, sq. feet.
10	14.30		14	5,113.10	182.
11	527.56		15	6,842.76	551.49
12	1,424.80		16	8,147.72	1,260.32
13	2,944.80	9.021			

BY PRISMOIDAL FORMULA.

Volume of, (1)	cubic yards..	760.609
Volume of, (2)	do	47.589
Total volume	do	808.198

2. By vertical sections from north end of base:

Section. *Feet.*	Areas. *Sq. feet.*	Section. *Feet.*	Areas. *Sq. feet.*	Section. *Feet.*	Areas. *Sq. feet.*
0	11.2	55	125.3	115	305.8
5	1.2	65	168.9	125	214.9
10	11.0	75	223.0	135	230.1
15	17.9	85	255.8	145	138.6
25	43.5	95	255.1	155	64.7
35	71.7	105	305.5	165	21.7
45	121.1				

The areas being found by Simpson's rule, the distance between the sections taken perpendicular to them being 10 × sin 61° 30′; then, using prismoidal formula, volume = 835.94 cubic yards; the mean of the two results being 822.069 cubic yards. There has also been made a map on a scale of 5 feet to the inch, showing vertical sections along lines of soundings of Luddington's Rock at distances of 75, 85, 95, 105, 115, 125 feet from north end of base. In this map the blue line represents plane of mean low water; heavy red line, plane of proposed excavation; black figures show amount (depth) to be removed at given points; and red figures show reduced soundings at those points. In this map the sand gulley in the rock is shown. On June 19, Ragged Rock, or C, was surveyed by checker-board method. The base, bearing south 42° west, was 190 feet long. The sections were 10 feet apart and made an angle with the base of 118° 33′, soundings being taken at every 5 feet along these sections for a distance of 220 feet. The rock is very jagged, there being several ridges upon it not more than a foot across and rising 5 or 6 feet above the surrounding rock, and having over them from 11.5 to 13.5 feet at mean low water. The sounding-pole was kept upon the bottom between all the soundings, and the position and extent of any marked inequality thus determined. Captain Dutton could not have struck these ridges, as he gives the least depth on the rock at 13 feet. Soundings were taken on the southwest side only to the depth of 20 feet, on account of the approach of darkness. There have been made two maps of Ragged Rock, one on a scale of 5 feet to the inch; in this the contours are at every foot 12 and 18 foot curves, heavy; 17-foot curves, (line of proposed excavation,) in blue. The shoalest point on the rock is 11.4 feet below mean low water, at Five-Mile Point, to which plane of reference were reduced the 610 soundings taken on the rock. The rock is about 210 by 160 feet, the axis being from northwest to southeast, (at 20-foot curve.) From appearances it is much cracked and fissured. Another map has also been made on a scale of 2 feet to the inch; from this it will be seen that there are four ridges having over them at mean low water 12.6, 13.2, 12.5, and 13.5 feet, and that to remove them to 17 feet below mean low water (blue line) would require the removal of but little rock, while the main portion of the rock is quite extensive. The volume of the rock has been computed by both methods. By horizontal sections the following results have been obtained:

Curves. *Feet.*		Areas. *Square feet.*
12		138.55
13	Second ridge	1.20
	Third ridge	2.50
	Main curve	726.565
14	First ridge	1.98
	Second ridge	3.26
	Third ridge	10.70
	Fourth ridge	1.10
	Main curve	1,928.56
15	First ridge	12.75
	Second ridge	8.10
	Third ridge	17.80
	Fourth ridge	3.50
	Main curve	4,372.32
16	First ridge	29.26
	Second ridge	17.64
	Third ridge	26.45
	Fourth ridge	5.50
	Main curve	5,865.155
17	Second ridge	27.45
	Fourth ridge	8.75
	Main curve	8,553.261

Then, by the prismoidal formula, volume of that portion of the rock separate from the ridges = 623 cubic yards; volume of ridges = 8.84 cubic yards, or total volume of rock above 17-foot curve (below mean low-water) = 631.84 cubic yards.

By vertical sections, at noted distances from end of base, the following results have been obtained:

Sections. *Feet.*	Areas. *Sq. feet.*	Sections. *Feet.*	Areas. *Sq. feet.*
50	2.0	120	340.7
60	25.3	130	257.7
70	79.9	140	96.5
80	119.2	150	64.0
90	252.4	160	5.4
100	300.9	169	0.
110	320.0		

Areas by Simpson's rule; then by prismoidal formula. Volume above 17-foot curve

617 cubic yards, the mean of the two results giving for most probable volume of the rock above 17-foot curve, (below mean low water,) 624.42 cubic yards. On June 20, Rock B, or Tortoise Rock, was surveyed. The base was 80 feet long, bearing north 20° east, the lines of sounding being included to it at an angle of 61° 54′, and being 5 feet apart, running southeast to northwest, soundings 5 feet apart commencing at southeast end. The south side of the rock below the 17-foot curve was not obtained in consequence of wind. As this is, however, quite uniform, the other contours were introduced without any difficulty. The rock is very smooth and rounded on the top. Three hundred and ninety soundings were taken and reduced to mean low water at Five-Mile Point. A map has been made of this rock on a scale of 5 feet to the inch, curves as in other rocks. The highest point on the rock is 12.9 feet below mean low water. The rock is about 100 by 60 feet axis northwest and southeast. The computations for areas and volumes give by the two methods the following results:

By horizontal sections—

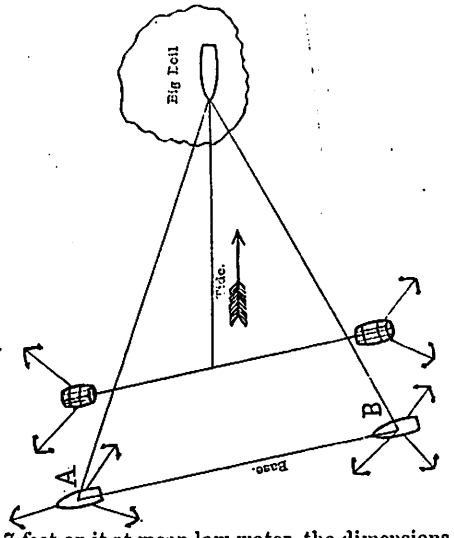
Curves. *Feet.*	Areas. *Sq. feet.*	Curves. *Feet.*	Areas. *Sq. feet.*
13	2.632	16	1,544.032
14	199.47	17	2,706.595
15	787.695		

Then, by prismoidal formula, volume = 138.99 cubic yards.

By vertical sections, the areas being found by the application of Simpson's rule, sections at noted distance from south end of base:

Sections. *Feet.*	Areas. *Sq. feet.*	Sections. *Feet.*	Areas. *Sq. feet.*
0	1.3	35	63.7
5	57.7	40	41.3
10	114.2	45	42.5
15	143.4	50	34.0
20	137.3	55	30.4
25	107.0	59	0.
30	101.6		

Then, by prismoidal formula, volume = 142.3 cubic yards, the mean volume above 17-foot curve (below mean low water) being 140.645 cubic yards. In order to preserve the connection, I will mention next the survey of the Big Boil, although it was not made until October 30, 1871. On the survey I was assisted by Mr. Charles R. Mather, civil engineer, and Mr. H. N. Babcock, civil engineer. The survey was made as shown in the diagram.



Boats were anchored at A and B, and their positions located by sextant angles between the following prominent objects: Light-house and Quixe's Ledge spindle; light-house and West Haven spire; these points being located on the principal survey as hereafter mentioned, the distances being calculated as well as the angles. From these data the length and bearing of the base have been calculated as follows: Length of base, 482.2 feet, bearing south 22° 2′ 8″ east, (true.) Two barrels were anchored between the base and the rock, and connected by a line, to which was attached another line to hold the sounding-boat in place while the soundings were being taken, this being necessary owing to the velocity of the tide. The soundings were then located from the ends of the base by sextant angles between sounding-boat and base. About 80 were taken and reduced to mean low water at Five-Mile Point. A map of this rock has been made on a scale of 5 feet to the inch, the soundings being platted from computed distances from the end of the base. The rock has 7 feet on it at mean low water, the dimensions at the 17-foot curve being about 110 by 80, the axis northeast and southeast. The areas and volume of the rock by horizontal sections have been computed and are given. Curves below mean low water, 17 feet.

Curved plane of proposed excavation—

Curve. *Feet.*	Area. *Sq. feet.*	Curve. *Feet.*	Area. *Sq. feet.*
8	47.73	13	1,313.13
9	231.58	14	2,171.59
10	486.11	15	3,004.42
11	714.12	16	4,175.88
12	971.35	17	5,539.63

Then, by prismoidal formula, volume above 17-foot curve, 586.71 cubic yards. On June 22, the rock at the entrance to the harbor, and the buoys in the harbor, were located by the theodolite. The shoalest point of each rock was located, the observers' stations being at the light-house station, (D,) and at the station on Brister's Hill, (E.) From this date until the dredging commenced, on July 10, the party was occupied in shipping Government property from Fort Hale, in measuring dredge-scows, and preparing for the dredging. Mr. Mather, as a mean of six observations, found the leaving of the base of the survey to be south 13° 58′ 55″ west, (mag.,) and, assisted by him, I ascertained, from a mean of seven observations, that the magnetic variation was 7° 22′ west. From July 10 until October 16, we were occupied by the dredging and removal of Luddington's Rock, Mr. Charles R. Mather, civil engineer, superintending the dredging. Mr. H. N. Babcock, civil engineer, joined us on July 26, and has been engaged principally in working up notes, mapping, &c. In accordance with your instructions, I commenced, on July 26, a series of simultaneous observations at Long Wharf and Fort Hale, for the purpose of ascertaining whether the discrepancies shown in the following table were due to the irregularities of the tide, or to defects in the gauges employed. These observations were continued until August 9, and established the fact that the former peculiarities were due to the tide, not to the gauges. (Five-Mile Point agrees very well with Long Wharf.)

Date.	Height of high water.		Difference.
	Fort Hale.	Five-Mile Point.	
	Feet.	*Feet.*	*Feet.*
March 31	5.29	5.79	.05
April 1	5.49	5.94	.05
April 3	7.14	7.49	.03
April 4	6.54	7.19	.65
April 6	6.04	7.00	.96
April 7	5.84	6.80	.96
April 8	6.14	6.39	.25
April 9	6.74	6.59	.15
April 10	6.04	6.24	.30
April 11	6.74	6.69	.05
April 12	5.79	6.09	.30
April 13	5.84	6.09	.25
April 14	6.04	6.29	.25
April 15	6.14	6.49	.35

On October 16, in accordance with your instructions, I commenced a survey of the Mill and Quinnipiac Rivers, above Tomlinson's bridge, and extending to the Grand-street bridge on the Mill River and to the Fair Haven bridge on the Quinnipiac River, the limits of navigation on both rivers. Primary triangulation stations were located on the 16th, and the base-line taken on Chapel-street bridge, its length being 914.5 feet, and bearing south 84° 56′ 02″ east, (mag.,) or north 87° 41′ 58″ east, (true.) On October 17 and 18 the angles of the primary triangulation were measured, each being read to 10″ three times on a different part of the plate. These angles have been corrected and the triangles computed. On October 19, a number of stations between Fort Hale and the light-house were replaced for use on the completion of the soundings to the entrance of the harbor. On October 21, about 100 soundings were located below the ending of the work in the spring; the gauge at Five-Mile Point was read, and the soundings reduced to mean low water at that point. From October 23 to 31, ran the shore-line of the Mill and Quinnipiac Rivers for a distance of 21,000 feet, a limited topographical survey being made in connection with the traversing by Mr. Charles R. Mather, civil engineer. On October 30 the Big Boil was surveyed, as before described. November 2, the soundings at entrance to the harbor were completed,

about 185 soundings being taken, and reduced to mean low water at Five-Mile Point. November 3, the place beyond the rocks, at the entrance to the harbor, was surveyed in the manner described under the head of dredging, it having been used as a dumping-ground. On November 4 the survey of 1871 was connected with the United States Coast Survey, by observations with the theodolite, stations B and C of the primary triangulation being used, and sights taken to light-house, West Haven spire, and southwest spire of Episcopal Church at corner of Olive and Chapel streets, New Haven. On November 8 commenced sounding Mill and Quinnipiac Rivers, locating soundings by two transits. This work was completed on November 16, 1,250 soundings having been taken, and reduced to mean low water at Chapel-street bridge. The channel dredged in 1871 was surveyed on November 17 and November 18. On November 27, operations being concluded for the year, Messrs. Babcock and Mather and myself returned to Newport. In addition to the maps already mentioned, there are prepared, or being prepared, the following: Map on a scale of $\frac{1}{2500}$, showing channel before and after dredging in 1871, (described under head of "Dredging;") map of the whole harbor, now preparing, on a scale of $\frac{1}{5000}$; sketch showing monthly progress of dredging. The following are to be made: Map of Mill and Quinnipiac Rivers, scale undetermined; map of dumping-ground, and comparison with United States Coast Survey map. The large map has the triangulation and traversing completed, the rocks located, and most of the soundings platted, so that the soundings yet remain to be completed, the shore-line and topography put in, and contours drawn. This will probably be done by January 20; until this time complete plans of the improvement of the bar below Fort Hale will have to be deferred, as there are so many circumstances affecting the deposition of sand in the sound harbors that any improvement of sand-bars in them can only be proposed after a careful investigation of the causes leading to their formation.

DREDGING.

From an examination of the channel made in the spring I determined, with your approval, to commence the dredging at the 13-foot curve, below mean low water, about 200 feet north of Black Buoy No. 5, and to make the west edge of the channel coincide with a line drawn from Black Buoy No. 5 to the end of Long Wharf. Morris & Cummings's dredge No. 2 arrived on July 3, and commenced making preparations for the work. At this time two scows, marked ○ and ⊕, were with the dredge. These were measured and found to contain 197.2 and 197.1 cubic yards respectively, and to draw about six feet when loaded. On July 10 the dredging was commenced at the point before determined, and as but little was to be taken off, the digging was done only at every other catch, the dredge making a cut fifty feet wide, and the bucket used holding three yards when flush with the top, and five yards when loaded up to the opening-wheel. For the first few days the progress was slow on account of the small number of scows, but on July 12 the tug Stephen Decatur arrived with two more scows, marked 1 and 2, and holding 202.5 and 199.4 cubic yards. Mr. Charles R. Mather, civil engineer, had previously been placed as superintendent of the dredging, in accordance with your instructions. The plan of dredging adopted was to run up on one cut until the back hawser, 700 feet in length, had been payed out; the dredge then dropped down to the point of beginning, and began another cut alongside of the former one, the average amount removed per day being about 1,600 yards, 2,400 yards being taken out on one day. The mud was dumped beyond Southwest Ledge, in 26 feet of water at low water, the locality being shown on the large map of the harbor. When a point about 1,000 feet from Black Buoy No. 5 was reached, it became necessary to dig at every catch, and sometimes to send the bucket down twice in the same place, the depth being regulated by tin figures placed upon the guide-poles of the buckets, and by board tide-gauges O′° at mean low water placed along at intervals as the work progressed. During July there were removed 28,697 cubic yards, about 2,100 feet of the first cut having been dug to 13 feet at mean low water, and about 1,400 of the second, and the same of the third to a corresponding depth. This progress is shown in red on the sketch showing progress of excavation. Before commencing work on July 10 I sent the following notice to the New Haven papers: "The engineer in charge of the harbor improvements wishes to have the steamers 'slow up' when they pass the anchor-lines at the dredge, as the motion of the waves is injurious to the machinery, and the wheels of the steamers are apt to cut the lines. A channel is being dug 200 feet wide and 13 feet deep at low water from Black Buoy No. 5 to Long Wharf." I expected I should have no further trouble in regard to the matter, and was somewhat surprised when informed by Mr. Mather that no attention was paid to this request. I then went twice to the office of the company, and made verbal requests that the steamers "slow up," but without effect. We were put to considerable inconvenience, as sometimes half an hour was lost by the steamer passing at full speed, as the speed had to be raised and the anchor-lines slacked, while the swell caused almost invariably washed into the fresh-water tank. I then wrote to the captains of the steamers requesting them to "slow up," officially informing them of the inconvenience they were putting us to, but without any success. On

the night of August 4 the steamer Continental, Captain Bowns, ran into the dredge, fortunately striking her in the middle of the stern, for, as the hull is composed of two boats, if either had been struck she would have instantly sunk, or the boiler being struck would have been ruptured or exploded. Knowing that there was abundance of room for the steamer to pass on either side, that the dredge had a light up at the time, and that the general disposition of steamer captains was not to avoid vessels lying at anchor, I was led to think that the steamboat-men were reckless, and disregarded the public work, besides endangering the lives of the passengers and of those on the dredge. I therefore addressed a communication to the newspapers of New Haven, calling public attention to what appeared to me to be reprehensible in the extreme. The work was delayed several hours by the collision and repairs, and I presume that quite extensive repairs will have to be made when the dredge is laid up, as she was much weakened by the shock, the bow of the steamer going into the stern of the dredge about seven feet, and breaking like a pipe-stem a 12-inch by 12-inch beam. During August the three cuts were completed to the north end of Long Wharf, 47,908 cubic yards being removed, making the channel 150 feet wide and 13 feet deep at mean low water; this is shown in green on the sketch. In September, as the appropriation warranted, a fourth cut was commenced at Black Buoy 5, at the point of commencing of the former cut, and continued to north end of Long Wharf, making the channel 200 feet wide; the dredge then commenced to widen the channel between Long Wharf and Canal Dock, making it 350 feet wide. This was rendered necessary by the curve in the channel, and from the fact that numerous vessels use it as an anchorage ground while waiting for berths at Long Wharf and Canal Dock. This opening up was completed in September, with the exception of a small portion above the south end of Canal Dock. The work for this month amounted to 42,895 cubic yards, shown in orange on the sketch. In October the channel to the steamboat dock, 13 feet deep at mean low water, and 100 feet wide, was dug thus: the east edge was run on range of Fair Haven church spire and end of peaked roof of freight-house on Old Beele Dock, the second cut being parallel to and west of the first. When about 300 feet north of north end of Canal Dock cuts were commenced running downward from a line from west edge of channel to end of dock, so as to cut off the corner between the wide and the narrow channel. The dredge then hauled back to the channel, and completed the dredging to the steamboat dock on October 31, having taken out in ninety-eight days 772 scow-loads, 153,817 cubic yards; having been laid up but two whole days on account of break-downs—one when the spud broke from the effects of a heavy gale, and the other spent in replacing friction-clutches—so that in ninety-six working days 153,817 cubic yards were removed, or 1,600 cubic yards per day, which rate has, I believe, never been exceeded for so extended a period of time, although for a single day Morris & Cummings have with one dredge taken out 3,600 cubic yards. The contractors are deserving of favorable mention for the manner in which they performed the work, and their strict adherence to the directions of the superintendent, Mr. Mather, from whose careful attention has resulted the successful prosecution of the work. On November 17 and 18 a survey was made of the channel dredged in the following manner: Buoys were anchored on the edge of the channel for convenience in sounding, and lines of soundings run across the channel, both edges being located by two transits, intermediate soundings being taken at equal intervals across the channel. Other lines were also run down the channel to ascertain if any shoal spots existed. The soundings were reduced to mean low water at Long Wharf. A map has been made of the channel on a scale of $\frac{1}{5000}$, before and after dredging. In this the green line represents 6-foot curve, broken black lines 9-foot curves, full red line 12-foot curve, before dredging; broken line (red) the channel as dredged; black figures, soundings before dredging; red figures, soundings after dredging. It will be seen that in no case is there less than 12.5 feet in the dredged channel, and then only on lumps so small that the sounding lead would scarcely rest upon them, and which would be knocked over by anything striking them. From this survey, then, the following conclusions may be drawn: a channel 200 feet wide and 13 feet deep at mean low water has been dredged from Black Buoy No. 5 to Long Wharf, a channel of same depth 350 feet wide from Long Wharf to Canal Dock, and one 100 feet wide from Canal Dock to Steamboat Dock. As a result of this several vessels drawing from 13 to 19 feet have gone up to the dock without previous lightering, and numerous others, drawing from 9 to 13 feet, have been towed up without waiting for the tide as heretofore. A survey of the dumping-ground was made November 3, the soundings being located by two sextants, and reduced to mean low water at Five-Mile Point; eighty soundings were taken, and showed no perceptible diminution of depth. A map of this will be made, and a comparison of the depths with those in the United States Coast Survey, for the purpose of ascertaining to what extent the dumping has affected the bottom.

REMOVAL OF LUDDINGTON'S ROCK.

Work was commenced on Luddington's Rock first, for the reason that it was a more formidable obstruction than Middle Rock, lying as it does directly in the west channel of the harbor, having only 9.8 feet over it at mean low water, and having been

struck several times by vessels, which were badly injured, while Midddle Rock has never been struck. Mr. Eugene Sullivan's blasting sloop arrived at New Haven on July 29, and, after placing dualine and powder in the magazine at mouth of Morris Creek, on the 31st the mooring-stones were taken aboard from Long Wharf, and on August 1 the sloop went out to Luddington's Rock. Upon sounding I found that the H. S. buoy placed on the rock by the tender Putnam, belonging to the Light-House Board, was on the highest point of the rock. On the 1st and 2d the mooring-stones and buoys were put down so that the vessel could be moored with the tide west-northwest and east-southeast. The divers reported the rock to be covered with rock-weed and the water to be very thick, the limit of vision being about a foot. Operations commenced on August 3, by the use of surface and face blasts of dualine and powder, about eight tons of rock being taken up. First deck-load of stone, amounting to forty-six and one-half tons, was discharged on August 8, having been removed entirely by face and surface blasts; the work commencing on the west side of the sand-gulley and progressing westward. To remove this amount of rock (21.21 cubic yards) were required 100 pounds of dualine and 265 pounds of powder, this being at the rate of two pounds of dualine and four pounds of powder for every ton of rock. As there were four and one-half working-days, the amount removed per day was ten tons. This large increase over the rate last year from the same kind of blasting is due to the superior convenience of Mr. Sullivan's vessel, and more especially to the competency of himself and assistant diver. I made three determinations of the specific gravity of the rock, and found it to be 2.599; weight of a cubic yard, 4,385.61 pounds. The method of weighing will be alluded to hereafter. The next deck-load of stone was discharged on August 17, and consisted of 44½ tons, and was removed by face and surface blasts of 140 pounds of dualine and 400 pounds of powder, being three and one-fifth pounds of dualine and nine pounds of powder per ton. During this time there were five and one-half working-days—rock being removed at the rate of eight tons per day. Finding that surface and face blasts removed the rock too slowly, Mr. Sullivan put in order his Burleigh drill, worked by steam from the hoisting-engine on deck. This drill was mounted on an iron tripod 23 feet long, weighing over a ton, and having adjustable legs to adapt it to the inequalities in the rock—the drill being secured in a joint which allowed it to drill at any angle within the triangle formed by the tripod legs. Mr. Sullivan was well supplied with drills, (having forty in all, of various lengths,) the edges being ×-shaped. He also had a portable forge and an experienced man to sharpen the drills, so that no time was lost in replacing a dull drill. The Burleigh drill worked as well as could be expected, when running under water, and having a drill-shaft 20 feet long to lift; frequently drilling 7 feet an hour, running time. When it is stated that in the operations at Middle Rock last year, the best progress made by Townsend's drill was 8 inches in an hour, but little further comment will be necessary on the relative rapidity of removing rock in 1870 and 1871. On August 31, a deck-load of stone was discharged of 27½ tons. Five holes—total depth, 15 feet—had been drilled, and 60 pounds of dualine and 212 pounds of powder exploded, or 2½ pounds of dualine and 8 pounds of powder per ton. There were seven working-days during this time, stone being removed at the rate of 4 tons per day; much time being lost owing to wind. Much difficulty was experienced in working the drill, as the boiler was not large enough to keep up steam, the drill requiring 80 pounds at least, on account of the heavy shaft. During September four deck-loads of stone of 49 tons 1,740 pounds, 36 tons 1,890 pounds, 51 tons 955 pounds, and 20 tons 1,820 pounds, respectively, were discharged, the weight being determined as follows: by the courtesy of the superintendent of New Haven and Northampton Railroad, Mr. Yeomans, I was enabled to weigh the second load upon the scales of the company. The vessel had previously been marked before leaving Boston, and before and after unloading the marks were taken. At this time the marks showed 34½ tons; then for other loads, actual weight

$$= \text{weight by marks} \times \frac{37\frac{1}{2}}{34\frac{1}{2}}.$$

The total amount removed during September was 159 tons 405 pounds, or 72.77 cubic yards; number of working-days twenty-one, or 7⅗ tons per day; 623 pounds of powder and 217 pounds of dualine being used, or 4 pounds of powder and 1½ pounds of dualine per ton. Five holes were drilled to a total depth of 21.3 feet, at the rate of 7.1 feet per hour, running time. Operations for the year were closed on September 30; there having been removed from the rock in thirty-eight working-days 267 tons 1,405 pounds of rock, or 126.85 cubic yards, or at the rate of 7 tons per day, by the expenditure of 1,426 pounds of powder and 549 pounds of dualine, or 2 pounds of dualine and 5⅓ pounds powder per ton. With a larger boiler the work would proceed faster; and as Mr. Sullivan proposes having one in the spring, there is no reason why the work should not progress with a satisfactory degree of rapidity.

FUTURE IMPROVEMENT.

Taking into consideration the relative positions of the rocks at the entrance to the harbor, I would suggest that no further work be done at Middle Rock, for the following

reasons: 1st. That the removal of Middle Rock would be of no advantage, except in connection with the removal of B, C, and Southwest Ledge, as the distance between them is so small that unless all were removed the channel would not be materially widened. 2d. Middle Rock is not in either channel, but on one side of East Channel, in which there is more water than would be obtained by its removal, while the Big Boil lies directly in the channel, and has been struck several times by vessels, as it is not laid down upon any chart. I would therefore recommend the removal of the Big Boil and the continuance of the operations for the removal of Luddington's Rock. I submit the following estimate for the removal of Big Boil to 17 feet below mean low water, and for the completion of the removal of Luddington's Rock to 16 feet below mean low water:

To remove Big Boil, 586.71 cubic yards, at $25	$14,667 75
To remove Luddington's Rock, 695.02 cubic yards, at $25	17,375 50
To remove both rocks	32,043 25

The removal of these rocks with the same degree of rapidity as that taken out by Mr. Sullivan this year will require three hundred and eighty-five working-days, but with increased boiler-room, so that the drill can be properly worked, there is no reason why this rate should not be doubled, especially as the Big Boil is well adapted for blasting. I would also suggest the dredging of the sand-bar between Fort Hale and the light-house, but consider it is a subject requiring reflection, for unless the improvement is to be in some degree permanent, it will be worse than useless to prosecute it. If the sand in New Haven Harbor moves as in some of the sound harbors, a channel through the bar would not stay open a single season, and it is too expensive an undertaking to be commenced without a fuller knowledge of the tidal currents than we have at present. If the direction of the currents is nearly identical with that of the proposed channel, it would, I think, remain open, as the scour would be sufficient to prevent deposit, especially as Five-Mile Point forms a natural breakwater, protecting the inner harbor from the swell of a southeast storm, the only cause in addition to the tidal currents that would make an accumulation of sand. I would therefore suggest that sufficient current observations be made to determine velocity and direction of the tidal currents in the stratum of water next to the bottom, and that after having obtained the general direction of the ebb and flood currents, perforated boxes be so placed as to collect the sand, if any is in motion over the bar. That there is no deposit going on at present is evident from a comparison of the reduced soundings made in 1871 with those of the United States Coast Survey, so that the sand movement can only be detected by placing an obstacle in its path. In case these observations prove favorable, I submit the following estimate of the cost of dredging a channel 200 feet wide and 16 feet deep at mean low water through the bar. The average depth of dredging is about 2 feet, and distance to be dredged 5,000 feet, therefore amount to be excavated $= \frac{200 \times 5000 \times}{27}$ cubic yards $= 74{,}747.4$ cubic yards, which, at 35 cents, is $26,161.60. The material, being comparatively soft sand, could be dredged at this rate, especially as the dumping-ground is over two and one-half miles from the bar. The iron spindle-socket on Southwest Ledge should be removed, as it is a dangerous obstacle in the path of small vessels. This would require the expenditure of not over $100. The total amount required to prosecute the improvement would be as follows:

For removal of rocks	$32,043 25
For dredging bar	26,161 60
For removing spindle	100 00
For current observations	250 00
Total	58,554 85

The importance of the harbor will warrant this expenditure, as the city is the terminus of railroads supplying a large section of the interior, as will be seen by the annexed statistics of the commerce of New Haven. Numerous vessels, drawing from 14 to 19 feet, are delayed by waiting for the tide to cross the bar, while, if the bar was dredged and the channel buoyed, the harbor would become *the* refuge harbor on the sound.

I am, general, yours, very respectfully,

GEORGE H. MANN,
Civil Engineer.

Brevet Major-General G. K. WARREN,
Major Engineers, United States Army.

NEW HAVEN HARBOR.—*Tide observations at Chapel-street bridge.*

Mean sea-level, 4.932.

Date.	5.30 a. m.	5.40 a. m.	5.50 a. m.	6 a. m.	6.10 a. m.	6.20 a. m.	6.30 a. m.	6.40 a. m.	6.50 a. m.	7 a. m.	7.10 a. m.	7.20 a. m.	7.30 a. m.
March 18													
March 19													
March 20													
March 21													
March 22				1.75	.7	.65	.63	.62	.67	.7	.82	2.0	.23
March 23							1.35	.4	.45	.5	.6	.7	.8
March 24									1.32	.22	.07, .12	.10	.18
March 25											1.85	.75	.65
March 26													
March 27													
March 28													
March 29													
March 30													
March 31								7.4	.5, .48	.48	.4	.35	.3
April 1												7.47	.55
April 2													
April 3													
April 4													
April 5													
April 6													
April 7				1.25	.18	.07	.0	0.95	1.02	.2	.42	.65	.9
April 8										1.18	.1	.0	0.91
April 9													
April 10													
April 11													
April 12													
April 13													
April 14				7.49	.59	.75	.89	.98	8.09	.15	.21, .20	.20	.18
April 15													7.9

Date.	7.40 a. m.	7.50 a. m.	8 a. m.	8.10 a. m.	8.20 a. m.	8.30 a. m.	8.40 a. m.	8.50 a. m.	9 a. m.	9.10 a. m.	9.20 a. m.	9.30 a. m.	9.40 a. m.
March 18									8.1	.13	.20	.22	.26
March 19													
March 20													
March 21													
March 22	.60	.75	.9	3.1	.3	.5	.75	4.0	.3	.6	.8	.95	5.15
March 23	.95	2.1	.4	.6	.85	3.05	.20	.40	.67	.97	4.26	.5	.8
March 24	.20	.17	.15	.20	.28	.5	.8	2.0	.1	.25	.42	.65	.85
March 25	.55	.45	.35	.25	.25	.32	.45	.52	.6	.66	.76	.93	2.05
March 26			1.25	.22	.2	.1	.098, .0	.0	.05	.1	.1	.17	.3
March 27							5.1	.1	.1	.0	4.9	.9	.95
March 28													
March 29													
March 30													
March 31	.15	.0	6.9	.75	.6	.4	.3	.22	.12	5.9	.68	.43	.25
April 1	.65	.75, .72	.72	.7	.62	.6	.5	38	.3	.18	.7	6.97	.8
April 2				8.4	.47	.55	.65	.62	.57	.45			
April 3										9.28	.36	.46	.46
April 4													
April 5													
April 6													
April 7	2.08	.26	.43	.62	.86	3.01	.37	.65	.40	.33	.67	.9	5.17
April 8	.93	1.0	.2	.45	.7	.9	2.1	.32	.57	.82	3.05	.3	.55
April 9			1.38	.42	.49	.53	.55	.61	.8	.98	2.2	.45	.77
April 10					2.0	1.09	.79	.65	.62	.68	.69	.78	.65
April 11									3.2	.0	2.83	.71	.68
April 12													
April 13													
April 14	.08	7.96	.8	.68	.48	.35	.21	.0	6.85	.72	.4	.15	5.98
April 15	8.0	.1	.2	.28	.29	.27	.23	.05	7.89	.68	.50	.35	.22

Tide observations at Chapel-street bridge—Continued.

Date.	9.50 a. m.	10 a. m.	10.10 a. m.	10.20 a. m.	10.30 a. m.	10.40 a. m.	10.50 a. m.	11 a. m.	11.10 a. m.	11.20 a. m.	11.30 a. m.	11.40 a. m.	11.50 a. m.
March 18	.20	.0	7.9										
March 19	8.05	.1	.2	.15	.1	.0	7.95	.8	.6	.4	.2	.0	6.8
March 20		8.0	.1	.3	.4	.5	.6	.6	.5	.45	.35	.25	.05
March 21					8.7	.8	.9	9.0	.05	.17	.20	.1	.07
March 22	.45	.65	.85	6.05	.25	.45	.62	.8	.97	7.15	.30	.35	.40
March 23	5.0	.29	.57	.8	6.0	.02	.39	.6	.9	7.15	.4	.45	.6
March 24	3.05	.3	.5	.75	.95	4.15	.35	.65	.9	5.15	.25	.45	.65
March 25	.2	.4	.6	.7	.85	3.05	.2	.4	.5	.7	.87	4.06	.2
March 26	.45	.5	.8	2.0	.25	.45	.6	.8	3.0	.2	.3	.5	.7
March 27	5.1	.1	.15	.25	.30	.4	.55	.65	.7	.8	.9	6.05	.27
March 28		2.68	.6	.53	.6	.66	.75	.8	.95	3.03	.18	.25	.31
March 29					2.3	.2	.2	.15	.2	.2	.15	.15	.2
March 30											2.6	.5	.5
March 31	.13	.0	4.9	.78	.62	.4	.23	.07	3.9	.7	.5	.21	.15
April 1	.65	.45	.32	.0	5.81	.6	.39	.02	.08	4.9	.72	.50	.33
April 2													
April 3	.40	.32	.27	.10	8.95	.8	.6	.35	.1	7.87	.62	.49	.25
April 4		8.9	.95	.98	.98	.9	.8	.63	.41	.2	.0	7.8	.55
April 5				7.3	.4	.43	.43	.5	.45	.4	.4	.3	.16
April 6										8.66	.74	.72	.7
April 7	.47	.6	.86	6.15	.47	.77	.95	7.2	.48	.63	.8	.95	8.1
April 8	.83	4.27	.5	.77	5.05	.3	.5	.7	.96	6.2	.43	.7	.92
April 9	.97	3.2	.4	.62	.85	4.12	.37	.63	.9	5.2	.46	.67	.88
April 10	.9	2.0	.13	.33	.65	.68	3.05	.28	.4	.61	.82	4.07	.3
April 11	.61	.57	.6	.69	.61	.6	.68	.69	.85	3.05	.2	.35	.68
April 12		3.05	2.94	3.0	2.78	.7	.55	.37	.28	.2	.2	.34	.5
April 13									3.1	2.9	.74	.59	.45
April 14	.81	.6	.35	.15	4.97	.76	.59	.4	.2	.05	3.9	.75	.55
April 15	.07	6.85	.69	.38	.13	5.98	.79	.52	.30	.10	4.91	.70	.5

Date.	12 m.	12.10 p. m.	12.20 p. m.	12.30 p. m.	12.40 p. m.	12.50 p. m.	1 p. m.	1.10 p. m.	1.20 p. m.	1.30 p. m.	1.40 p. m.	1.50 p. m.	2 p. m.
March 18													
March 19	.55	.3	5.95	.8	.6	.32	.1	4.8	.5	.3	.15	3.9	.7
March 20	7.9	.7	.5	.25	.0	6.75	.5	.2	.1	5.9	.7	.5	.25
March 21	.02	.0	8.8	.55	.37	.05	7.72	.55	.30	.0	6.9	.7	.45
March 22	.42	.45	.5	.47	.45	.15	.05	6.92	.75	.65	.46	.25	5.95
March 23	.72	.8	8.1	.15	.15	{.25 .30	.26	{.15 9	.20	.0			
March 24	.75	.95	6.2	.3	.45	.6	.75	.9	7.0	.1	.15	.05	.10
March 25	.4	.47	.55	.8	.93	5.15	.35	.4	.55	.67	.85	.85	.9
March 26	.95	4.15	.35	.55	.75	.95	5.05	.3	.45	.55	.65	.78	.95
March 27	.45	.55	.70	.75	.75	.8	.9	7.0	.1	.2	.25	.32	.42
March 28	.50	.60	.70	.82	4.0	.98	.46	.6	.74	.9	5.1	.25	.4
March 29	.3	.37	.45	.57	.62	.8	.95	3.1	.25	.47	.60	.75	.9
March 30	.57	.6	.55	.49	.5	.57	.62	.75	.8	.9	3.25	.3	.32
March 31	.08	.0	2.88	.78	.71	.67	.67	.67	.67	.68	.70	.75	
April 1	.27	.18	3.99	.75	.66	.59	.52	.43	.25	.1	2.98	.92	.98
April 2													
April 3	.01	6.79	.51	.27	.0	5.72	.42	.19	.05	4.9	.67	.43	.78
April 4	.33	.1	6.9	.6	.33	.11	5.86	.6	.3	.01	4.8	.55	.30
April 5	.0	6.72	.55	.25	.0	5.76	.5	.25	.0	4.72	.5	.23	3.95
April 6	.69	.7	.63	.5	.3	.07	7.86	.63	.40	.12	6.9	.7	.46
April 7	.21	.35	.5	.55	.6	.55	.45	.4					
April 8	7.12	.40	.59	.77	.9	8.0	.1	.25	.37	.37	.37	.30	.18
April 9	6.1	.35	.56	.80	7.1	.3	.4	.6	.77	8.07	.10	.2	.32
April 10	.52	.8	5.03	.3	.48	.6	.79	.92	6.27	.52	.8	.93	7.1
April 11	.95	4.28	.48	.7	.88	5.1	.28	.48	.68	.8	6.05	.35	.65
April 12	.66	.85	.99	3.1	.19	.19	.33	.65	.9	4.17	.4	.68	.88
April 13	.35	.25	{.15 .17	.16	{.2	.26	.3	.34	.38	.5	.78	.92	3.14
April 14	.35	.2	.1	2.9	.77	.57	.4	.36	.39	.47	.49		
April 15	.36	.12	3.92	.79	.60	.45	.27	.08	2.97	.82	.7	.59	.51

Tide observations at Chapel-street bridge—Continued.

Date.	2.10 p. m.	2.20 p. m.	2.30 p. m.	2.40 p. m.	2.50 p. m.	3 p. m.	3.10 p. m.	3.20 p. m.	3.30 p. m.	3.40 p. m.	3.50 p. m.	4 p. m.	4.10 p. m.
March 18			2.1	1.95	.82	.7	.59	.6	.6	.5	.45	.55	.8
March 19	.5	.25	.05	2.9	.63	.4	.2	1.95	.75	.65	.6	.58	.55
March 20	4.95	.8	.5	.25	.1	3.85	.65	.45	.20	2.95	.8	.55	.4
March 21	.2	5.9	.55	.25	.0	4.75	.55	.35	.05	.0	3.85	.65	.45
March 22	.7	.5	.3	.05	4.8	.6	.35	.05	3.95	.75	.55	.35	.15
March 23													
March 24	.03	.03	6.9	.7									
March 25	.9	.9	.85	.8	.75	.65	.45						
March 26	6.1	.33	.35	.48	.48	.45	.45	.41	.35	.38			
March 27	.45	.42	.4	.47	.45	.53	.53	.44	.4	.23	.15		
March 28	.55	.70	.85	6.1	.25	.4	.55	.7	.8	.85	.90	.95	7.0
March 29	4.1	.3	.5	.65	.8	.95	5.1	.2	.3	.47	.6	.75	.8
March 30	.49	.6	.8	.95	4.05	.2	.3	.47	.67	.85	5.15	.2	.37
March 31													
April 1	3.02	.75											
April 2		3.01	2.9	.88	.92	.93	.92	.95	.99	3.02			
April 3	3.98	.78	.65	.5	.35	.19	.1	2.95	.83	.73	.7	.72	.78
April 4	.10	.0	3.8	.6	.4	.2	.0	2.8	.5	.3	.1	.0	1.9
April 5	.65	.40	.1	2.9	.72	.55	.28	.0	1.6	.5	.36	.25	.1
April 6	.2	5.95	.62	.32	.02	4.83	.5	.3	.01	3.82	.6	.32	.02
April 7													
April 8													
April 9	{.45 .47	.45	{.43	.42	.3								
April 10	.28	.33	.68	.79	.9	.99	8.02	.02	.02	.0	7.9		
April 11	.85	.95	7.2	.4	.5	.6	.84	8.01	.23	.27	.30	.45	.48
April 12	5.0	.2	.4	.6	.78	.91	6.11	.31	.4	.55	.78	7.03	.18
April 13	.31	.46	.69	.88	4.11	.30	.55	.77	.94	5.15	.4	.7	.88
April 14													
April 15	.47	.44	{.44 .41	.44	{.49	.57							

Date.	4.20 p. m.	4.30 p. m.	4.40 p. m.	4.50 p. m.	5 p. m.	5.10 p. m.	5.20 p. m.	5.30 p. m.	5.40 p. m.	5.50 p. m.	6 p. m.	6.10 p. m.	6.20 p. m.
March 18	.9	.95											
March 19	.50	.35	.3	.35	.5	.65							
March 20	.2	.05	.0	1.95	.85	.8	.85	.85	.90	2.05	.0		
March 21	.15	2.9	.7	.5	.25	.15	.15	.2	.2	.1	.0	.0	.1
March 22	2.95	.7	.55	.35	.2	.0	1.85	.7	.6	.55	.5	.45	4
March 23													
March 24													
March 25													
March 26													
March 27													
March 28	.0	.0	.95	.8	.8								
March 29	.97	6.1	.2	.27	.3	.3	.32	.35	.37	.42	.4	.35	.35
March 30	.49	.6	.72	.85	6.0	.25	.37	.5	.7	.75	.8	.75	.77
March 31													
April 1													
April 2													
April 3	.85												
April 4	.82	.8	.7	.72	.83	.93							
April 5	.98	.8	.78	.7	.65	.52	.45	.42	.5	.67			
April 6	2.82	.6	.4	.15	1.90	.7	.52	.45	.38	.3	.25	.20	.31
April 7													
April 8													
April 9													
April 10													
April 11	.55	.64	.62	.46	.3								
April 12	.3	.45	.6	.69	.8	.9	.98	8.02	.05	7.98	.91		
April 13	.99	6.1	.28	.51	.78	.97	7.1	.3	.45	.5	.7	.85	.9
April 14													
April 15													

Tide observations at Chapel-street bridge.—Continued.

Date.	6.30 p. m.	6.40 p. m.	6.50 p. m.	7 p. m.	7.10 p. m.	7.20 p. m.	High-water stand.	Low-water stand.	Duration of ebb.	Duration of flood.	Rise.	Fall.
							Min.	*Min.*	*h. m.*	*h. m.*	*Feet.*	*Feet.*
March 18								5	6 9			6.81
March 19							8	5	6 28½			6.90
March 20							10	10	6 15			6.80
March 21	.25	.5	.8				0	10	6 35			7.20
March 22	.4	.4	.45	.6	.8		15	10 / 20	6 17½	5 37½	5.88	6.10
March 23							0	5		6 17½	6.90	
March 24							0	0		6 25	6.08	
March 25							20	10		6 5	4.65	
March 26							10	0		6 0	5.50	
March 27							10	10		5 40	2.63	
March 28							20	5		6 22½	4.47	
March 29							0	10		6 15	4.27	
March 30	.82	.8	.75				0	0		6 00	4.33	
March 31							0	35	6 17½			4.83
April 1							0	5	5 59½			4.83
April 2							5	5	5 55			5.67
April 3							10	10	6 15			6.76
April 4							15	5	6 20			7.28
April 5							10	5	6 42½			7.01
April 6	.42						5	5	6 30			7.49
April 7							10	5		5 57½	7.65	
April 8							20	5		5 57½	7.46	
April 9							0	5		6 12½	7.09	
April 10							25	5		6 25	6.40	
April 11							0	0		6 37½	6.08	
April 12							5	10		6 12½	5.85	
April 13	8.03	.17	.1	.2	.21	.16	7.96	0	0	6 40	6.06	
April 14							0	0	6 05			5.86
April 15							5	0	5 32½			5.88

NEW HAVEN HARBOR.—*Tide observations at Long Wharf.*

Mean sea-level, 5.189.

[At Chapel-street bridge it was 4.932; diff.=.257; so the readings at Long Wharf were reduced .3]

Date.	5.30 a. m.	5.40 a. m.	5.50 a. m.	6 a. m.	6.10 a. m.	6.20 a. m.	6.30 a. m.	6.40 a. m.	6.50 a. m.	7 a. m.	7.10 a. m.	7.20 a. m.	7.30 a. m.	7.40 a. m.
March 18														
March 19														
March 20														
March 21														
March 22	1.6	.5	.45	.4	.4	.35	.35	.4	.5	.65	.8	2.05	.3	.5
March 23						1.3	.3	.35	.4	.5	.6	.7	.8	.95
March 24									1.1	.0	0.95	1.0	.05	.05
March 25										1.85	.75	.55	.55	.45
March 26														
March 27														
March 28														
March 29														
March 30														
March 31				7.3	.4	.45	.45	.5	.5	.47	.43	.37	.3	.1
April 1												7.5	.6	.67
April 2														
April 3														
April 4														
April 5														
April 6														
April 7				.85	.85	.72 / .78	.75	.8	.9	1.09	.3	.59	.75	.99
April 8									1.02	.0	0.9	.8	.76	.79
April 9														
April 10														
April 11														
April 12														
April 13														
April 14				7.7	.9	8.0	.1	.17	.2	.22	.2	.15	.13	
April 15										7.7	.8	.95	8.05	.15

Tide observations at Long Wharf—Continued.

Date.	7.50 a. m.	8 a. m.	8.10 a. m.	8.20 a. m.	8.30 a. m.	8.40 a. m.	8.50 a. m.	9 a. m.	9.10 a. m.	9.20 a. m.	9.30 a. m.	9.40 a. m.	9.50 a. m.	10 a. m.
March 18					7.9	8.0	.1	.1	.2	.3	.3	.3	.2	.0
March 19											8.0	.1	.2	.2
March 20														
March 21														
March 22	.7	.9	3.1	.4	.65	.9	4.2	.45	.65	.85	5.1	.3	.5	.7
March 23	2.15	.4	.65	.9	3.1	.3	.6	.95	4.2	.45	.75	5.0	.25	.55
March 24	.05	.1	.15	.25	.5	.8	2.0	.2	.35	.6	.8	3.0	.2	.45
March 25	.35	.25	.2	.25	.35	.45	.5	.6	.7	.8	.9	2.1	.3	.5
March 26			1.2	.1	.0	0.95	.95	1.0	.03	.1	.2	.3	.45	.55
March 27														
March 28														2.52
March 29														
March 30														
March 31	6.95	.8	.65	.5	.4	.3	.15	.0	5.8	.6	.35	.22	.1	4.97
April 1	.72 / .72	.7	.67	.62	.57	.5	.4	.3	.1	.0	6.9	.7	.55	.35
April 2				8.55	.65	.7 / .7	.67	.6	.5					
April 3									9.4	.47	.5	.5	.45	.4
April 4													8.85	.95
April 5														
April 6														
April 7	2.18	.3	.55	.85	3.08	.50	.8	4.08	.29	.50	.95	6.25	.45	.7
April 8	.91	.97	1.32	.52	.84	2.1	.38	.65	.92	3.2	.48	.78	4.8	.4
April 9	1.4	.35 / .36	.38	.45	.48	.55	.64	.8	2.05	.35	.55	.8	3.07	.45
April 10				1.9	.75	.66	.6	.6	.62	.7	.75	.8	.9	2.0
April 11								3.0	2.81	.71	.7	.6	.6	.65
April 12														2.95
April 13														
April 14	.05	7.9	.8	.65	.45	.3	.2	.0	6.75	.5	.3	.05	5.9	.7
April 15	.23	.35	.35	.32	.27	.2	.13	.0	7.8	.65	.57	.4	.2	.0

Date.	10.10 a. m.	10.20 a. m.	10.30 a. m.	10.40 a. m.	10.50 a. m.	11 a. m.	11.10 a. m.	11.20 a. m.	11.30 a. m.	11.40 a. m.	11.50 a. m.	12. p. m.	12.10 p. m.	12.20 p. m.
March 18	7.8	.6	.4	.3	.1	6.8	.6	.4	.2	5.9	.6	.3	.0	4.8
March 19	.2	.2	.1	.0	7.9	.8	.6	.4	.1	6.9	.1	.4	.2	5.9
March 20														
March 21								9.25	.2	.15	.1	.05	.0	8.8
March 22	.9	6.1	.3	.5	.7	.9	7.1	.2	.3	.35	.35	.45	.45	.45
March 23	.75	6.0	.25	.4	.65	.9	7.1	.35	.45	.6	.75	.9	8.0	.1
March 24	.75	4.0	.2	.45	.6	.85	5.0	.25	.40	.6	.8	.95	6.15	.35
March 25	.65	.8	3.05	.15	.35	.55	.7	.9	4.05	.2	.35	.55	.7	.8
March 26	.72	.97	2.2	.4	.6	.8	3.0	.2	.4	.6	.8	4.0	.22	.45
March 27														
March 28	.5	.55	.6	.7	.8	.9	3.0	.1	.25	.4	.5	.6	.7	.85
March 29			2.2	.15	.15	.15	.13	.1	.13	.17	.25	.35	.4	.6
March 30					3.2	2.8	.7	.6	.5	.5	.55	.5	.5	.55
March 31	.85	.7	.5	.35	.2	.0	3.75	.57	.37	.2	.1	.0	2.9	.75
April 1	.12	.0	5.75	.55	.35	.2	.0	4.75	.6	.45	.3	.15	.0	3.85
April 2														
April 3	.3	.15	8.92	.82	.52	.3	.1	7.87	.65	.4	.2	6.92	.6	.37
April 4	.95	.95	.95	.85	.70	.50	.35	.1	7.9	.7	.45	.15	6.9	.6
April 5	7.2	.3	.35	.35	.45 / .42	.42	.35	.3	.3	.2	.1	6.95	.7	.35
April 6						8.48	.6	.7	.72	.7	.7	.68	.68	.6
April 7	.95	6.28	.55	.76	7.07	.3	.55	.75	.81	.91	8.09	.23	.35	.5
April 8	.75	5.0	.25	.5	.7	.92	6.12	.37	.62	.87	7.09	.3	.5	.75
April 9	.58	.75	4.1	.4	.6	.9	5.15	.4	.6	.5	6.08	.3	.48	.75
April 10	.15	.40	.7	.95	3.2	.37	.55	.85	4.0	.25	.5	.78	5.0	.25
April 11	.69	.69	.6	.7	.67	.8	.9	3.12	.32	.52	.92	.42	.4	.62
April 12	.9	.85	.7	.59	.42	.30	.22	.20	.28	.41	.57	.73	.93	3.05
April 13								2.80	.65	.52	.42	.32	.21	.16
April 14	.5	.25	.05	4.8	.65	.45	.3	.15	3.95	.8	.6	.4	.2	.1
April 15	6.7	.4	.2	.0	5.8	.6	.4	.2	.0	4.75	.55	.4	.2	3.9

Tide observations at Long Wharf—Continued.

Date.	12.30 p. m.	12.40 p. m.	12.50 p. m.	1 p. m.	1.10 p. m.	1.20 p. m.	1.30 p. m.	1.40 p. m.	1.50 p. m.	2 p. m.	2.10 p. m.	2.20 p. m.	2.30 p. m.	2.40 p. m.
March 18	.7	.4	.2	3.9	.6	.3	.1	2.9	.7	.6	.4	.2	.0	1.8
March 19	.7	.5	.2	4.9	.65	.4	.1	3.9	.7	.5	.3	.1	2.9	.7
March 20														
March 21	.55	.25	.0	7.7	.5	.25	.0	6.85	.65	.35	.1	5.75	.35	.05
March 22	.4	.3	.15	6.95	.8	.65	.45	.30	.1	5.8	.6	.3	.1	4.85
March 23	.2	.3	.2	.15	.1	.0	7.9							
March 24	.6	.75	.9	7.0	.1	.2	.1	.05	.0	6.95				
March 25	.05	5.05	.25	.4	.5	.7	.8	.9	.95	.95	.9	.85	.8	.75
March 26	.02	.82	5.02	.17	.35	.52	.65	.75	.9	6.1	.2	.3	.4	.45
March 27													7.5	.5
March 28	4.05	.3	.5	.7	.85	.95	5.15	.3	.45	.6	.75	.95	6.1	.3
March 29	.75	.95	3.1	.3	.5	.65	.75	.9	4.1	.3	.5	.6	.8	5.0
March 30	.55	.57	.65	.75	.80	.9	3.0	.15	.35	.5	.65	.8	.95	4.1
March 31	.7	.65	.6	.6	.6	.62	.65	.7						
April 1	.7	.55	.45	.45	.3	.15	.0	2.9	.85	.9	3.0	.05		
April 2												2.95	.9	.89
April 3	.1	5.8	.6	.4	.15	4.95	.7	.5	.25	3.95	.8	.6	.37	.25
April 4	.4	.1	5.8	.5	.2	4.95	.75	.5	.25	.0	3.8	.6	.35	.15
April 5	.15	5.85	.6	.3	.09	4.85	.59	.25	3.98	.7	.4	.1	2.85	.65
April 6	.4	.2	.0	7.71	.45	.21	.0	6.67	.5	.29	5.97	.72	.4	.5
April 7	.53	.58	.5	.4										
April 8	.72	8.05	.14	.24	.35	.4	{.45 .42}	{.43}	.3	.25				
April 9	7.0	.22	.4	.6	.7	.9	8.1	.18	.3	.35	.4	.49	.5	.4
April 10	.47	.6	.75	6.0	.25	.45	.7	.9	7.07	.2	.4	.6	.72	.87
April 11	.8	5.03	.29	.56	.66	.86	6.07	.38	.52	.79	.82	7.1	.35	.5
April 12	.07	.13	.32	.68	.90	4.1	.4	.66	.85	5.0	.15	.37	.51	.72
April 13	.16	.20	.23	.28	.37	.48	.63	.82	3.01	.23	.46	.63	.82	4.03
April 14	2.95	.85	.65	.45	.4	.4	.45	.47	.5	.6				
April 15	.7	.55	.35	.2	.0	2.9	.8	.7	.55	.5	.4	.4	.35	.3

Date.	2.50 p. m.	3 p. m.	3.10 p. m.	3.20 p. m.	3.30 p. m.	3.40 p. m.	3.50 p. m.	4 p. m.	4.10 p. m.	4.20 p. m.	4.30 p. m.	4.40 p. m.	4.45 p. m.	5 p. m.
March 18	.7	.6	.5	.4	.4	.3	.4	.5	1.7	.8				
March 19	.5	.2	.0	.18	.62	.52	.5	.42	.4	.32	.22	.22	.3	.4
March 20														
March 21	4.85	.65	.40	.15	.0	3.9	.7	.4	.1	2.8	.6	.3	.2	0.5
March 22	.6	.4	.1	3.9	.7	.5	.3	.0	2.8	.6	.4	.3	.1	1.9
March 23														
March 24														
March 25	.65													
March 26	.45	.5	.45	.4	.3	.25								
March 27	{.57 .55}	{.55}	.5	.45	.25									
March 28	.45	.55	.65	.7	.85	.9	.95	.95	.95	7.0	.07	.0	6.95	
March 29	.15	.25	.4	.5	.6	.75	.85	.95	6.1	.2	.25	.25	.3	.35
March 30	.2	.3	.5	.7	.9	5.1	.25	.4	.6	.7	.9	6.05	.15	.25
March 31														
April 1														
April 2	.89	.89	.9	.92	.97	3.0								
April 3	.15	2.9	.85	.75	.7	.65	.6	.6	.67	.77				
April 4	2.9	.7	.5	.3	.1	1.9	.85	.75	.7	.7	.65	{.6 .6}	{.65}	.7
April 5	.4	.25	1.91	.7	.45	.3	.68	0.95	.75	.65	.55	.5	.5	.35
April 6	4.7	.55	.28	.0	3.8	.45	.23	.0	2.75	.55	.30	.12	1.85	6.10
April 7														
April 8														
April 9	.3													
April 10	.97	8.1	.12	.12	.08	.0								
April 11	.6	.8	8.02	.25	.25	.25	.45	.52	.55	.7	.65	.5		
April 12	.9	6.05	.27	.41	.57	.75	7.0	.2	.3	.36	.65	.73	.8	.91
April 13	.25	.50	.69	.9	5.12	.41	.65	.82	6.0	.05	.21	.41	.7	.95
April 14														
April 15	.4	.5												

Tide observations at Long Wharf—Continued.

Date.	5.10 p. m.	5.20 p. m.	5.30 p. m.	5.40 p. m.	5.50 p. m.	6 p. m.	6.10 p. m.	6.20 p. m.	6.30 p. m.	6.40 p. m.	6.50 p. m.	7 p. m.	7.10 p. m.	7.20 p. m.
March 18														
March 19	.6	.8												
March 20	1.9	.8	.8	.9	2.1	.3								
March 21	.0	.0	.1	.0	1.9	.9	.95	2.05	.2	.4				
March 22	.75	.6	.5	.4	.3	.25	.25	.25	.3	.4	.5	.75	.95	2.1
March 23														
March 24														
March 25														
March 26														
March 27														
March 28														
March 29	.35	.4	.4	.4	.45	.35	.25							
March 30	.4	.55	.65	.7	.73	.7	.75	.85	.85	.8				
March 31														
April 1														
April 2														
April 3														
April 4														
April 5	.25	.2	.25	.4	.5									
April 6	.45	.32	.27	.19	.13	.1	.15	.2	.3					
April 7														
April 8														
April 9														
April 10														
April 11														
April 12	8.0	.05	.1	.08	.0	7.91								
April 13	7.08	.26	.44	.5	.67	.8	.91	8.02	.2	.2	.15	.22	.2	.0
April 14														
April 15														

Date.	7.30 p. m.	7.40 p. m.	7.50 p. m.	8 p. m.	8.10 p. m.	8.20 p. m.	8.30 p. m.	8.40 p. m.	8.50 p. m.	9 p. m.	High-water stand.	Low-water stand.	Duration of ebb.	Duration of flood.	Rise.	Fall.
											Min.	*Min.*	*h. m.*	*h. m.*	*Feet.*	*Feet.*
March 18											10	0	6 5			7.00
March 19											30	10	6 30			6.98
March 20											(*)	10	(*)			( )
March 21											0	10	6 35			7.35
March 22	.3	.5									{10 20}		6 0	5 45	6.10	6.20
March 23											10	0		6 15	7.00	
March 24											0	0		6 10	6.25	
March 25											10	10		5 45	4.75	
March 26											0	15		6 17½	5.55	
March 27											0	(*)		5 25	2.63	
March 28											0	10		6 25	4.57	
March 29											20	5		6 7½	4.30	
March 30											15	15		6 20	4.35	
March 31											15	20	6 12½			4.90
April 1											5	0	5 57½			4.87
April 2											5	30	6 5			5.81
April 3											15	10	6 22½			6.90
April 4											25	10	6 22½			7.35
April 5											0	10	6 25			7.25
April 6											c	0	6 30			7.62
April 7											5	0		5 47½	7.86	
April 8											0	5		5 57½	7.69	
April 9											5	0		6 22½	7.15	
April 10											15	15		6 25	6.52	
April 11											0	15		6 32½	6.10	
April 12											5	5		6 12½	5.90	
April 13											10	10		6 35	6.06	
April 14											5	20	5 52½			5.82
April 15											15	5	5 30			6.05

*Not determined.

NEW HAVEN HARBOR—*Tide observations at Fort Hale.*

Mean sea-level on box, 2.740; with indicator before April 7, 5.151 − 3 } To Chapel-street bridge gauge.
With indicator after and including, 4.151 + 7 }

Date.	5.30 a. m.	5.40 a. m.	5.50 a. m.	6 a. m.	6.10 a. m.	6.20 a. m.	6.30 a. m.	6.40 a. m.	6.50 a. m.	7 a. m.	7.10 a. m.	7.20 a. m.	7.30 a. m.	7.40 a. m.
March 31						7.3	.3	.4	.3	.25	.2	.2	.15	.0
April 1													7.45	.6
April 2*														.55
April 3														
April 4														
April 5														
April 6														
April 7				1.5	.35	.3	.25	.25	.35	.45	.55	.7	.9	2.3
April 8						1.3	.2	.1	.0	.0	.05	.05	.05	1.1
April 9														
April 10														
April 11														
April 12														
April 13														
April 14														
April 15							7.90	8.0	.10	.15	.15	.15	.10	.05
												7.90	.95	8.05

Date.	7.50 a. m.	8 a. m.	8.10 a. m.	8.20 a. m.	8.30 a. m.	8.40 a. m.	8.50 a. m.	9 a. m.	9.10 a. m.	9.20 a. m.	9.30 a. m.	9.40 a. m.	9.50 a. m.	10 a. m.
March 31	6.8	.7	.6	.5	.3	.25	.0	5.7	.65	.5	.4	.2	4.9	.8
April 1	.55	.55	.5	45	.35	.3	.2	.1	6.95	.8	.7	.65	.4	.25
April 2*														
April 3					8.8	9.0	.15	.2	.25	.25	.25	.2	.1	.0
April 4														
April 5														
April 6														
April 7	.5	.85	3.0	.15	.4	.75	4.0	.5	.8	5.0	.3	.5	.9	6.05
April 8	.15	.25	.45	.70	.95	2.1	.2	.45	.60	.75	3.25	.60	.95	4.2
April 9	1.60	.50	.45	.40	.45	.50	.55	.70	.95	2.15	.45	.70	3.05	.25
April 10					1.70	.65	.50	.55	.65	.65	.65	.70	.80	.95
April 11										2.75	.60	.60	.60	.60
April 12														
April 13														
April 14	7.95	.75	.70	.60	.50	.35	.10	6.90	.70	.50	.35	.15	.0	5.7
April 15	.15	.25	.25	.20	.15	.10	.0	7.95	.80	.60	.50	.35	.15	.0

Date.	10.10 a. m.	10.20 a. m.	10.30 a. m.	10.40 a. m.	10.50 a. m.	11 a. m.	11.10 a. m.	11.20 a. m.	11.30 a. m.	11.40 a. m.	11.50 a. m.	12 m.	12.10 p. m.	12.20 p. m.
March 31	.7	.45	.4	.2	3.9	.85	.65	.45	.2	.1	2.95	.85	.75	.7
April 1	5.95	.7	.6	.55	.3	.1	4.9	.7	.5	.45	.2	.0	3.8	.7
April 2*														
April 3	8.9	.7	.55	.35	.15	7.9	.65	.45	.15	6.9	.7	.35	5.9	.8
April 4	8.6	.65	.65	.45	.3	.2	.1	7.9	.7	.55	.3	.05	6.75	.5
April 5														
April 6														
April 7	.4	.6	.9	7.3	.6	7.85	8.05	.05	.15	.15	.15	.05	.0	7.9
April 8	.5	.75	5.0	.25	.50	.9	8.05	.1	.2	.3	.5	.6	.7	.45
April 9	.50	.70	4.05	.25	.55	.75	6.0	.25	.55	.70	.95	7.15	.35	.50
April 10	2.20	.35	.55	.70	3.05	.40	5.15	.45	.70	.95	6.15	.30	.50	.75
April 11	.60	.60	.65	.70	.80	.95	.65	.90	4.15	.40	.60	.95	5.15	.40
April 12		2.75	.65	.55	.35	3.05	.30	.60	.90	4.20	.35	.60	.75	
April 13						.20	.15	.25	.30	.35	.55	.85	.95	3.0
April 14	.45	.20	.0	4.8	.60	3.20	.25	2.9	.55	.40	.25	.20	.20	.25
April 15	6.70	.55	.30	.05	5.85	.65	.40	.20	4.95	.75	.55	.30	.10	2.95
													.10	3.95

* No observation on account of [illegible]

Tide observations at Fort Hale—Continued.

Date.	12.30 p. m.	12.40 p. m.	12.50 p. m.	1 p. m.	1.10 p. m.	1.20 p. m.	1.30 p. m.	1.40 p. m.	1.50 p. m.	2 p. m.	2.10 p. m.	2.20 p. m.	2.30 p. m.	2.40 p. m.
March 31	.65	.6	.55	.5	.5	.55	.6	.65	.7	.8				
April 1	.6	.5	.3	.2	.05	2.85	.8	.8	.7	.7	.7	.65	.7	.8
April 2*														
April 3	.6	.3	.1	4.9	.7	.45	.2	3.95	.75	.65	.5	.45	.2	.05
April 4	.2	.0	5.7	.55	.2	4.85	.5	.2	3.95	.8	.55	.3	.1	2.9
April 5														
April 6	.8	.6	.45	.2	.05	6.9	.75	.45	.0	5.7	.4	.1	4.8	.45
April 7	.9	.8												
April 8	.65	.80	.90	8.05	.15	.25	.20	.15						
April 9	7.0	.20	.45	.70	8.0	.25	.40	.55	.70	.85	.85	.75	.60	
April 10	.55	.70	.95	6.15	.40	.60	.70	.95	7.25	.35	.45	.70	.90	8.0
April 11	5.00	.20	.50	.65	.80	.95	6.15	.35	.55	.80	7.05	.25	.45	.55
April 12	.15	.30	.55	.85	4.0	.20	.50	.75	.95	5.1	.40	.60	.5	.95
April 13	.25	.30	.35	.40	.50	.65	.70	.85	3.0	.2	.45	.70	.95	4.2
April 14	.75	.60	.50	.40	.30	.20	.20	.25	.35	.40				
April 15	.75	.55	.35	.15	2.95	.80	.65	.55						

Date.	2.50 p. m.	3 p. m.	3.10 p. m.	3.20 p. m.	3.30 p. m.	3.40 p. m.	3.50 p. m.	4 p. m.	4.10 p. m.	4.20 p. m.	4.30 p. m.	4.40 p. m.	4.50 p. m.	5 p. m.
March 31														
April 1														
April 2*														
April 3	2.95	.85	.75	.7	.65	.6	.6	.6	.7	.8				
April 4	.7	.5	.15	1.85	.55	.45	.2	.0	0.95	.85	.85	.9	.95	1.0
April 5														
April 6	.1	3.8	.5	.25	2.9	.7	.5	.25	.0	1.8	.7	.4	.15	0.95
April 7														
April 8														
April 9														
April 10	.05	.10	.05	7.95										
April 11	.70	.85	8.0	.25	.55	.75	.85	.85	.80	.75	.65	.50		
April 12	6.20	.35	.45	.55	.65	.90	.85	7.0	.2	.4	.65	.75	.85	.90
April 13	.40	.65	.75	5.0	.29	.35	.55	.75	6.0	.15	.30	.55	.80	.95
April 14														
April 15														

Date.	5.10 p. m.	5.20 p. m.	5.30 p. m.	5.40 p. m.	5.50 p. m.	6 p. m.	6.10 p. m.	6.20 p. m.	6.30 p. m.	6.40 p. m.	6.50 p. m.	7 p. m.	7.10 p. m.	7.20 p. m.
March 31														
April 1														
April 2*														
April 3														
April 4	.1	.3												
April 5														
April 6	.8	.7	.7	.45	.40	.35	.3	.5						
April 7														
April 8														
April 9														
April 10														
April 11														
April 12	.90	.90	.80	.70	.55									
April 13	7.1	.20	.40	.65	.70	.95	.95	.95	.85	.70	.55	.30		
April 14														
April 15														

* No observation on account of northeast storm.

Tide observations at Fort Hale—Continued.

Date.	7.30 p. m.	7.40 p. m.	7.50 p. m.	8 p. m.	8.10 p. m.	8.20 p. m.	High-water stand.	Low-water stand.	Duration of ebb.	Duration of flood.	Rise.	Fall.
							Min.	*Min.*	*h. m.*	*h. m.*	*Feet.*	*Feet.*
March 31							5	15	6 32			4.90
April 1							0	5	6 37			5.95
April 2*												
April 3							25	25	6 30			6.65
April 4							10	15	6 24			7.80
April 5												
April 6							20	5	6 27½			7.85
April 7							5	20		5 47½	7.70	
April 8							5	10		6 27½	7.25	
April 9							10	10		5 45	7.45	
April 10							5	10		6 17½	6.65	
April 11							20	50		6 2½	6.25	
April 12							20	10		6 00	5.75	
April 13							20	15		6 07½	5.75	
April 14							25	10	5 42½			5.95
April 15							15	30	5 32½			6.15

*No observation on account of northeast storm.

NEW HAVEN HARBOR.—*Tide observations at Five-Mile Point.*

Mean sea-level on box, 3.158; with indicator, 4.564; .4 to Chapel-street bridge gauge.

Date.	5.30 a. m.	5.40 a. m.	5.50 a. m.	6 a. m.	6.10 a. m.	6.20 a. m.	6.30 a. m.	6.40 a. m.	6.50 a. m.	7 a. m.	7.10 a. m.	7.20 a. m.	7.30 a. m.	7.40 a. m.
March 31									7.6	.50	.55	.45	.35	.30
April 1									7.35	.40	.50	.60	.70	.70
April 2														8.40
April 3														
April 4														
April 5														
April 6														
April 7			1.10	.00	0.90	.90	.90	.95	1.00	.20	.40	.60	.90	2.20
April 8				1.50	.40	.60	.00	0.90	.85	.80	.80	.85	.90	1.10
April 9										1.60	.50	.40	.30	.25
April 10												2.90	.75	.50
April 11														
April 12														
April 13														
April 14								8.00	.05	.10	.10	.10	.00	7.90
April 15														8.20

Date.	7.50 a. m.	8 a. m.	8.10 a. m.	8.20 a. m.	8.30 a. m.	8.40 a. m.	8.50 a. m.	9 a. m.	9.10 a. m.	9.20 a. m.	9.30 a. m.	9.40 a. m.	9.50 a. m.	10. a. m.
March 31	.25	.05	6.90	.80	.65	.40	.30	.10	5.90	.80	.50	.40	.30	.20
April 1	.75	.75	.75	.70	.60	.55	.40	.35	.20	.10	6.90	.80	.60	.45
April 2	.50	.70	.70	.60	.60									
April 3				8.95	9.27	.15	.22	.30	.30	.27	.22	.20	.20	.15
April 4								8.32	.50	.65	.75	.85	.90	.95
April 5														
April 6														
April 7	.40	.60	.80	3.00	.20	.50	.90	4.10	.40	.70	5.00	.30	.60	.90
April 8	.30	.50	.60	.70	.80	2.10	.40	.70	3.00	.25	.40	.70	4.00	.30
April 9	.25	.20	.30	1.40	.60	.80	.90	2.10	.30	.50	.70	.90	3.10	.30
April 10	.35	.25	.10	1.90	.70	.65	.60	.55	.55	.60	.60	.70	.80	2.00
April 11							3.10	.00	2.80	.80	.70	.60	.65	.55
April 12														
April 13														
April 14	.80	.70	.60	.50	.40	.20	.00	6.80	.60	.40	.20	.00	5.80	.60
April 15	.25	.30	.30	.30	.20	.05	7.10	.70	.50	.30	.20	.10	.00	6.70

Tide observations at Five-Mile Point—Continued.

Date.	10. 10 a. m.	10. 20 a. m.	10. 30 a. m.	10. 40 a. m.	10. 50 a. m.	11. a. m.	11. 10 a. m.	11. 20 a. m.	11. 30 a. m.	11. 40 a. m.	11. 50 m.	12. m.	12. 10 p. m.	12. 20 p. m.
March 31	.00	4.95	.75	.55	.35	.15	3.90	.75	.65	.45	.30	.15	.00	2.90
April 1	.25	.00	5.80	.65	.40	.30	.10	4.90	.75	.55	.40	.20	.00	3.95
April 2														
April 3	.00	8.85	.70	.50	.27	.02	7.80	.57	.25	6.95	.72	.47	.22	.00
April 4	9.00	8.95	.85	.75	.60	.40	.20	.00	7.77	.52	.30	.10	6.85	.55
April 5		7.40	.60	.70	.50	.40	.50	.50	.40	.20	6.90	.70	.40	.20
April 6							8.70	.70	.80	.80	.80	.75	.65	.50
April 7	6.20	.40	.60	.80	7.00	.10	.50	.70	.90	8.10	.35	.40	.60	.60
April 8	.60	.80	5.10	.40	.70	.90	6.20	.40	.60	.80	7.00	.20	.40	.60
April 9	.50	.70	.90	4.10	.30	.50	.70	5.10	.40	.60	.90	6.20	.40	.60
April 10	.25	.50	.70	.80	3.10	.30	.50	.70	4.00	.20	.40	.70	5.00	.20
April 11	.50	.60	.60	.60	.80	.90	3.00	.20	.45	.60	.80	4.00	.20	.40
April 12				2.50	.30	.25	.30	.35	.40	.50	.60	.70	.80	.90
April 13										2.30	.15	.20	.20	.20
April 14	.30	.10	4.90	.70	.55	.30	.10	3.90	.70	.50	.35	.20	.10	2.90
April 15	.40	.20	.00	5.80	.60	.40	.20	.00	4.80	.60	.30	.10	3.90	.60

Date.	12. 30 p. m.	12. 40 p. m.	12. 50 p. m.	1 p. m.	1. 10 p. m.	1. 20 p. m.	1. 30 p. m.	1. 40 p. m.	1. 50 p. m.	2 p. m.	2. 10 p. m.	2. 20 p. m.	2. 30 p. m.	2. 40 p. m.
March 31	.85	.85	.80	.70	.70	.75	.80	.85						
April 1	.85	.70	.55	.40	.25	.20	.20	.15	.10	.10	.10	.15	.20	.25
April 2											3.30	.20	.00	.00
April 3	5.77	.55	.37	.15	4.85	.60	.37	.15	3.95	.82	.67	.47	.32	.20
April 4	.25	.00	5.80	.55	.24	4.97	.70	.47	.20	3.90	.67	.50	.25	.00
April 5	5.90	.70	.40	.20	4.95	.65	.40	.20	.15	3.90	.60	.40	.20	2.90
April 6	.40	.20	.00	7.80	.50	.30	.10	6.90	.50	.20	5.90	.60	.40	.10
April 7	.60	.50	.40	.25										
April 8	.80	.95	8.10	.20	.10	.10	0.5	7.90	.80					
April 9	.80	7.10	.30	.50	.70	.80	.90	8.05	.25	.25	.30	.40	.35	.30
April 10	.40	.60	.90	6.00	.20	.40	.70	.90	7.10	.40	.50	.60	.70	.80
April 11	.70	5.10	.20	.40	.60	.90	6.20	.40	.60	.70	.90	7.10	.25	.40
April 12	3.10	.50	.70	.90	4.20	.40	.60	.90	5.10	.40	.60	.70	.80	6.00
April 13	.20	.25	.30	.40	.50	.70	.90	3.00	.10	.30	.40	.65	.80	4.10
April 14	.70	.60	.50	.45	.40	.35	.40	.45						
April 15	.40	.30	.20	.00	2.90	.80	.70	.60	.50	.40	.40	.40	.40	.50

Date.	2.50 p. m.	3 p. m.	3.10 p. m.	3.20 p. m.	3.30 p. m.	3.40 p. m.	3.50 p. m.	4 p. m.	4.10 p. m.	4.20 p. m.	4.30 p. m.	4.40 p. m.	4.50 p. m.	5 p. m.
March 31														
April 1	.35	.40												
April 2	.00	.00	.00	.05	.10									
April 3	.07	2.95	.85	.77	.72	.70	.70	.75	.85	.97				
April 4	2.80	.62	.45	.30	.15	1.97	.85	.75	.67	.62	.62	.67	.75	
April 5	.70	.40	.20	1.90	.60	.35	.10	0.90	.80	.80	.60	.50	.35	.25
April 6	4.65	.40	.20	3.95	.65	.40	.10	2.90	.70	.50	.20	.00	1.80	.60
April 7														
April 8														
April 9	.20	.10	.00											
April 10	.90	8.00	.05	.00	.00	7.90	.80							
April 11	.60	.80	8.00	.10	.20	.30	.35	.40	.45	.50	.40	.30	.20	
April 12	.10	.20	.40	.60	.80	.90	7.10	.25	.40	.50	.65	.65	.75	.90
April 13	.40	.60	.80	5.00	.20	.40	.60	.80	6.00	.20	.40	.60	.80	7.10
April 14														
April 15	.60													

Tide observations at Five-Mile Point—Continued.

Date.	5.10 p. m.	5.20 p. m.	5.30 p. m.	5.40 p. m.	5.50 p. m.	6 p. m.	6.10 p. m.	6.20 p. m.	6.30 p. m.	6.40 p. m.	6.50 p. m.	High-water stand.	Low-water stand.	Duration of ebb.	Duration of flood.	Rise.	Fall.
												Min.	*Min.*	*h. m.*	*h. m.*	*Feet.*	*Feet.*
March 31												(*)	10	(*)			4.90
April 1												20	20	6 00			4.65
April 2												30	40	6 15			5.60
April 3												20	20	6 40			6.60
April 4												10	0	6 15			7.40
April 5	.20	.30	.40	.60	.70	.90	1.10					0	0	6 30			7.50
April 6	.50	.40	.20	.00	.20	.25	.30	.35				20	0	6 00			7.80
April 7												20	20		6 00	7.70	
April 8												0	10		5 55	7.40	
April 9												0	0		6 20	7.20	
April 10												0	10		6 05	6.50	
April 11												10	0		6 20	6.60	
April 12	.90	.90	.90	.85	.75							20	0		6 15	5.65	
April 13	.20	.30	.40	.60	.70	.80	.90	.90	.90	.85	.80	20	30		6 15	5.70	
April 14												20	0	5 40			5.75
April 15												20	30	5 55			5.90

* Not determined.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, January 20, 1872.

GENERAL: I have the honor to make the following report of the operations of improving the Housatonic River, Connecticut, during the past season.

The condition of this work at the date of my last annual report, August 31, is given in your printed annual report for 1871, pp. 777, 778, 779.

The work continued in progress till the autumn weather compelled us to desist. The improvement, consisting of a riprap embankment at Sow and Pigs Rocks, was completed. A channel 80 feet wide and 7 feet deep was dredged through Drew's Bar, and a channel 42 feet wide and 7 feet deep was excavated through Mill Bar. These depths are at mean low water. Surveys were also made in addition to the previous ones. The expenditures have been as follows:

For riprap embankment at Sow and Pigs Rocks, 778.34 cubic yards, at $1.90	$1,478 84	
For dredging at Drew's Bar, 28,922.41 cubic yards, at 18 cents	5,206 03	
For dredging at Mill Bar, 9,447.85 cubic yards, at 18 cents	1,700 61	
For engineering and incidental expenses	3,446 31	
Balance on hand December 31	3,168 21	
	15,000 00	

An additional appropriation of $15,000 has been asked for.

Along with this report I transmit the report of Henry Harding, civil engineer, who superintended the execution of the work, which gives all the details deemed desirable. Mr. Harding's report is accompanied by four maps, one being of the work at Sow and Pigs Rocks, another of the dredging at Drew's Bar, another of the detailed survey of Drew's Rock, and the other of the dredging done at Mill Bar. These maps of the bars where dredging was done are colored, so as to show the monthly progress of the work.

The original survey was made by Captain W. S. Edwards, civil engineer, but the locations of the improvements were made by General T. G. Ellis, civil engineer.

Yours, respectfully,

G. K. WARREN,
Major Engineers and Brevet Major General, U. S. A.

Brigadier General A. A. HUMPHREYS,
Chief of Engineers United States Army, Washington, D. C.

NEWPORT, R. I., *January* 1, 1872.

GENERAL: I have the honor to submit the following final report of operations for the season ending November 29, 1871, for the improvement of Housatonic River, Connecticut, conducted in accordance with section 1 of the appropriation act for rivers and harbors, approved March 3, 1871. The amount of the appropriation was $15,000.

The navigable portion of the Housatonic River (heretofore only so at high water) is about thirteen miles in length, from the sound to Derby, at which point there are two other thriving towns, Huntington and Ansonia; the latter about a mile north, and situated on the Naugatuck River, which flows into the Housatonic River at Derby. These towns are of growing importance, and already carry on a large freighting business by the river. This is attended by a considerable delay and expense, as they are often compelled to lighten their barges at Bridgeport, having to make two trips from that place, where, if the river was improved, but one would be necessary. Heretofore much of the material used in the manufacturing at these places has been carried by railroads, which would have come by river had not the navigation been so difficult.

Drew's Bar was the first point where the improvement commenced, and was that of dredging, which was begun July 18, 1871, by P. W. Myers, contractor for the above, as also all other work done at the two other points on the river, (Sow and Pigs Reef and Mill Bar.) The dredging was done with an Osgood dredge.

The object at this point (Drew's Bar) was to connect the deep waters of the two separate channels above and below the bar. When the improvement was commenced, the design was to remove Drew's Rock, as it is located in the channel usually navigated. Further surveys, however, showed that the cost of removing it would be far more than the cost of an embankment from it to the shore. Estimates for the removal of this rock, and for an embankment, will be found further on. It was first proposed to make a channel 1,540 feet long, 100 feet wide, and 7 feet deep at mean low water. This was done, with exception of the width of the channel, which was left at 80 feet, in order to make the necessary improvement at Mill Bar this season. Below Drew's Rock it was deemed necessary to make one cut of 20 feet wide, so as to enable vessels to keep more to the eastward coming up to the rock. This makes an addition to the above distance of 440 feet.

Total amount excavated during the season at the above points, 28,922.41 cubic yards. I do not think that it will be necessary to do any more dredging at this point the coming season. Work at this point was finished the 23d of October, 1871.

While the work was going on at Drew's Bar, according to your order, I made a survey and soundings at Sow and Pigs Reef, and laid out the work for the wing-dam, which was also built during the time that the contractor was at work at Drew's Bar.

The total length of the dam from the initial point on Sow and Pigs Reef to high-water mark on east shore is 163 feet; width on top 10 feet, and a slope on both, up and down stream, sides of one to one. The up-stream slope has a layer of quarry waste exceeding 6 inches in depth over its entire surface, so as to render it impervious to both sand and gravel.

Total number of cubic yards of stone in dam is 778.34. The object of this dam is to obviate various difficulties to navigation at this point. Its design is not so much to increase the depth opposite (or the river's cross-section) as to render the safe passage of vessels going down stream. Heretofore when vessels would near that portion of the river, they experienced great difficulty in overcoming that point from the danger of being drawn on or against the rock by the force of the body of the current at that point passing between the rock and the east bank, which opening was not practicable for vessels.

Although but limited observations have been made since the construction of the dam, I think it safe to say that this one serious impediment is already overcome. The position of the dam is not at right angles with the thread of the stream, or, in other words, is not exactly in the line of the transverse section. This location was considered advisable on account of the solid rock on the east bank for the dam to bed against, therefore obviating any danger of washing around the shore-end. This position was selected by General Ellis and approved by you.

Mill Bar was the next and last point of improvement on the river, and was but partially completed. This work was commenced the 23d of October, 1871. The nature of the work was dredging in sand, so as to give a 7-foot channel at mean low water, otherwise opening the old channel to a width of 150 feet, and to connect the north and south deep-water channels. This is done at present to a width of only 42 feet, and in length a distance of 750 feet. The amount dredged at this point is 9,447.85 cubic yards. This does not seem to be the river's natural channel, inasmuch as it is out of direction of the main body of water in coming down stream, although it has been the main sailing-track since 1864, and is doubtless the most feasible as regards expense.

The old channel navigated previous to 1864 has a serious obstruction opposite the mouth of the stream leading out of the Mill Pond, consisting of a rock 3 feet under water at mean low water.

I would here suggest that, in further prosecution of the work at this point, the dredging in the upper portion of the channel should be done on the east side of where the work has already been done, but in the south portion continue from the sand island down, as at present laid out.

I find from observation that there is a cross-current which causes the sand, so that it deposits on the island and its vicinity, (therefore cutting into the island, as this present lay-out does.) The liability would be that of soon filling up; therefore the suggestion of moving eastward, so as to overcome the above difficulty. The cutting is even heavier than indicated on the map; that is, that portion which begins at the sand island, thence north.

During the prosecution of the work at Mill Bar, I made a survey and soundings at Drew's Rock, according to your directions. I have made an approximate estimate in reference to its removal. The number of cubic yards to be removed, to give 7 feet at mean low water, is about 419; at $15 per cubic yard, would amount to $6,285.

I have also made an approximate estimate for a wing-dam at the same point, of the following dimensions: 123 feet long, 10 feet wide on top, with a slope of 1 to 1 on both the up and down stream sides, and to extend to mean high water the entire length. The amount of stone required would not far exceed 330 cubic yards, and cost, at $1.90, (price paid for same kind of work this season,) would amount to $627.

This dam to run from the west bank to rock, starting from the shore at a point far enough below the rock so as to make an angle of 70° with the bank and stream.

Recapitulation of work done on Housatonic River during the season.

Dredging 38,370.26 cubic yards, at 18 cents		$6,906 64
Wing-dam, 778.34 cubic yards, at $1.90		1,478 84
		8,385 48
Engineering and incidental expenses		3,446 31
Total amount expended		11,831 79
Amount of appropriation for improvement		15,000 00
Total amount expended		11,831 79
Balance remaining		3,168 21

Accompanying this report will be found maps, as follows: Map of Sow and Pigs Rocks, (or Reef,) containing the survey of the above point, plan, and position of dam, with cross and longitudinal section of same; scale of map, 30 feet to 1 inch. Maps of Drew's Bar and Mill Bar, on scale of 24 inches to the mile, or 220 feet to 1 inch. These maps show the progress of work during each month, and is indicated as shown by color. Map of survey of Drew's Rock, (1871,) scale 10 feet to 1 inch.

Very respectfully,

HENRY HARDING.

Brevet Major General G. K. WARREN,
Major of Engineers, U. S. A., Newport, Rhode Island.

E.

Letter from the Secretary of War, in answer to a resolution of the House of March 20, relative to removing the light-house at New Haven Harbor, Connecticut, to Southwest Ledge.—April 5, 1872, referred to the Committee on Commerce and ordered to be printed.

WAR DEPARTMENT, *April* 2, 1872.

The Secretary of War has the honor to invite the attention of the House of Representatives to the accompanying report of the Chief of Engineers and its inclosure, on the subject of the expediency of removing the light-house at New Haven Harbor, Connecticut, to Southwest Ledge, which are based on the resolution of the House of the 20th ultimo asking for information on that subject.

WM. W. BELKNAP,
Secretary of War.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., April 1, 1872.

SIR: In compliance with the following resolution of the House of Representatives of March 20, "that the Secretary of War and the Secretary of the Treasury be requested to inquire into the expediency of removing the light-house at New Haven Harbor, Connecticut, from its present position to Southwest Ledge, so called, near the entrance of said harbor, and make report to this House," I beg leave to transmit herewith a copy of a letter on the subject, dated March 27, 1872, from Major G. K. Warren, Corps of Engineers, the officer in charge of the improvement of New Haven Harbor, to whom the question was referred. Major Warren's letter, it is believed, will afford the information contemplated by the resolution.

The resolution is herewith returned.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

Hon. W. W. BELKNAP,
Secretary of War.

ENGINEER OFFICE, UNITED STATES ARMY,
Newport, Rhode Island, March 27, 1872.

I have the honor to submit the following report in regard to the expediency of removing the light-house at the entrance to New Haven Harbor, Connecticut, from its present position to Southwest Ledge.

I would recommend that the change be made for the following reasons:

1st. In approaching the harbor from the eastward the light is not visible until nearly abreast of it, being shut out by woods. In coming from the westward the light is so situated as to render its position very deceptive, making it appear nearer than it actually is; many vessels ground on the west-shore flats from this cause.

2d. If the light-house was on the ledge, vessels could run for it until it was close aboard, then haul to the northward, pass to the westward of the light, and head up the harbor directly for the fixed red light on Long Wharf, thus following the line of best water up the harbor, avoiding all rocks and shoals. The light-house would also serve as an excellent channel-mark by day as well as by night. In consequence of the present position of the light, it is necessary to run by bearings and estimated distances, thus rendering dangerous the entrance to the harbor.

3d. The woods in the vicinity of the present light-house so deaden the sound of the fog-bell that in fogs accompanied by a southerly breeze it is impossible to hear the bell more than six hundred or seven hundred feet, except when directly abreast to the westward of the light. This would be obviated by placing the light-house upon the ledge. Besides thus greatly improving the entrance to the harbor itself, the position of the light on Southwest Ledge would be about one mile farther out in the sound, and would furnish an excellent object for vessels passing along the sound to steer by and correct their positions from in thick weather. New Haven Harbor is much used as a harbor of refuge, and should the light-house be placed on Southwest Ledge, vessels whose captains are not acquainted with the harbor could readily find refuge. The nearest lights are the Falkland Island light, twelve miles to the eastward, and Stratford light, twelve miles to the westward. Every reason that occurs to me justifies the removal of the light to Southwest Ledge. Five-Mile Point should be reserved as a site for a fort. Southwest Ledge has now over it, at mean low water, 7.5 feet, and is composed of granitic rock. The contours of the rock on a scale of 10 feet to the inch are shown on a tracing I sent you with my report of December 23, 1871, (H. Ex. Doc. No. 137.)

I return herewith the copy of the resolution sent me.

Yours, respectfully,

G. K. WARREN,
Major Engineers, Brevet Major General U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

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