47TH CONGRESS, 1st Session. } HOUSE OF REPRESENTATIVES. { Ex. DOC. 1, Part 2.

REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE FIRST SESSION OF THE FORTY-SEVENTH CONGRESS.

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APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

UNITED STATES ARMY.

(CONTINUED.)

APPENDIX O O.

IMPROVEMENT OF RIVERS AND HARBORS IN OREGON AND IN WASHINGTON TERRITORY—IMPROVEMENT OF LOWER CLEARWATER RIVER, IDAHO—CONSTRUCTION OF CASCADE CANAL, COLUMBIA RIVER.

REPORT OF MAJOR GEORGE L. GILLESPIE, CORPS OF ENGINEERS, BVT. LIEUT. COL., U. S. A., OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1881, *WITH OTHER DOCUMENTS RELATING TO THE WORKS.*

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., July 14, 1881.

GENERAL: I have the honor to submit herewith my annual report upon works of river and harbor improvements and of surveys and examinations under my charge for the fiscal year ending June 30, 1881.

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

G. L. GILLESPIE,
Major of Engineers,
Bvt. Lieut. Colonel, U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

O O 1.

IMPROVEMENT OF LOWER WILLAMETTE AND COLUMBIA RIVERS, FROM PORTLAND, OREGON, TO THE SEA, INCLUDING BAR AT MOUTH OF COLUMBIA RIVER, OREGON.

The amount available at the opening of the fiscal year for the continuance of this improvement was $44,995.32.

The project submitted for the application of the appropriation—$45,000, act June 14, 1880—received the approval of the department July 16, 1880, and on the 20th of September sealed proposals were opened at this office for building 1,000 feet, more or less, of pile dike, to complete the work of similar character begun the previous year, to close Coon Island Slough on the left bank of the Willamette River near its mouth. The award was made the same day to Messrs. Holmes and Sweeney, the lowest responsible bidders, and on the receipt of the department's approval measures were taken for the purchase of all the necessary materials for construction. Pile-driving was begun October 23, with three drivers, and carried on so rapidly during the pleasant weather which prevailed in October and November that the whole num-

ber of the required piles was in place by the first week in December, and were properly secured, or nearly so, by waling timbers and rods. The stone and fascine filling at this time had well advanced to more than one-half of the entire length of dike, and a fair proportion of the outer riprap and shore revetment had been completed. As the top of the dike was only 2 feet above mean low-water, the work of construction was subject to suspension by the smallest rise in the river. During the last week in December the river began to rise gradually until a 6-foot stage was reached, requiring all timber work to cease; then it began to fall, and on the 1st of January had again almost reached the mean low stage. In January heavy snow storms were repeated at short intervals, almost immediately followed by prolonged rains, which caused the Columbia and Willamette rivers to rise to almost unprecedented heights. On the 7th of February the latter river reached a stage of 23½ feet above low-water, remained steady for several days, and then began to fall uniformly and slowly until the 20th of the month, when it began to rise again. With many oscillations the water has kept above the stage of 2 feet above low-water since February 1, and at the date of this report is 17.2 feet. The work of timber construction which was suspended in December cannot be resumed until after the next low-water season, which it is anticipated will commence as early as the latter part of August.

The dam which was built last season in Willamette Slough has not been injured in any way by the many freshets which have occurred since its completion. It is subject, however, to one danger, which can only be restricted in its injurious effects by the constant attendance of the snag-boat during the medium freshets, and that is the lodgment of drift upon it. The trees which drift down the Willamette River are often 300 feet long and 6 or 7 feet in diameter, and sinking, as they do, at the heavier end, several feet, they are liable to catch upon the dike and form, by continued accretions, a raft, whose pressure may in time, if not guarded against, cause great damage to the improvement.

On the right bank of the slough, a short distance below the dam, an extensive erosion commenced during the winter, at the medium stage, when the river was falling, which threatened great damage to the heel of the dike on that side, but a prompt revetment both of the bank and bed of the slough, extending from above the erosion to several hundred feet below it, stopped the advance of the erosion and has probably entirely checked it.

The dam has been instrumental in raising the water over the several adjacent bars in the Willamette River from 10 inches to 1½ feet, and has forced the channel through the bar at Saint Helen's farther down stream, as anticipated.

The dike at the mouth of the Willamette has had the effect of shoaling the slough behind it, enlarging the width, and increasing the depth of the main channel to a junction with that of the Columbia River.

A small submerged dam of fascines and stone behind Nigger Tom Island, rising to low-water level, or a little higher, will still farther improve the entrance. It is not thought that a dike on the east side is necessary for the purpose of reducing the cross-section of the outlet.

SURVEYS.

Surveys have been made, at favorable times after the freshets, of all the bars in the two rivers where commerce has met with detentions. These surveys were made principally to ascertain the points where in-

creasing shoaling was to be found. The great amount of railroad construction going on in Oregon and Washington Territory has brought to the port many sailing vessels, laden with iron and other supplies, with a deeper draught than that of those vessels usually coming here at low-water season. Then, again, the steam propellers lately built for the trade with San Francisco have increased draught over those formerly used. The demand, then, for deep water, not only on the bar at the entrance to the Columbia River, but also on all the river bars, is a matter which has earnestly engaged the minds of the community.

By using the dredger immediately after the discovery of shoal-water at any of these bars, vessels have been enabled to reach Portland at all times during the year without any special detention. It is not to be ignored that many have grounded and have had to be lightered, before reaching their destination, but an investigation of all such occurrences has shown that the vessels were not in the channel when they ran ashore.

The Martin's Island and Walker Island bars have been slightly obstructed during the year; at the former the bottom was covered with wide shoal lumps of gravel and shingle, giving only a navigable depth of 17½ feet, which by the use of the large rake were reduced until the depth was increased to 19 feet, at low stage; at the latter there was sufficient water for easy navigation, but the channel was different from the one used at the time by deep draught vessels, and only needed to be properly surveyed to be conveniently navigable.

The principal survey made, not including that of the Columbia River Bar at the entrance, was over the Hog's Back Shoal, where the changes in the long and intricate channel, due to the freshets, had caused frequent complaints of shoal-water to be made to this office. The survey was a very careful one, in a channel very nearly 7 miles long, and it was found that the most noticeable change was at the head of Snag Island, where the currents had cut well to the southward and threatened to open the old channel south of that island. In the main channel the usual depth was in excess of 24 feet, except at two places, where it was reduced as low as 18 feet at low-tide across a narrow bar. Minor surveys were made at Swan Island and Post-Office bars, and of the bar at the mouth of the Willamette, for the details of which I respectfully refer to the accompanying report of Assistant Engineer R. A. Habersham.

DREDGING.

The dredger began operations October 4, at the mouth of the Willamette, and after working seventeen days, completed a channel 430 feet long, 110 feet wide, and 19 feet deep at low-water. The amount removed was 7,230 cubic yards.

It was then taken to Swan Island, where the channel was carried 70 feet wide, through a bar 2,640 feet long, giving 18 feet at mean low-water. The amount removed was 7,320 cubic yards, making the total removed during the year 14,550 cubic yards. The dredge is completely worn out, and will be replaced before next low-water season by a powerful Osgood dredge, the machinery of which is now being manufactured. The money available for the improvement during the fiscal year ending June 30, 1882, is so small that the allotment for renewing the dredger will be limited to the manufacture of new machinery, and the construction of a new hull, and proper appliances. An allotment from the appropriation for the following year will be required to be reserved to rebuild the scows which for the present may be so repaired

as to be serviceable for one year more probably. The rivers throughout the year have been in a good navigable state from Portland to the sea, except during the first ten days immediately after the subsidence of the freshet; the bars were then all in their worst state, and before I could succeed in procuring a tender for the dredger at anything like reasonable rates, a few vessels were unfortunate enough to ground between Portland and the mouth of the Willamette. They got off without requiring much lighterage, and after the dredge was put in operation no similar experience was had during the year.

MOUTH OF THE COLUMBIA RIVER.

In August a party was organized and sent to Astoria to make a limited survey of the two channels over the bar, and to determine the changes which had taken place since the survey of the previous year. It was discovered that the North Channel had shoaled to 14 feet at low stage behind Sand Island, and that the South Channel, besides being shoaler, was also narrower, and full of massy sand lumps. The inner middle sands embraced between these two channels had two breaks through them, one at a point immediately south of Cape Disappointment, and 1 mile distant, and the other an outlet from the South Channel near where the line of range beacons on the east end of Sand Island crosses the southern end of the sands.

The latter opening in the sands was noticed in my report of December 17, 1879, as the probable new channel of deep water seaward, but as the upper opening had been reduced to only 600 feet wide with 17 feet depth at low-tide, it was thought that this narrow neck of sand might be destroyed, and deep water over it gotten by scraping.

The harrow was put to work on the 12th of August, and discontinued on the 12th of September, having been able to work only at wide intervals on account of dense fogs and high seas. About 500 crossings were made, and the depth was increased from 17 to 19 feet at low-tide, in a channel 600 feet wide.

The sands were overlaid with a thick hard crust, which it was impossible to break through, except by heavily ballasting the harrow; this increased weight proportionately increased the difficulties of towage in rough seas, and after ten days' trial it was decided to abandon the project as the weather was too unfavorable for its continuance. The channel has deepened gradually since the operation, and as there has been no favorable change either in the North or South Channel, vessels, as a rule, have preferred to go through this cut-off, which was buoyed early in September, except at very low water, or when a high sea was running.

The approach to the bar is now from the northwest, and the automatic buoy has been removed from the south channel to mark the new approach. The light and fog-signal established upon Tillamook Rock, off Tillamook Head, in January enables mariners to make the entrance without detention. In January the seas imprisoned in the outer harbor by strong southerly weather began to cut the beach near high-tide line at Indian Mound, a short distance west of Fort Stevens. Although it was not feared that the erosion would end in any great damage to government interests, and certainly not that the high beach bounding the garrison would be cut through so as to separate the quarters from the fort—as was repeatedly reported by the commanding officer—still, to allay the apprehensions of the garrison, and to protect the ditch against damages by extraordinary seas, a revetment of mattresses and fascines ballasted with sand bags was laid from high-tide to beyond low-tide line, from Indian

Mound westward for 350 feet. It effectually checked erosion, and caused an accretion of sand all along that point to such a distance to the north and westward as to practically close the outlet of the lagoon, which has been the origin of the cutting.

On the 5th of December, 1880, a report was submitted to the department embodying estimates for the building of a pile-dike, filled with fascines and stone, along the east side of Clatsop Spit to prevent the ebb-tides from spreading over the spit, and to direct them farther westward along the line of the main channel, so as to utilize them in deepening the water in the northern opening through the Middle Sands.

The Board of Engineers, to whom the report was referred for consideration, disapproved the project for two main reasons; first, that the dike would be "too short to effect the purpose designed of making a breach for a channel across the Middle Sands;" and second, that "if extended far enough to be effectual the training wall would consolidate Clatsop Spit in position and extent, and constitute a hurtful impediment to a future improvement of the channels."

A third reason was given, which rather inclined to the opinion that *no work of improvement of any kind was necessary at the present time* to assist nature in opening a passage through the sands. A comparative chart, embracing all important authenticated surveys of the entrance from near the beginning of the century to date, is submitted for the consideration of the department.

In 1839 and 1841, when there was deep water in both channels, the outer end of Point Adams, which was high above high-tide line, and heavily covered with timber, projected a half mile farther towards Cape Disappointment than the extreme outer point of Point Adams of to-day. As the point, after that date, wore away and lost its timber, the submerged spit beyond changed from the westward to the northward; Sand Island was increased in extent and pushed towards the north, narrowing all the while the channel on that side, and the Middle Sands grew to the southward, forcing the south channel every year more and more towards the west shore of Point Adams. Now it remains a question if Point Adams had been prevented from wearing away; if it had kept its inshore consolidation intact and unchanged, would the ebb-currents not have been better able to resist the growth of Sand Island and the extension of its accompanying sands?

The dike which I proposed had for its object the return of Point Adams to the position and character it held forty years before, when there was deep water over the bar, and when the cross-sections between Point Adams and Cape Disappointment and between Point Adams and Chinook Point were less disproportionate than they are to-day. It has seemed to me that if the harbor entrance south of Cape Disappointment were contracted so as to conform approximately to the cross-section at Chinook Point, and the east side of Point Adams made permanent by revetment, the Middle Sands would be driven from the throat of the entrance and no extent of southerly seas could heap up sands which the ebb-tides, supplemented by backwater, would not remove. As the Board of Engineers, to whom my report of December 5 was referred, disapproved the plan contained therein, and considered it unnecessary to submit a plan of improvement, in view of the fact that the imminent changes at the entrance would make all construction at this time premature, I have no recommendation to make for an appropriation for the commencement of an improvement at the entrance to the Columbia River beyond that contained in my report referred to.

I send a chart of the entrance, made under my direction in May, 1881,

by Lieut. P. M. Price, Corps of Engineers, whose interesting report is also transmitted for your information.

Lieutenant Price reported to me January 31, 1881, in compliance with Special Order 255, paragraph 6, Adjutant-General's Office, December 1, 1880, and was assigned to duty as assistant in this office.

The following important changes, which have occurred at the entrance during the year, have been developed by the survey:

The continuity of the Middle Sands is broken; the inner portion, including Sand Island, has moved to the northward, and the outer portion has divided into two well marked detached banks, with diminished depths over them, the northern part of the latter apparently swinging to the westward, and the southern part to the eastward, with detached lumps reaching out to the west shore of Point Adams as if the whole broken mass were ready to aggregate upon Clatsop Spit. Peacock Spit has prolonged to the southward, and the ship-channel between north and south channels, across the middle sands, which carries 20 feet at mean low-stage, has had its width, east and west, increased to 1 mile, and its length, north and south, diminished to 1,000 feet between the 25-foot curves. This is now the only channel which deep-draught vessels can use; the other channels, 2 miles and 4 miles, respectively, farther to the southward, are blocked with sand lumps which have no stability or permanence, and change almost as frequently as the tides. The movement of the northern branch of Sand Island 1,200 feet to the northward has proportionately contracted the width, and diminished the depth of the north channel on that side of the inner harbor, closing it to vessels of deep draught, and has occasioned a still further diminution of the anchorage area in Baker's Bay.

Clatsop Spit has changed but slightly, either in width or length. It is difficult to predict with accuracy, at this time that particular change which will increase in the near future the depths at the entrance, but as the unusually large river flow during the year, supplemented by the tides, has not been able to open the southern entrances, it seems probable that the present channel at the cut-off will be the main ship-channel during the coming year.

The appropriations made for this improvement from Portland to the sea, from act of June 23, 1866, to act of March 3, 1881, both inclusive, have been in the aggregate $405,365.

Of this amount there have been expended to date $365,627.12. Amount required to complete existing project, adopted in 1879, $133,974.

The amount available at this date will be applied in building and equipping a new dredger; in running the dredger during eight months of the next fiscal year; and in the purchase of materials for protection and preservation of existing works of improvement.

I would recommend for the improvement of the rivers, exclusive of the bar at the entrance to the Columbia River, the sum of $100,000, to be applied as follows:

Building submerged dam at mouth of the Willamette	$10,000 00
Running expenses of the dredger for one year	15,000 00
Building two new scows complete	10,000 00
Surveys of bars, and purchase of materials for the repair and preservation of existing improvements	15,000 00
Construction of a low dike at Swan Island, Willamette River	45,000 00
Contingencies of engineering and office expenses	5,000 00
	100,000 00

These rivers are in the collection district of Oregon, with a port of entry at Astoria, 12 miles from the mouth of the Columbia; and of the Willamette, with a port of entry at Portland, 12 miles above the mouth of the Willamette River.

There is a light-house and a work of defense on either shore, at the entrance to the Columbia River.

During the year the steam fog-whistle has been discontinued at the light station on the south side.

In January the light station upon Tillamook Rock was established. It exhibits a flashing white light (scintillating) of the first order, at intervals of five seconds, and sounds a steam fog-siren of the first class during thick and foggy weather—blasts of five seconds at intervals of ninety seconds.

ASTORIA STATISTICS.

Through the courtesy of Mr. J. D. Merryman, collector of customs at Astoria, I am enabled to give the following commercial statistics relative to that port from July 1, 1880, to May 31, 1881:

Value of exports	$1,185,030 00
Value of imports	129,115 00
Revenue collected	53,954 08
	Tonnage.
Coastwise vessels entered, 186	358,288
Coastwise vessels cleared, 174	343,611
Foreign vessels entered from foreign ports, 9	8,193
Foreign vessels cleared for foreign ports, 18	18,758
American vessels entered from foreign ports, 5	4,341
American vessels cleared for foreign ports, 11	12,223

PORTLAND STATISTICS.

I am under obligations to Mr. F. N. Shurtliff, collector of customs at Portland, Oreg., for the following information referring to Portland for the 11 months ending May 31, 1881:

1. Amount of revenue collected	$392,891 53
2. Value of imports	566,021 00
3. Value of exports	2,701,003, 00
	Tonnage.
4. Number of foreign vessels entered from foreign countries, 58	40,113
5. Number of American vessels entered from foreign countries, 10	8,238
6. Number of foreign vessels cleared for foreign countries, 54	44,338
7. Number of American vessels cleared for foreign countries, 25	22,857
8. Number of coastwise entrances, 135	219,910
9. Number of coastwise clearances, 89	181,333

The following statistics referring to the "Sound" have been furnished me through the courtesy of Mr. H. A. Webster, collector of customs, Port Townsend, Wash.:

DISTRICT OF PUGET SOUND.—STATISTICS FROM JULY 1, 1880, TO MAY 31, 1881.

Amount of revenue collected	$15,751 00
Value of imports	19,767 00
Value of exports	426,556 00
	Tonnage.
Number of foreign vessels entered, 94	30,346
Number of foreign vessels cleared, 93	29,738
Number of American vessels entered, 295	180,780
Number of American vessels cleared, 276	160,690

During the year about 250,000 tons of coal and 200,000,000 feet of lumber left Puget Sound coastwise, in vessels under enrollment and license, which are not required to enter and clear.

The introduction of large capital to be used in building railroads through the productive areas of Oregon and Washington Territory, in making connection with the eastern systems of railroads, and in develop-

ing coal and lumber interests, has caused great increase in the value of the imports over the Columbia River Bar, and it is expected that the commerce of the Northwest will in the next few years greatly exceed any ever recorded. It is highly important, therefore, that the Columbia and Willamette rivers should be kept in a navigable condition equal to the wants of the growing commerce.

Abstracts of proposals and contracts, a statement of funds, and charts of surveys made, and of the water curves of both rivers during the year are transmitted herewith.

Money statement.

July 1, 1880, amount available	$44,995 32	
Amount appropriated by act approved March 3, 1881	45,000 00	
		$89,995 32
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	45,960 05	
July 1, 1881, outstanding liabilities	4,297 39	
		50,257 44
July 1, 1881, amount available		39,737 88
Amount (estimated) required for completion of existing project		133,974 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		100,000 00

Abstract of proposals for building 1,000 *feet more or less of a pile dike at the mouth of the Willamette River, Oregon, opened by Maj. G. L. Gillespie, Corps of Engineers, September* 20, 1880.

No.	Names and residences of bidders.	Pile dam complete, exclusive of filling.		Fascines in place.		Stone in place.		Total.
		Linear feet.	Price per linear foot.	Cords.	Price per cord.	Cubic yards.	Price per cubic yard.	
1	Nott & Neilson, Portland, Oreg	1,000	$7 50	2,300	$4 00	9,000	$1 37½	$29,075 00
2	Holmes & Sweeney, Portland, Oreg*	1,000	6 75	2,300	3 20	9,000	1 15	24,460 00
3	John P. Sheldon, San Francisco, Cal	1,000	11 95	2,300	7 95	9,000	1 45	43,285 00
4	Paquet & Smith, Portland, Oreg	1,000	7 00	2,300	4 60	9,000	1 00	26,580 00
5	P. Paquet, Oregon City, Oreg	1,000	6 89	2,300	3 50	9,000	1 65	29,790 00
6	Vincent Cook, Portland, Oreg	1,000	11 75	2,300	3 25	9,000	1 75	34,975 00

* Contract awarded.

Abstract of contract for the improvement of the Lower Willamette and Columbia rivers in force during the fiscal year ending June 30, 1881.

No.	Names and residence of contractors.	Date of contract.	Subject of contract.	Remarks.
1	Holmes & Sweeney, Portland, Oreg.	October 9, 1880	Building pile dike at the mouth of Willamette River.	Contract expires October 1, 1881.

REPORT OF FIRST LIEUTENANT P. M. PRICE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., July 13, 1881.

MAJOR: I have the honor to submit herewith my report upon the survey of the mouth of the Columbia River, Oregon.

The report is accompanied by the original chart on a scale of 1:20,000; a tracing of the same; reduced chart on a scale of 1:40,000, on which the characteristic soundings only are

shown; a tracing of the latter to be used in printing copies by the "blue process" for distribution to pilots and others interested in navigation; a tracing showing the directions and velocities of the surface currents at important points; and maps on a scale 1 inch to 400 feet of Sand Island and the shore line of Point Adams.

In accordance with your instructions I went to Astoria on April 29, accompanied by Assistant Engineer J. A. Gillespie and Messrs. F. E. Habersham and E. W. Dodge.

On the 30th the sites for theodolite stations on Cape Disappointment, Point Adams, and Sand Island were selected. The preliminary arrangements, including the employment of the remainder of the party, the establishment of tide-gauges, and the erection and location by triangulation of the stations having been completed, the first sounding was done on May 7, and continued on every suitable day thereafter until June 21, when we returned to Portland. It is almost superfluous to state that there were many days during this interval on which roughness of the bar or rains prevented work. On July 5 I returned to Astoria with a portion of the party, and made additional soundings on the middle sands on July 6 and 8.

METHODS OF SURVEY.

Tide-gauges were established at Astoria and Cape Disappointment.

The Astoria gauge was fastened to a pile near the inner end of Trenchard & Upshur's Wharf. Its zero was fixed at mean low-water by levels run from the Coast Survey B. M., the height of which above mean low-water is 9.547 feet.

The gauge at Cape Disappointment was attached to one of the piles on the north side of the Fort Canby Wharf. Its zero was set approximately at mean low-water, and the height of low-water was there noted on it every day during the survey. A mean of the difference between these readings and those for low-water on the same days at Astoria was then taken as the difference in level of the zeros of the two gauges. The zero of the Cape Disappointment gauge was thus found to be 0.3 foot higher than mean low-water, and all its readings were corrected accordingly.

Both gauges were read every fifteen minutes when soundings were being made. All soundings were reduced to mean low-water, the cape gauge being used in the reduction of soundings west of the line from Chinook Point to Point Adams; the Astoria gauge for all soundings east of that line. A mean of all the high-water readings on the Hancock gauge, taken during the survey, gives an average of 6 feet above mean low-water, but as these readings do not include those highest tides which occurred at night, this average height of tide should be slightly increased. The highest tide recorded was 7.3 feet.

On my arrival at Astoria the United States Engineer's tug "Gen. H. G. Wright" with J. E. Denny, master, reported to me for duty, and was employed in the sounding on the bar until May 24, when it returned to Yaquina Bay.

The new dredge tender Robert T. Lincoln, with E. D. Brock, master, having reported to me on May 21, was employed during the remainder of the survey for work inside the bar. The bar tug Astoria, Capt. A. D. Wass, was hired for work on the bar on June 15 and 16 and July 6 and 8.

When sounding the steamer moved at a rate of 3 to 4 knots an hour, and was kept on the desired lines by shore ranges when possible, otherwise by compass. Alternate soundings were taken by two leadsmen, one on each side of the boat, at quarter, half, or whole minute intervals, depending upon the depth of the water. The lead lines were carefully tested at the close of each day's work, and the proper corrections, if any, applied to the soundings.

The positions of the steamer were determined by three simultaneous theodolite readings from stations on shore to a canvas balloon hoisted to the top of a mast. The balloon was cylindrical in shape, 3½ feet long by 1½ feet in diameter, the upper half painted black, the lower white. The theodolite observers followed this balloon with their telescopes, and at the moment it was dropped clamped and read their instruments and noted the time. Their time-pieces were usually compared with that used on the steamer each morning and evening. As a warning to the observers, before dropping the balloon a long blast of the whistle was blown, the steam attracting their attention when the sound could not be heard. Usually the steamer was located at five minutes intervals, but frequently where the lines of soundings had to be made short on account of shoals, or when for any other reason it became desirable to do so, the intervals were reduced to one, two, or three minutes, or a location was made at any arbitrary time.

The stations occupied during the greater part of the survey were on Sand Island, Cape Disappointment, and Point Adams. The Coast Survey line from Cape Disappointment to Scarboro Hill was taken as the base line for the survey.

In order to have the work plotted as the survey progressed there were two sets of note-books, and while one set was in use outside, the notes in the other were plotted in the office at Astoria. The plotting, on a scale of 1:20,000, was all done by Assistant Engineer J. A. Gillespie and Rev. A. T. Perkins.

The reduced chart, on a scale of 1:40,000, and the tracing of it, were drawn by Assistant Engineer R. A. Habersham.

The surveys of Sand Island and Point Adams were made by Assistant Engineer J. A. Gillespie, using the stadia for the determination of horizontal and vertical distances. His maps show the high and low water lines and the elevations of characteristic points.

RESULTS OF THE SURVEY.

An examination of the accompanying chart shows the present condition of the mouth of the Columbia River to be as follows. Depths of water are all referred to mean low-water, directions are true bearings, and distances are expressed in statute miles:

Between Astoria, 15 miles in a straight line east of the outside edge of the bar, and Point Ellice the river flows between high stable banks and is 4 miles wide, with two deep channels; one of these, with a general depth of 27 feet, runs close to the north bank, but shoals a few miles east of Point Ellice; the other, which is the main ship channel, runs along the south bank immediately in front of the Astoria wharves, and takes almost a direct course to Point Adams. Its least depth is 20 feet, and its average width between the 18-foot curves is five-eighths mile.

West of Smith's Point, 1 mile below Astoria, the river opens out to the south, forming Young's Bay, which lies south of a line drawn from Smith's Point to Tansy Point, the most eastern point of Point Adams. The distance from Smith's to Tansy Point is 3¼ miles.

Between Point Adams and Chinook Point the river again contracts to about the same width that it had at Astoria, but west of the latter point the shore recedes to the northward, making a deep bend around to Cape Disappointment, and forming Baker's Bay, which may be said to lie north of a line drawn from Chinook Point to the cape. The distance between the two latter points is 7½ miles.

Several small rivers empty into both Young's and Baker's bays. The waters of these bays are separated from those of the Pacific Ocean by Point Adams and Cape Disappointment, respectively. The former is a low sand point, with constantly changing shore line, having a width of about 2½ miles, except at the northern point, on which Fort Stevens is situated, where the width is about three-quarters of a mile. Cape Disappointment is a bold, rocky bluff 280 feet high, and only one-quarter of a mile wide at its southern extremity.

Should the shore line of Baker's Bay be considered as the concave bank of a bend in the river, of which Point Adams is the convex bank, it will be observed that while the distance from Point Adams to Chinook Point on the northeast is 3¾ miles, the distance to the cape on the northwest is 6¼ miles.

The main channel after passing Tansy Point turns to the northward and takes a northwest course along the eastern side of Point Adams and Clatsop Spit. The latter is a broad sand bank, about 3½ miles long and 2¼ miles wide between the 18 feet curves, making out in a northwest direction toward Cape Disappointment from Point Adams. The sea breaks constantly on this spit.

Between Clatsop Spit and Chinook Point the main ship channel and the channel along the north bank of the river meet, and they together form one channel 2 miles wide, with a general depth of 35 feet, which turns to the west around the north end of Clatsop Spit, and flows between it and Sand Island. The width between Sand Island and Clatstop Spit is 1 mile, and the least depth 54 feet. For many years past the main body of the water coming out of the river has been divided at the eastern end of Sand Island into 2 channels, one running north and the other south of it, called respectively the north and south channels, and these channels remained distinct and separate out over the bar into the sea. But the steady movement of Sand Island to the northward has now progressed so far that a line from Chinook Point to Cape Disappointment passes through the southern part of it, and as a consequence the body of water flowing through the north channel has become so reduced that it has rapidly shoaled within the past few years, and now not more than 12 to 13 feet of water can be carried between Sand Island and Chinook Spit.

The larger class of vessels have within a few months abandoned the use of this part of the channel.

The rapidity of the movement of Sand Island can be judged from the fact that a comparison of this year's survey with the Coast Survey chart of 1868, shows that its axis is now 1¼ miles farther north than it was then. Its form has also materially changed, the western end having made to the north more rapidly than the eastern, so that the island is now crescent shaped, with its concavity towards the northeast. Since the survey of 1880 the north point of the island has made out 1,200 feet, and its eastern point 575 feet; otherwise it shows but little change.

There is still good water in the north channel to the north and west of Sand Island. A sand bank makes out to the westward from Sand Island to a distance of about 1½ miles, and at this point the Middle Sands, as they are called, has been cut through, and there is now a practicable channel with 20 feet of water between the north and south

channels. Nearly all vessels now pass through this cut-off, taking the north channel west of it, and the south channel east of it. In fact, this is now the only route open to deep-draught vessels, on account of the shoaling of the south channel between the Middle Sands and Clatsop Spit, and the north channel east of Sand Island. Nevertheless the cut-off cannot be considered a good channel, at present at least, on account of the numerous lumps and ridges of sand with from 14 to 17 feet of water on them. These lumps are constantly forming and washing away, and a vessel drawing 20 feet may strike in the channel over which, a week previously, she crossed without difficulty.

Two and a half miles west of Sand Island there is a large sand bank, the upper part of the Middle Sands, having a least depth of 10 feet. The north channel passes out to sea in a direction about north of east between this bank and Peacock Spit. The latter is the sand bank which makes out for 1½ miles in a southwest direction from Cape Disappointment. The sea breaks constantly on it. The least depth of water on the north channel bar is 20 feet.

The south channel now pours most of its water over the Middle Sands in a southwest direction, about 1½ miles below the north channel. No available channel for deep-draught vessels has, as yet, been cut through the sands, however, for although they are now narrow here and the average depth of the water is 18 to 19 feet, there are many lumps just as on the cut-off above.

Below this middle channel there is another large sand bank, with a least depth of 12 feet. In the south channel between these sands and Clatsop Spit there are almost everywhere 18-feet lumps, and many of 16 and 17 feet. The best water seems to be close to Clatsop Spit, although there are places there with only 18 feet. In fact, it is impossible to draw accurately the 18-feet curve over the great sand flat which encircles the mouth of the river, anywhere except along the north channel. The 18-feet soundings are so mingled with those of 19 and 20 feet that the 18-foot curve as drawn on that part of the chart is in fact rather the 17-foot curve. The difficulty of drawing these curves satisfactorily has been further increased by the changes in the depths which took place between the dates on which soundings were made, these changes often amounting to several feet.

The time and money allotted for the survey did not admit of anything being done in the way of current measurements beyond the determination of the set of the surface currents at a few of the important points. This was done by dropping surface floats of wood, weighted at one end so as to stand upright in the water, from the steamer, and then following them up and having them located by the observers on shore. The results are shown on the accompanying tracing, on which the arrows show the paths of the floats during the times and at the stages of tide written above them.

To make at all satisfactory current observations at the mouth of the Columbia, where the currents are so extremely complicated and irregular, and where so few suitable days for the work can be obtained, would require months of labor, and the expenditure of an amount of money which might in the end be found disproportionate to the value of the results obtained.

In accordance with my instructions, which only required a *survey* of the bar to be made, I submit the above report on its actual condition as found, without any expression of opinion as to probable changes, or possible remedies for existing difficulties.

I am, very respectfully, your obedient servant,

PHILIP M. PRICE,
First Lieutenant of Engineers.

Maj. G. L. GILLESPIE,
Corps of Engineers, U. S. A.

REPORT OF MR. ROBERT A. HABERSHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., June 30, 1881.

COLONEL: I have the honor to submit the following report of operations on the Lower Willamette and Columbia rivers during the fiscal year ending June 30, 1881:

STAGES OF WATER.

The annexed sheet shows the water profile at Umatilla, Celilo, The Dalles, Upper Cascades (head of locks), Lower Cascades (steamboat landing), Vancouver, and the mouth of the Willamette, and Saint Helen's, on the Columbia; and at Corvallis, Albany, and Salem, on the Upper Willamette, and Portland, on the Lower Willamette, drawn from the daily readings of the water gauges at the several stations.

The height of the lower rivers varied during the year as follows:

Date.	Locality.	Height.	Locality.	Height.	Locality.	Height.
1880.		*Feet.*		*Feet.*		*Feet.*
July 2	Portland	27.3	Vancouver		Saint Helen's	21.5
September 30	do	2.5	do	1.5	do	1.4
November 27	do	—0.5	do	—1.0	do	0.2
December 15	do	7.9	do	4.7	do	5.6
December 24	do	3.6	do	1.0	do	2.3
1881.						
January 1	Portland	10.5	Vancouver	6.3	Saint Helen's	7.2
January 10	do	4.1	do	1.5	do	2.0
January 16	do	21.5	do	13.9	do	11.9
January 28	do	3.3	do	2.0	do	2.2
February 7	do	23.6	do	20.0	do	18.0
February 20	do	6.6	do	3.4	do	4.0
March 3	do	17.8	do	14.3	do	12.8
March 22	do	6.0	do	3.2	do	3.2
April 9	do	13.5	do	12.8	do	10.2
April 18	do	11.0	do	9.9	do	8.2
April 28	do	17.5	do	16.5	do	13.6
June 1	do	13.6	do	12.7	do	10.0
June 16	do	19.7	do	19.0	do	15.7
June 30	do	17.2	do	16.8	do	13.4

The want of uniformity in the slope of the water surface from Portland to Saint Helen's is due partly to the influence at Portland of backwater from the Columbia, and during low stages especially, to the difference in the heights of the tide at the same hour (the gauges are read at 12 m. daily) at the several stations.

The freshets in January, February, and March were caused by violent rains following immediately upon heavy snows, principally in the Willamette Valley and the Cascade Range, and in less degree in the Blue Mountains in Eastern Oregon.

The highest point reached at Portland was on February 7, when the water rose to 23.6 feet, or within 1.5 feet of the flood of 1861–'62, the highest on record.

Navigation was much obstructed during the freshets by the drift composed of trees, some of which were 200 feet long and from 4 to 6 feet through, mingled with the ruins of bridges and dwellings and broken booms of saw-logs from the upper river.

Fortunately calm weather prevailed during the higher stages of the floods. A strong easterly wind at such times, aided by the direction of the currents which set across towards the left bank of the Willamette at Portland, would have driven the drift, trees, and logs into the pile wharves along the city front, and probably destroyed them with their stores, causing damage impossible to estimate. The principal loss was that of about 1,200 tons of wheat which had been stored on the lower level wharves and could not be removed in time.

SURVEYS.

Upon the subsidence of the summer flood, surveys were made of Swan Island Bar; of the Willamette from its mouth to half a mile above the head of Sauvies Island, including Post-Office Bar; of the Willamette Slough from its head to 800 feet below the dam; of the upper and lower ship channels across Saint Helen's Bar; of Martin's Island Bar; of Walker's Island Bar; and of the Hog's Back Shoal.

Swan Island Bar showed a least depth of 14 feet and a length of 3,900 feet between 18-foot curves, with no material change in the axis of the channel since 1879.

At Post-Office Bar the ruling depth found was 17½ feet, the distance between 18-foot curves 700 feet, showing since the building of the dam across the Willamette Slough a gain in depth of 1 foot and a reduction in length of 800 feet.

At the mouth of the Willamette the least depth in the line of deepest water was 17 feet; the navigable depth, however, being reduced to 15 feet at low-water for 200 feet by a sharp curve in the deepest channel. The deposit of sediment over that portion of the bar where slackwater prevailed during the Columbia flood was shown by comparing the soundings taken before and after the flood to average between 5 and 6 feet.

At Saint Helen's Bar, upper crossing, the ruling depth was found to be 17 feet. The distance between 18-foot curves averaged 500 feet, but at three points did not exceed from 30 to 100 feet. The depression forming the ship channel was found 400 feet farther down stream than in 1879. The changes which have appeared here, shown by this survey, are all favorable to navigation, and may without doubt be credited to the Willamette Slough dam.

The lower crossing, near Columbia City, showed 14½ feet least depth and 800 feet length between 18-foot curves, without material change in the contour of the bar or the position of the deep channel since 1875. In fact, since the beginning of naviga-

tion on the Columbia, this crossing has maintained its shape and depth with little variation, the currents which traverse it being constant in their direction and parallel to the line of greatest depth, while the upper end of the bar under the disturbing effect of three distinct streams, viz, Lewis River, the Columbia, and the Willamette Slough, changes constantly.

Martin's Island Bar, 5 miles below Saint Helen's, is 3,000 feet long and 1,500 feet wide, with depths ranging from 19 to 25 feet at low-water. The bottom, however, is traversed by ridges of pebbles and shingle, which, occurring every few yards, reduce the ruling depth to 17½ feet. The survey covered an area of 5,000 by 3,000 feet with soundings at intervals of from 25 to 30 feet, and showed the best channel to be near the middle of the stream, on the line marked *ship channel*, on the chart of the rapid survey made in November, 1878. Shortly after the completion of the survey of 1880, the rake was used on this line for a width of 300 feet, leveling off the crests of the ridges on the bottom, producing a uniform least depth of 19 feet at low-water across the bar, and the cut marked by two black buoys at its extremities.

Walker's Island Bar, 45 miles above Astoria, resembles that at Martin's Island except in the material of which the bottom is composed, which is loose sand. It is 4,000 feet long and 1,500 feet wide, with depths varying from 16 to 22 feet at extreme low-tide. The line of greatest depth, as shown by the survey, was buoyed, affording a channel 18 feet deep at mean low-tide. The general contour of the bar has changed very little since the coast survey was made in 1877.

The Hog's Back Shoal is 7 miles long, extending from Tongue Point, 5 miles above Astoria, to the head of Snag Island. Attention is here respectfully invited to the chart of my survey of this shoal, herewith submitted, and to the United States Coast Survey chart of the Columbia River, sheet No. 2, showing the Cordell and Woody islands channels across this shoal. The last named was the ship channel up to 1875, when it became too shoal for ships, and at the same time the Cordell channel was found to afford the best depths. Since then, gradual changes in the latter have caused detention to vessels, requiring a new survey, in order to have the channel properly buoyed.

This survey was begun in July, 1880, as soon as the freshet had abated sufficiently to admit of accurate work, and was completed in August. It included the Cordell channel within the three fathom curves, from just below Jim Crow Point to Tongue Point, a distance of 9 miles, and the Woody Island channel, 4 miles long. The triangulating points of the United States Coast Survey were used as principal signals. The soundings were located by angles taken simultaneously with two sextants, and were reduced to the mean of lowest low-tides by ½ hour readings of two gauges set at Tongue Point and Snag Island, verified by the bench mark of the coast survey at Astoria. The depths in the ship channel, which is from an eighth to half a mile wide, were found to be from 24 to 56 feet, except at two points, viz, at the head of Snag Island, where there is a bar 500 feet long and 300 feet wide with 19 feet ruling depths, and near the middle of the shoal, where the bar is 300 feet long, 450 feet wide, with 18 feet ruling depths. At the lower end of the shoal, opposite Tongue Point, where there was formerly a bar carrying 14 feet, I found 22 feet least depth and a channel 1,000 feet wide.

As these depths at low-tide give 21 feet least depth at mean half tide, and as vessels drawing 22 feet crossed the shoal easily while others drawing 18 feet grounded several times before reaching the middle shoal, and then passed the middle and upper shoals without touching, the complaints of insufficient depths in this locality would seem to be without cause. As soon as the chart of the recent survey could be plotted the buoys were changed so as to properly mark the channel, since which there has been no trouble, except, as before, when vessels did not follow the channel.

The soundings through Woody Island channel showed a bar at the head 3,100 feet long with 12 feet depth. Below the bar the depths increased from 20 to 30 feet. This channel is nearly straight and about a quarter of a mile shorter than the other, and is consequently preferred by pilots. Within the last two years the current has attacked the south bank of the river above Snag Island, caused shoaling on the bar at its head, and shown a general inclination towards Woody Island channel. If this continues it may become advisable to close the slough which makes out above the head of Channel Island, in order to concentrate the current through Woody Island channel.

Additional soundings were made at the *mouth of the Willamette* and over *Post-Office Bar* in January, 1881, after the subsidence of the first freshet, to ascertain its effects upon the bottom. *At the mouth* 22½ feet least depth in the channel was found, with 530 feet width between 18-foot curves, and 510 feet length over the bar between 4-fathom curves. The depth at the head of Coon Island had been reduced from 33 to 21 feet by the sand scoured from the bar 200 feet above. The flood had added 3½ feet in depth and 410 feet in width to the channel.

The dike across Coon Island Slough had been practically closed before the river rose. No soundings were made after the freshets of February and March, but it is probable that by them the ruling depth was increased to not less than 24 feet. It is not possible to predict with any certainty the amount of deposit to be expected from the present year's flood, but unless it exceeds that of last year, 18 feet least depth may be looked

for at the mouth of the Willamette at the next low-water stage. The soundings also disclosed a layer of very tough mud extending from the foot of Nigger Tom's Island towards the foot of Coon Island revetment, terminating at the 18-foot curve about the middle of the stream, beyond which, close to Coon Island, the depths varied from 28 to 37 feet. This material resists erosion almost entirely, forcing the flood waters of the Willamette over against the revetment at the lower end, causing settlement of the riprap. In February the riprap was protected by bolsters 50 feet long, distributed uniformly in front and along the foot of the rubble, and over all an apron of mats 10 feet wide by 20 feet long, made of fascines, strengthened by small bolsters bound crosswise to the mats, was laid in front of the riprap, resting on the bottom, so as to slide forward in case of further cutting by the current. The apron was extended along the whole base of the riprap to the head of the revetment, as a protection against the Columbia flood, which strikes the revetment at right angles. As the layer of mud not only contracts the water-way of the Willamette to the prejudice of the revetment, but also presents a breakwater to the Columbia current during floods, increasing the area of slackwater and consequently the deposit in the channel of the Willamette, on the bar, its partial removal by dredging would undoubtedly be beneficial.

The soundings over *Post-Office Bar* made at the same time gave 18½ feet ruling depth, and a channel 400 feet wide, in the center of which a flat knob, about 200 feet wide by 250 feet long, with 16½ feet depth, surrounded by deep water, had resisted the current. This should be dredged if possible during the next low stage, so as to allow the winter flood to cut out a clear channel.

Current measurements in the Willamette at Portland were made from Market to E streets, extending entirely across the river. The chart, showing the directions and velocities at stages ranging from 3.8 to 20.9 feet above low-water, has been submitted with a full report. The velocities varied from 0.83 to 5.50 miles per hour, the greatest occurring when the gauge showed 19.9 feet flood. The non-coincidence of the greatest velocity with the highest water is due to the fact that at that time (January 15) the Willamette was rising faster than the Columbia, increasing the slope of its surface. The velocities were measured by a float submerged 3½ feet, surmounted by a vane, its direction being determined by following closely in a boat and taking angles with two sextants simultaneously, at regular intervals, to triangulating points on shore.

DREDGING

was begun at the mouth of the Willamette October 4, the water being then 1 foot above mean low-water, to open a cut through the bar to the eastward of the sinuous channel above described. This was accomplished by the 21st of the same month. The cut was 110 feet wide, 430 feet long, and carried 19 feet at low-water. The dredge was then taken to Swan Island Bar, where work was begun on the 25th, and a cut 2,640 feet long, 70 feet wide, and 18 feet deep opened on the line of the buoyed channel by December 1, when unfavorable weather caused suspension of operations, which were not resumed during the season owing to continued high-water.

The summary of work done by the dredge during the year was—

	Cubic yards.
At the mouth of the Willamette	7,230
At Swan Island Bar	7,320
Total	14,550
Number of days (of ten hours) actually worked	33.3
Number of days (of ten hours) lost in hauling out of channel to make way for passing vessels, repairing dredge, bad weather, &c	17.7

The tug Katata, belonging to Messrs. Badollet & Co., of Astoria, was employed as tender, for $580 per month, during the time the dredge was at work.

PERMANENT IMPROVEMENTS.

The work done under this head consisted principally in closing the interval of 975 feet in the dike across the head of Coon Island Slough, which was not completed last year for want of funds. The depths along the interval varied from 7 to 33 feet, the greater depth occurring at the head of Coon Island, where the currents through the mouth of the river and Pearcy's Slough meet during the Columbia flood, forming a strong whirl which has excavated a deep hole about 300 feet across.

To provide the dike with the additional strength required in deeper water and a more exposed location, the dimensions of the waling timbers were increased from 6 by 12 inches to 8 by 12 inches, and the cross-ties from 6 by 12 inches to 10 by 10 inches, the intervals between the cross-ties reduced from 12 to 6 feet, and the drift bolts supple-

mented by short screw-bolts of three-quarter-inch iron extending through piles and waling at intervals of 8 feet; and the piles were driven from 15 to 25 feet into the bottom, as far in fact as they would penetrate without splitting. In all other particulars the dike was identical with the portion built in 1880, which has been fully described in the Report of the Chief of Engineers for the same year, page 226.

The experience of the preceding year having shown the difficulty and delay attending the sinking of fascines, owing to their lightness, it was decided to use for filling the dike, bolsters from 12 to 20 feet long, made by grouping five or six fascines around a core of rubble rock heavy enough to cause them to sink readily, the whole securely bound with bale rope. The exterior slopes were formed of bolsters from 50 to 80 feet long, with long saplings from 3 to 5 inches thick, bound outside, the fascines breaking joints throughout the length. The bolsters were all made on a platform of heavy plank laid along the dike on the cross-ties, the rock and fascine scows being moored alongside, and then rolled with handspikes into the water, those for the outside being guided in sinking by piles driven parallel to the dike 6 feet off. The outer slopes were afterwards faced with rubble to the depth of from 3 to 10 feet, according to the depth of water. For filling and revetting where the bottom is soft the bolsters have proved superior to any material with which I am acquainted. They are more easily made and sunk into position than mats; their flexibility causes them to conform readily to inequalities of surface, and to sink into and fill up holes which may be cut under them by the current; they are not heavy enough to sink more than 1 or 2 feet into a silt bottom, nor yet so light as to be displaced by any ordinary current. If laid, as is proper, so as to break joints, which is easily done, the mass settles very little and uniformly; they soon become filled with sediment and closely packed, turning the water effectually; and at the ordinary prices of $3.25 per cord for fascines, and $1.25 per yard for rock, in place, cost from 30 to 40 per cent. less than rubble in construction, and very little for repairs, while loose rubble will often sink many feet into the bed of the stream and have to be rebuilt and kept up to the proper level by the addition of fresh rock at an expense greater than the original cost of the work.

This work was done by Messrs. Holmes & Sweeney, of Portland, under their contract dated October 9, 1880. Construction was begun on the 26th of the same month, and as low-water and good weather prevailed throughout November and the greater part of December, the dike would have been completed by the 1st of January but for the neglect of the contractors to prepare fascines and piles during the month of October. During January and February the river was almost constantly in flood, and work on the dike was seldom possible. However, the contractors persevered against all difficulties, and by the end of February had practically completed their work, only a small portion of the waling being unfinished, when the Columbia rose suddenly, forcing them to withdraw their plant until low-water, which cannot now be expected before next fall. No injury is apprehended, however, from the Columbia flood, as the dike is closed, filled, and revetted.

The materials used in completing the dike, including filling and revetting, were as follows:

Timber for waling, and cross-ties	feet, B. M..	47,450
Piles	linear feet..	34,125
Iron for drift and screw bolts and tie-rods	pounds..	12,850
Fascines measured on the barges	cords..	1,262
Stone measured on the barges	cubic yards..	5,540

EFFECTS OF THE SUMMER FLOOD ON THE CHANNEL AND ON THE IMPROVEMENTS.

Comparison of the profiles of water curves at Portland, since 1875, shows this flood to have been greater in duration and volume than any heretofore recorded. The deposit in the channel at Swan Island Bar was 2½ feet; at Post-Office Bar 1 foot; and at the mouth of the Willamette 6 feet.

The bay between Coon Island dike and Sauvie's Island silted up almost to low-water mark, except along the shore line, where a strong eddy had maintained a depth of from 6 to 10 feet, and caused a slight settlement of the stone riprap and filling near the heel of the dike, not, however, to any injurious extent.

At *Willow Bar* in the Columbia, 6 miles below the mouth of the Willamette, the width of the ship-channel was increased by about 1,000 feet by the cutting away of the end of the bar which makes out from the left shore and extended nearly across the river. This additional width, which is doubtless due in part to the dam across Willamette Slough assisting to confine the Columbia within its own channel, probably prevented the ice from forming a gorge at Willow Bar last winter, and enabled ocean steamers to make regular trips.

At the *Willamette Slough*, for 500 feet above and 150 feet below the dam, in the line of the wings, the depths were reduced by from 2 to 8 feet by deposit, and 18 feet clear depth was found on both sides of the dam in the center of the stream, the old deep channel along the left bank having filled up to the average level of the bottom. No

settlement of the rock, or other disturbance of the work, worthy of note, could be found. But the falling flood had created a whirl about 150 feet below the dam and 100 feet from the bank of Sauvie's Island, which attacked the bottom of the slough, cutting a hole 43 feet deep and 100 feet across at the 4-fathom curve, undermining slightly the lower wing-wall of the dam, and the bank of the island for 200 feet below the dam. The location and extent of the injury are shown on the annexed sketch. The erosion was greatest when the flood was 10 feet above low-water, and ceased altogether when it fell to 3 feet. As the funds available for this work were not sufficient to build a permanent structure to control the current and prevent repetition of the mischief, and as any plan of repair must necessarily be experimental, it was decided to do at that time only such work as was required to prevent the injury from extending to the dam during the next freshet, and await further developments. To this end the bottom, up to low-water mark, all over the eroded surface, was lined with bolsters from 20 to 50 feet long, and the bank of the island from low-water mark back to the top of the bank, sloped at an angle of 50°, and covered with willow fascines staked into the ground, and further secured by battens of 3 by 1 inch lumber, spiked to the stakes; after which, a course of rubble from 2 to 3 feet thick was spread over the fascines for 10 feet above and below low-water mark.

The work of lining the slope of the bank was rendered very difficult by the action of several springs of water supplied by the large ponds on the island, which had been filled by the flood and left full as it fell. These entered the slough near low-water mark, with a head which increased as the water fell in the slough, undermining rapidly the loose earth composing the bank, pressing the fascines out into the water, and forming tunnels 3 or 4 feet in diameter and several feet in depth. These had to be filled with rubble rock, roughly built into a wall before the fascines could be made to stand. The slope lining was carried 40 feet below and 60 feet above the slide, and joined on to the upper wing-wall of the dam. The island below low-water was further protected by laying long bolsters at right angles to the current, so as to cause a deposit of sediment between them.

This work was not quite completed when the winter freshets occurred, without, however, doing any more injury than to displace a few fascines which had not yet been fully secured. The plan of protection selected seems to be effective, and will probably answer permanently. The dam was uninjured by either the summer or winter floods. Some of the fender piles from the cribs had been broken off by drift, and new ones were driven.

Respectfully submitted.

ROBT. A. HABERSHAM,
Assistant Engineer.

Col. G. L. GILLESPIE,
Major of Engineers, U. S. A.

PROJECT OF MAJOR G. L. GILLESPIE, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., December 5, 1880.

GENERAL: I have the honor to submit for the consideration of the department a chart of the mouth of the Columbia River, showing the location and character of an improvement which I now propose as a means for hastening the deepening of the channel through the Middle Sands inside the bar.

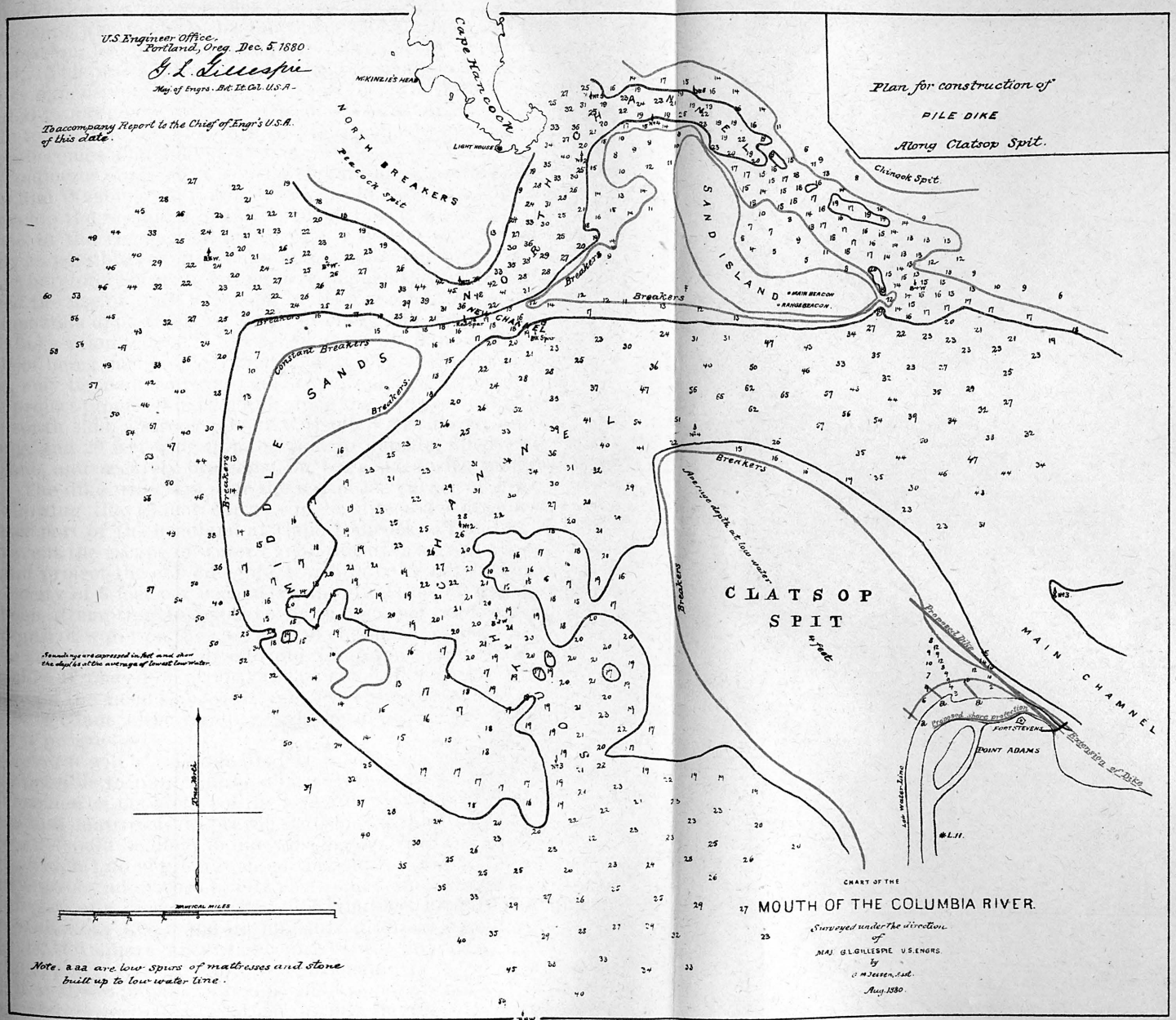
On the 17th of December, 1879, I submitted a plan and estimates for a stone dike on the south side of the entrance, but the project, as is stated in my last annual report, will cost a great deal of money and will consume a great deal of time, owing to the manner in which appropriations are made for large undertakings. This latter consideration has led me for some time past to a thoughtful study of the harbor and its shoals, to ascertain if it be not possible to dispense with the massive structure which the original project contemplated. The shoals, and the two channels of approach through them, are now in a favorable condition for attempting, by a speedy process, to build up Clatsop Spit, and to hold the banks of the inside channel for a proper direction of the currents to maintain deep water along the line observed in the chart of 1841. The short passage between the north and south channels, through the Mid-

U.S. Engineer Office,
Portland, Oreg. Dec. 5. 1880.

G. L. Gillespie
Maj. of Engrs. Bvt. Lt. Col. U.S.A.

To accompany Report to the Chief of Engr's U.S.A. of this date.

Plan for construction of PILE DIKE Along Clatsop Spit.



Soundings are expressed in feet and show the depths at the average of lowest low water.

Note. a aa are low spurs of mattresses and stone built up to low water line.

CHART OF THE
MOUTH OF THE COLUMBIA RIVER.
Surveyed under the direction of
MAJ. G.L. GILLESPIE U.S. ENGRS.
by
C.M. Jessen, Asst.
Aug. 1880.

dle Sands, at the point indicated in my previous reports on this harbor, has not been opened with the rapidity and success I anticipated. I believe the cut is gradually deepening, but the process is so slow that the channel cannot be used with convenience by deep-draught vessels when winds and tides are unfavorable.

An attempt was made to hasten the deepening by harrowing across the depression, leaving the currents to carry out to sea the displaced material. This was a laborious undertaking with the means available, and very expensive; an increase of 3 to 4 feet was obtained, but I was compelled to forego operations on account of insufficiency of funds applicable to the object. The work will be resumed when the new appropriation becomes available.

The commerce of the river is increasing rapidly, capital is flowing into Oregon and Washington Territory in large quantities to build railroads and develop the resources of the country, and it is of the greatest importance to the commercial public that a deeper channel be made as speedily as possible from the outside to a safe anchorage on the inside.

I have heretofore been unwilling to recommend any construction which involved the use of timber because of the exposure of the site; but the great demands upon the river and the many and new interests centering in this section induce me to recommend an improvement which is capable of being made rapidly and quickly, and which, if not permanent at first, may be made so by annual strengthenings and additions.

The project proposed is to build, along the line previously established on the south side, a strong pile-dike, rising 3 feet above low-tide, 8,000 feet long, and 20 feet wide from outside to outside, filled with fascines and stone, and securely protected on both sides with mattresses and stone. The dike will start near the northeast corner of Fort Stevens, and, following the 12-foot curve, will be directed a little westward of the outer part of the headland at Cape Hancock. The dike so located will prevent the escape of water at ebb-tide over a great part of Clatsop Spit, and project the ebb currents, which have usually a maximum surface velocity of 6 feet per second, in the direction of the cut which I have been attempting to improve by the scraper, and will have sufficient depth of water on the east side to enable the plant to work easily and the scows to move alongside and dump their material directly into the work. If placed on or near the spine of the shoal, a landing must be made on the inside some distance from the work; a tramway must be built to connect the landing with the dike, and extended over the dike as it progresses.

Wherever it will be possible to drive piles in the latter case, it will be equally possible to approach the dike with the scows in the former case. The shore-line on both sides of the heel of the dike will be revetted with fascines and mattresses to prevent erosion by the waves and currents. This work should be done in one working season; and if it proves efficacious, which I do not doubt, in cutting out the Middle Sands, it can be strengthened by additions of mattresses and stone, converting the structure into one of a permanent character, and may be extended at will.

The Columbia River and its affluents drain an agricultural area of nearly 200,000 square miles; the country through which it passes is settling up rapidly, and foreign capital is coming in to promote manufacturing industries, to build railroads, and to open the valuable coal mines. These undertakings are still in their infancy, but they have assumed such proportions as to make the opening of the inner shoals at the river's mouth an object of interest to our whole country. The execution of the plan will not be without its difficulties, but I believe it to be thoroughly prac-

ticable if commenced with an appropriation equal to the estimate for the entire work.

It is desirable that the work be commenced as early as the 1st of April next, and pushed vigorously during the summer and autumn, before the coming of the heavy southwesterly gales, which create the highest seas and offer the greatest impediments to continuous and safe labors. I do not think it can be doubted that the proper place for the improvement is on the south side, or that the maintenance of a deep-water channel through the inner shoals is dependent mainly upon the building up of Clatsop Spit, and the holding of it in a position approximate to the one it now has.

A strong revetment will be required on the inside of the dike, after completion, extending across the little bay to the eastward of the government landing, but this need not be undertaken at once, and will be much simpler and less costly in its construction than the dike.

ESTIMATE OF COST.

6,500 feet of dike, at $50 per foot	$325,000
1,500 feet of dike (inshore), at $40 per foot	60,000
2,500 feet of shore revetment, at $10 per foot	25,000
Total	410,000
Contingencies of engineering, surveys, inspection, &c	20,000
	430,000

The success of the project is so dependent upon rapidity of construction, only obtainable by the use of strong and costly plant, that I would urge the appropriation of the full amount of the estimate so that the dike may be built in its entirety before the opening of the next winter.

Charts accompany this report showing the location and character of the proposed improvement.

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

G. L. GILLESPIE,
Major of Engineers,
Bvt. Lieut. Colonel, U. S. A.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

REPORT OF THE BOARD OF ENGINEERS.

OFFICE OF BOARD OF ENGINEERS FOR FORTIFICATIONS AND FOR RIVER AND HARBOR IMPROVEMENTS, &C.,
New York, February 12, 1881.

GENERAL: This Board, in accordance with instructions from the office of the Chief of Engineers, dated December 24, 1880, to consider the whole subject of the improvement of the mouth of the Columbia River, have the honor to report:

A careful examination has been made of the documents and charts in connection with the subject transmitted from the office of the Chief of Engineers, including the various reports made by the local engineer, Maj. G. L. Gillespie, Corps of Engineers.

As a first step in this inquiry, a comparative study of the charts to note the changes in the shoals and channels became necessary.

Admiral Vancouver's chart of 1792 represents the river discharge, through a single channel, nearly due west into the ocean, with a depth

on the bar of 4½ fathoms. The Clatsop Shoal, or South Breakers, which formed the southern margin of the channel, had an extent in a westerly direction of about 7¼ miles. The north edge of the channel lay about one-half mile south of Cape Disappointment. The chart is on a small scale, and its claims to accuracy of detail not known, but the striking feature of the existence of but one channel could not have been a matter of mistake.

Sir Edward Belcher's admiralty chart of 1839 exhibits for the first time Sand Island, whose eastern extremity was 1¼ nautical miles north from Point Adams. The island formed the eastern apex of a large triangular shoal, which presented its base to seaward, the line of the base extending nearly north and south. The island and shoal separated the waters into a north and south channel, the former leading northwest, towards the cape, where it was turned abruptly to the south-southeast, skirting the North Breakers, which had extended southerly for a distance of a little more than 2 nautical miles, and then entered the ocean in a west by south course, over a bar with 4½ fathoms over it. The south channel from Sand Island ran nearly west, past Point Adams, supported on the south by the South Breakers, for a distance of 5 nautical miles, to its junction with the north channel. Before this juncture, however, the south channel sent off an outlet through the south shoal into the ocean, with a depth on the bar of 3½ fathoms, the navigable depth in the north channel until the bar was reached being 6 fathoms, and in the south channel 4½ fathoms. The level of reduction of soundings is not known, but was probably that of lowest waters.

The chart of the exploring expedition under Captain Wilkes of 1841 exhibits a similar middle ground, with Sand Island as its eastern apex, not quite 1 mile north from Point Adams. The channels much resemble those of the former survey, but the south channel had now no separate outlet into the ocean. The depths appear to be the same. The westerly extent of the South Breakers was 4¾ nautical miles, and of the North Breakers southward 2½ miles. The Coast Survey chart of 1851 shows a change in position of Sand Island, placing it 1½ nautical miles from Point Adams. The attached shoal was considerably elongated towards the northwest and south-southwest, and had become distorted in shape, the south-southwest portion extending so far as to completely separate the two channels. The depths over the bars and in the north channel had diminished.

The Coast Survey charts of 1854 and 1875, with hydrography of 1868, and the Engineer charts of 1876, 1878, 1879, and 1880, show the progressive changes, which may be briefly summarized.

Sand Island has continuously moved northerly from Point Adams, its present distance being 3⅜ nautical miles north-northwest from that point, and its western extremity a little more than 1 mile west from Cape Hancock. Sand Island, and shoals tailing from it, have by this movement crowded the portion of the north channel east of the cape close upon Chinook Spit, thereby much diminishing its width. A shoal at the eastern extremity of this channel gradually formed, which had of late years increased in length westward to 2 miles, has a depth over it of only 14 feet at the mean of lowest low-waters. Towards the cape the depth increases, and again diminishes at the outer bar, where it is about 21 feet.

The North Breakers, or Peacock Spit, extend 1 mile south-southwest from the cape.

The Middle Sands, extending first westward from Sand Island until south of the cape, thence by a quick turn in a southerly direction, termi-

nate in a southeast course about three-fourths of a mile south of an east-and-west line through Point Adams. The total length, including Sand Island, is about 8¾ nautical miles. There are two depressions in these sands, where it has been supposed the south channel might break through, the one a little west of the line joining Point Adams with the cape, and the other northwest from the range of the beacons on the eastern portion of Sand Island.

The south channel, after a westerly course, is deflected to the southward by the Middle Sands, into which, however, it first cuts a deep, sharp indentation, and is finally deflected in a southeast direction (through a channel narrowed to one-half mile by the tail of the Middle Sands and by a projection from Clatsop Spit) into the ocean, over a bar with about 20 feet on it.

Clatsop Spit, from a westerly has been thrown into a northwesterly direction, extending over 3 miles from Point Adams, and occupies fully one-half of what was formerly the channel space between Point Adams and Cape Hancock.

Mean rise and fall of tides at Point Adams, 6.9 feet, C. S., 1851.

Mean rise and fall of tides at Astoria, 6.4 feet, C. S., 1851.

Mean rise and fall of tides at Astoria, 6.1 feet, C. S., 1854.

A brief summary of the changes since the date of Vancouver's chart of 1792 is necessary to obtain an adequate idea of the immense wave and current action prevailing at this bar. From a single broad and deep outlet at that date, the charts of 1839 and 1841 show a division into two channels, caused by the formation of Sand Island, with an attendant triangular shoal covering an area of about 8 square nautical miles, the common outlet of these two channels being moved about 2⅓ miles southerly from Cape Disappointment by the growth of the North Breakers.

Subsequent surveys of the Coast Survey and the United States Engineers develop striking changes in the channels and shoals, which have been uniform in their causes and results.

The north channel has not only been narrowed and shoaled by the movement of Sand Island, but it has also been considerably curved northwards. The North Breakers have been cut away from a southerly projection of 2¼ miles from Cape Disappointment to that of 1 mile.

The southeast end of the Middle Sands and a projection from Clatsop Shoals have considerably narrowed the south channel near the outlet, and threaten even to close it.

The navigable depth in the north channel has decreased since 1841 from 6 fathoms to 14 feet at the present time, and over the bar from 4½ fathoms to 21 feet. The depth over the bar of south channel has also decreased from 4¼ fathoms in 1868 to 19 feet.

The distance of the north bar from Cape Hancock has varied from about 4 miles in 1839 to 2 miles at the present time. The distance of the south bar from Point Adams has varied from 4 to 3½ miles nearly west from Point Adams.

The northward swing of Clatsop Spit has been particularly hurtful to the south channel, as thereby a considerable portion of its flow has been forced over the Middle Sands to the detriment of the bar.

Between 1879 and 1880 both Peacock Spit and Clatsop Spit have approached the Middle Sands and narrowed the width of the northern depression. This in 1878 had a width across between the 3-fathom curves of 2,800 feet, with a depth of 14 feet; in 1879 a width of 2,400 feet, and the same depth as before; in 1880 a width of 1,000 feet, and a depth of 17 feet. The great decrease in width and increase in depth

in one year, between 1879 and 1880, indicate a possible close approach to a breach at this point through the Middle Sands.

The more southerly depression had in 1878 a width between the 3-fathom curves of 4,600 feet, with a depth of 13 feet; in 1879 the same width, with a depth of 13 feet; and in 1880 a width of 1,700 feet, and a depth of 17 feet. The great decrease in width and increase in depth during the last year of observations indicate likewise a close approach to a breaking through at this point.

Considering also that here the currents of the south channel set directly against this narrow bulkhead, it becomes not impossible that the breach here may be the first effected.

The proposition to construct a training wall starting from the shoreline at Point Adams north from Point Stevens, to have a length of 6,500 feet, and a direction about west-northwest along the interior 2-fathom curve of Clatsop Spit, although earnestly recommended and made the occasion of a call for immediate construction, is not approved.

The distance from Point Adams to the section of the Middle Sands which it is the object of this structure to wash away by its action in deflecting the current of the channel is 5 nautical miles, and it is quite probable, considering the distance of the point to be effected and the large volume of water in the channel to be deflected, that to accomplish the desired result a training wall nearly if not quite 3 miles long would be required.

The probability of an early breach at one or two points of the Middle Sands, so far at least as the rapid wearing away during the past year can support the assertion, is very great, and it becomes a matter of serious consideration whether before material progress in the construction of the proposed work could be made, or even preparations to undertake it perfected, the natural causes now in active operation would not have accomplished the desired result.

As a training wall long enough to effect this object would consolidate and fix Clatsop Spit in its present position, it might be well to inquire into the influence of such consolidation upon the future condition of the channel. The spit has been for years near its present position and extent, and though contracting considerably the water-way between Point Adams and Cape Hancock, it has not had the effect of deepening the outlets, which have, on the contrary, diminished both in width and depth. The present position of this spit invites, if it does not compel, the tail of the Middle Sands to trend to the southeast, and thus injuriously affects the outlet of the south channel. Although its position and considerable projection into the south channel have for many years been effectual in moving the Middle Sands to the west and also to the north, thereby injuriously affecting the north channel in depth and width, as also in changing the direction of the south channel to its injury and deterioration in depth and width, yet it does not appear that its effect in forcing a break through the Middle Sands, which might prove at least temporarily beneficial, has been conspicuous. This naturally leads to the statement of a fact that the increased southerly projection of Peacock Spit during the past year has probably been the principal cause of the considerable increase of erosion across the Middle Sands west of Sand Island.

Clatsop Spit in its change of position and growth has unfortunately been associated with a great deterioration of navigation over the bar, and it constitutes a principal feature in the poorest exhibition of navigable facilities which the Columbia River at its mouth has afforded for the past ninety years.

It is not the purpose to analyze the changes which have taken place in the channel and other features—which, however, have been mainly dependent upon the movement of Sand Island with its shoal, and of Clatsop Spit—nor determine whether the one is caused by the other, or whether both movements were forced by the same powerful agency.

It is sufficient, after what has been pointed out, to state that the present extent and position of Clatsop Spit constitute it a hurtful feature of the outlet, and that it would be a beneficial change if it were set back in the place which it formerly occupied, in a direction nearly west.

The conclusion is that the proposed training wall along the inner edge should not be built because—

First, it would be too short to effect the purpose designed, of making a breach for the channel across the Middle Sands;

Second, if extended far enough to be effectual, the training wall would consolidate Clatsop Spit in position and extent, and constitute a hurtful impediment to a future improvement of the channel; and,

Third, because the natural causes now at work would succeed in making the desired breaches through the sands, or operate some other convulsion, entirely changing the present condition of the entrance before effectual progress could be made in the construction of the training wall.

The features of the outlet, as they have been and now exist, possess neither fixed position nor outlines, and it would seem to be first necessary, by the construction of a solid work, to force the ever-shifting channels and shoals to assume general characteristics of permanence before a definite solution of the problem of improvement could be effected, or the possibility even of such result be predicated.

If the Middle Sands, for instance, could be consolidated by a detached work across the opening of the river, leaving large intervals at its extremities, viz, for a north channel between its north end and Cape Hancock, and for a south channel between its south end and Point Adams, a considerable advance would be made to bring the problem within the result of such solution as it would admit of. Auxiliary works, as experience might dictate, would possibly be necessary, or submerged jetties might be run out from Cape Hancock and Point Adams, so as to insure a limited scour in a fixed direction, and thus obtain a suitable depth over the bar.

But the changes which appear now to be imminent lead the Board to think that all constructions at this time would be premature, as it is likely that the benefit from natural causes which will follow a change may endure for years.

Moreover, any plan which could be devised might probably interfere with the new courses of the channels supposed about to form, and even be impracticable under the new condition of things.

For the above reasons, the Board consider it unnecessary to submit any plan at this time for the improvement of the mouth of the Columbia.

Respectfully submitted.

Z. B. TOWER,
Colonel Engineers, Bvt. Maj. Gen., U. S. A.
JOHN NEWTON,
Colonel Engineers, Bvt. Maj. Gen.
HENRY L. ABBOT,
Lieutenant-Colonel Engineers, Bvt. Brig. Gen.

Brig. Gen. H. G. WRIGHT,
Chief of Engineers, U. S. A.

To accompany report of Board of Engineers for Fortifications and River and Harbor Improvements of February 12th 1881.

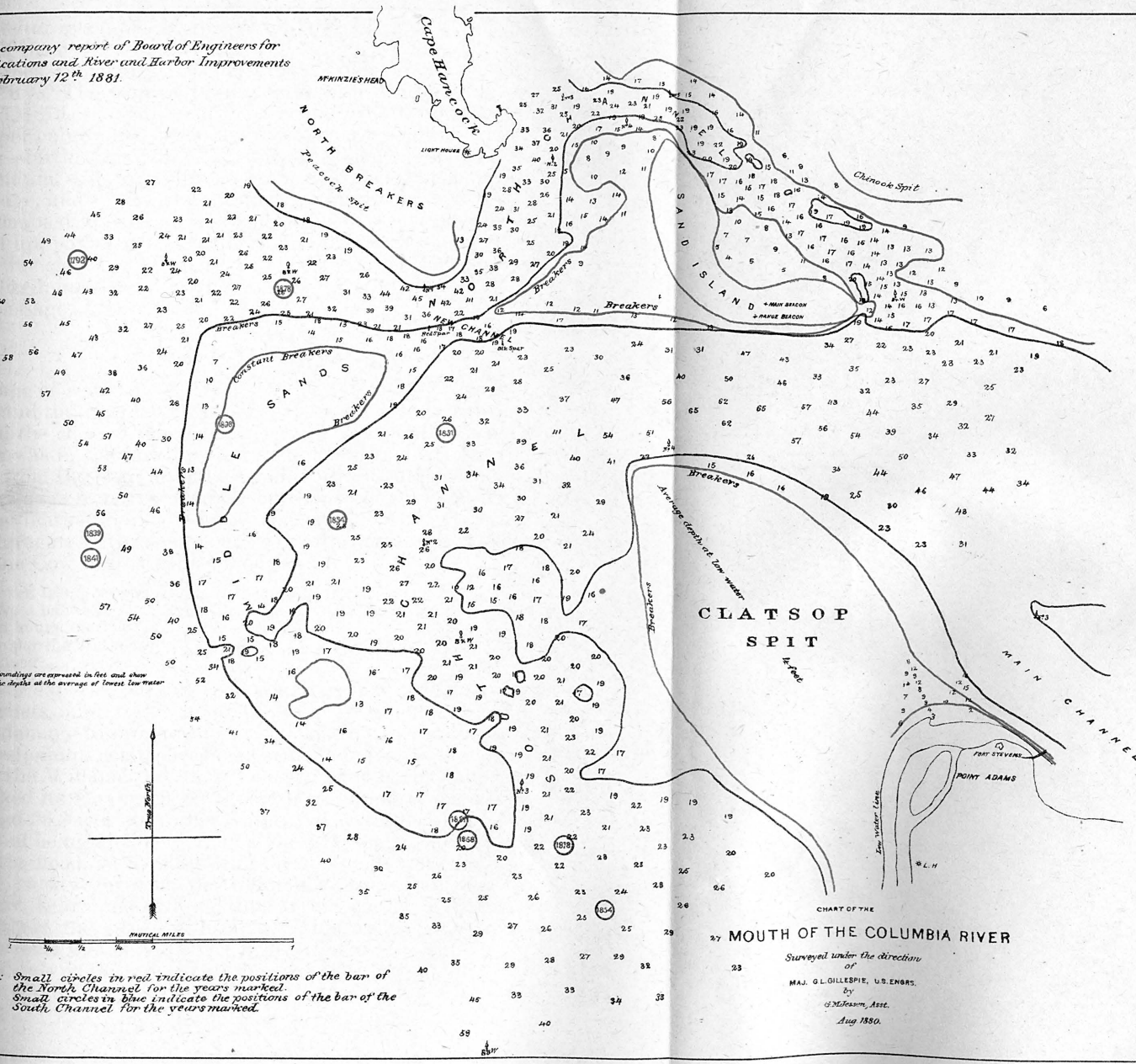


CHART OF THE

MOUTH OF THE COLUMBIA RIVER

Surveyed under the direction of

MAJ. G.L.GILLESPIE, U.S.ENGRS.

by

G.McLeeson, Asst.

Aug 1880.

Note: Small circles in red indicate the positions of the bar of the North Channel for the years marked. Small circles in blue indicate the positions of the bar of the South Channel for the years marked.

O O 2.

IMPROVEMENT OF UPPER WILLAMETTE AND YAMHILL RIVERS, OREGON.

The amount available for the continuance of this improvement at the opening of the fiscal year was $18,373.16, a part of which was under contract for rock removal at Rock Island Rapids a short distance above Oregon City. This contract was made with Mr. Joseph Paquet, September 25, 1879, and called for the removal of 500 cubic yards solid rock at $7.40 per cubic yard. Before the contractor could complete arrangements for starting his work the water rose and remained too high for convenient and safe work until August, at which time it receded to near lowest stage, and the contractor during that month and the one following was enabled to execute his contract. In September his work was measured up, payment was made to him for 496.76 cubic yards, and his contract was closed. All that was expected from the improvement has been realized, and boats find no difficulty even at lowest stage in making the passage of the rapids.

THE SNAG-BOAT.

The stage of water in the river was high during the early part of the summer, and the snag-boat was not sent out till late in July. From that time until the close of the year, except for two months from October 12, when she was in the Cowlitz River, she has patrolled the river uninterruptedly from the head of navigation to the mouth of the Willamette, removing snags from the channel, cutting trees from the banks, and assisting navigation in almost every conceivable way.

The aggregate of the snag-boat's work during the year, excepting that done in the Cowlitz River, is as follows:

Snags removed from channel	1,121
Trees cut from banks	382
Days of ten hours, worked	184
Days lost repairing and moving	65
Miles traversed	2,013½

The river experienced during the winter and spring two very prominent freshets, and three moderate ones. The one which caused the greatest damage to property of every class along the banks and on the lowland adjoining commenced early in January, as the result of heavy snows in the Willamette Valley, followed by long continued warm rains, and reached its maximum on the 16th of January, when the gauge at Salem read 36.3 feet above low-water, the corresponding gauge reading at Portland being 21.5 feet. The highest reading at Portland due to the Willamette flood, occurred during the succeeding freshet in February, when the back-water from the Columbia raised the stage to 23.5 feet, only 2 feet below the street grade at the corner of Stark and Front streets, where the gauge is located. This was a remarkable rise, and the water-level was only 3.8 feet below that due to the Columbia River freshet of July 2, 1880, when all the streets of the city of Portland north of Morrison, and three streets west of the river, were flooded for nearly one week.

BRIDGE ACROSS WILLAMETTE RIVER AT PORTLAND, OREGON.

The January rise in the Willamette occurred at the time when the expediency of permitting the bridge company, organized under the State

legislative act of October 18, 1878, to build a wooden bridge across the Willamette River at Morrison street was under consideration, and enabled me to determine by actual measurement the current velocities in the channel at the highest stage.

The following is the history of the operations of the bridge incorporators under the State act of October 18, 1878, and of the action of this office in relation thereto:

In the early part of October, 1880, the incorporators began the driving of piles in the Willamette River, at Morrison street, for the bridge piers and starlings. The property holders south of the site, represented by Messrs. Hatch and Lownsdale, who felt themselves aggrieved by the construction, and desired to test the right of the incorporators to build without Congressional authority, addressed a communication to this office dated October 9, in which, after stating the character of the bridge which it was proposed to build, they asked for "an inquiry on the part of the proper department of the government into the necessity for and the effect of such an obstruction on the navigation of the river as is contemplated in the proposed bridge and roadway." This letter was forwarded, by indorsement, to the Chief of Engineers, by Lieut. C. F. Powell, Corps of Engineers, in charge of the office in my absence East under orders, and on the 28th October I was instructed by the department to give the matter my attention, and if it was found that the bridge referred to was "being built without authority of law, or under the authority contained in act June 23, 1874 (bridge across Willamette, at Portland, Oregon), and in violation of its provisions, or to the detriment or damage of any navigation interests intrusted by law to the Secretary of War," I was further directed to call the attention of the parties interested to the fact, and to submit a statement of the case to the department for presentation of the whole question to the honorable the Secretary of War for his action thereon. Letters were addressed to the interested parties embodying questions relative to the authority for construction, nature, and location of the bridge, and all other things necessary for a full compliance with the department's instructions, and after carefully considering the question, my views were transmitted to the department in a report dated November 20, 1880, accompanied by several explanatory papers from the bridge company. December 1 the Oregon Railway and Navigation Company addressed a protest against the same construction to the department, which was referred to me for investigation, and on the 29th of December I made a second report to the department more in detail than the first, and again on 17th January, 1881, transmitted a third report, giving the results of current observations along the city front from Ross Island to the gorge at D street during the freshet then prevailing in the Willamette.

January 3, 1881, Messrs. Hatch and Lownsdale filed in the United States court a bill to enjoin the bridge company from constructing the bridge, on the ground that the same was and would be a serious and unlawful obstruction to the navigation of the river. On the 28th of March, the court, Judge M. P. Deady presiding, in an opinion delivered in open court restrained the defendants from construction until the matter could be further heard before the circuit judge at the next term of court. April 11 the question came up for another hearing, Justices Sawyer and Deady presiding, and on the 16th of the same month the previous opinion of Judge Deady was confirmed by Judge Sawyer and the injunction granted. The incorporators then gave bonds and work was indefinitely suspended. The construction of this bridge was a question which so vitally affected the commercial interests of the city, that, in

the language of the opinion rendered by Judge Deady, it is surprising that "any person should have the hardihood to undertake such an important enterprise without first obtaining the sanction of Congress."

I respectfully invite attention to the report of Assistant Engineer R. A. Habersham, on this improvement, which accompanies this report.

The appropriations made for this improvement from March 3, 1871, to March 3, 1881, both inclusive, aggregate	$130,500 00
Of this amount there has been expended to date	121,278 77
Balance	9,221 23

It is expected that this balance will be applied during the fiscal year ending June 30, 1882, in defraying the running expenses of the snag-boat in making surveys of bars, and in payment of contingencies of engineering and office expenses.

The amount which can be profitably expended during the fiscal year ending June 30, 1883, is as follows:

Annual expense of snag-boat, crew, &c	$7,500 00
Repairs to snag-boat	1,000 00
Surveys and contingencies of engineering, &c	2,000 00
Total	10,500 00

This river is in the collection district of Willamette. Portland, Oreg., is the nearest port of entry, and the nearest works of defense are at the mouth of the Columbia River. There are no lights on the river, and the only buoys which are maintained at the expense of the government are on bars below Portland.

The amount of revenue collected at the port of Portland, Oreg., during the eleven months ending May 31, 1881, is $392,891.53.

The commerce of the river is carried, with few exceptions, on boats owned or controlled by the one great transportation company of Oregon, called the Oregon Railway and Navigation Company. This company has for several years owned the locks at Oregon City, and has during the year acquired possession or control of all railroad lines built or proposed to be built, not only in the Willamette Valley, but throughout Oregon, and Washington Territory. It is to the interest of the farmers in the Willamette Valley that the Willamette and Zamhill rivers should be kept open by the use of the snag-boat as a check on the freight rates adopted by the railroad lines. The navigation which is benefited by the improvements embraces 170 miles of the river. The valley is fertile and very productive, and yields abundant quantities of all kinds of cereals.

Abstract of contract, statement of funds, and chart of water-curves are transmitted herewith.

Money statement.

July 1, 1880, amount available	$18,373 16	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$33,373 16
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880		24,151 93
July 1, 1881, amount available		9,221 23
Amount (estimated) required for completion of existing project		38,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		10,500 00

Abstract of contract for the improvement of the Upper Willamette River, in force during part of the fiscal year ending June 30, 1881.

No.	Name and residence of contractor.	Date of contract.	Subject of contract.	Price per cubic yard.	Remarks.
1	Joseph Paquet, East Portland, Oreg.	Sept. 25, 1879	Rock excavation..	$7 40	Contract closed October 1, 1880.

REPORT OF MR. ROBERT A. HABERSHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., June 30, 1881.

COLONEL: I have the honor to submit the following report on the Upper Willamette River for the fiscal year 1880–'81:

STAGES OF WATER.

The profile of water curves herewith submitted shows a long low stage, followed by high floods. The gauge at Salem, which, being just below the river's principal tributary, may be taken as the characteristic station, shows the following turning points:

Above low-water:	Feet.
July 1, 1880	8.7
July 31, 1880	2.4
October 24, 1880	0.2
November 3, 1880	3.8
November 30, 1880	0.7
December 13, 1880	13.2
December 24, 1880	3.3
December 31, 1880	17.7
January 9, 1881	6.6
January 16, 1881	36.3
January 28, 1881	7.8
February 5, 1881	31.6
February 25, 1881	8.7
March 2, 1881	22.3
March 21, 1881	4.2
June 4, 1881	2.3
June 15, 1881	8.0
June 30, 1881	2.9

Except during the winter of 1861–'62, when the river rose at Salem 3 feet, and at Portland 1.5 feet higher than in January last, the high stage which prevailed through the winter and spring has had no parallel since the settlement of Oregon. A succession of heavy snows and warm rains sent flood after flood down the Willamette, inundating the flats, destroying dwellings and other improvements, and fields of winter wheat, carrying away a number of railway and county bridges, washing out miles of newly built railroad embankments, interrupting traffic and travel for several weeks. The principal cause of the destruction of the bridges was the drift which had been accumulating on the river bottoms above the level reached by ordinary winter freshets for nineteen years, augmented by a large number of trees from 100 to 200 feet long, which had been uprooted by the tornado of January 9, 1880. These trees, lodging against the piers, formed in a few hours rafts extending from bank to bank, filling the trough of the river for several hundred yards up stream, damming the water, which rose rapidly, in some cases from 8 to 10 feet above the height due to its volume, until, yielding to the enormous pressure, the mass moved down stream sweeping everything before it. In some cases, especially on the Santiam, where the bridge foundations had not been completely protected before the flood came, the concentration of the current under the rafts undermined the piers, causing the bridges to fall up stream. For several days the river was filled with floating islands, composed of drift and the timbers of broken bridges. The locks at Oregon City were closed for several weeks, and navigation above that point suspended in consequence. The steamer Willamette Chief, which was fortunately above the locks at the time, went to the rescue of the farmers on the river flats, steaming over the flooded bottoms to their houses, collecting families with their effects and live stock and transferring them to places of safety. The timely aid thus rendered saved the sole possessions, and not improbably the lives, of many poor people.

The operations for the maintenance and improvement of the channel consisted in the removal of portions of several rocks from the vicinity of Rock Island, 16 miles above Portland, and in the ordinary work of the snag-boat, removing snags and drift, cutting overhanging trees from the banks, repairing injuries to wing-dams, scraping shoal bars, straightening crooked channels across the gravel bars, &c.

The rock excavation was done by Joseph Paquet, under his contract dated September, 1879, but, owing to continued high-water, not executed until August and September, 1880. This contract provided for blasting and removing from the channel 500 cubic yards, more or less, of rock at $7.40 per cubic yard.

The work done was distributed as follows:

	Cubic yards.
From rock No. 1	135.13
From rock No. 2	199.47
From rock No. 3	0.47
From tangent rock	161.69
Total	496.76

The rocks blasted are shown on the general chart of Rock Island Rapid heretofore submitted. The first three named were excavated to 2 feet and the last to 4 feet below mean low-water mark. Buoys were placed to mark the channel as altered, and at Tualatin Rocks, a mile below Rock Island. There is now certainly no danger in navigating this portion of the river.

THE SNAG-BOAT.

Cool weather, by causing the snow in the Cascade range to melt slowly, kept the river up so long that the snag-boat was not sent out until late in July. On the 26th of that month it was ordered to Booneville Chute, 6 miles above Corvallis, and begun work there August 1. From that time it was occupied patrolling the river between the head of Centennial Chute and Oregon City, an extent of 112 miles, until October 18, when, the channel having been thoroughly cleared, it was sent to Cowlitz River, Washington Territory. The report of operations on this river has been submitted. Having finished work on the Cowlitz the boat returned to the Willamette December 17, and spent two weeks removing snags from the mouth of the river up to Portland. On the 29th she returned to the upper river, and, beginning at Oregon City, ascended to Centennial Chute, clearing out the drift which had been brought down by the recent flood. The first freshet in January deposited rafts of drift on the dike then building at Coon Island and the dam at Willamette Slough, composed principally of trees so large that all attempts to remove them with a river steamboat failed. The snag-boat was therefore ordered down for this purpose, and, the drift continuing to accumulate on the dike, obstructing the work, and the upper river being too high to permit snag pulling, it was retained on the lower river, where it rendered valuable service; among other, that of clearing the Willamette Slough throughout its length of bad snags, until March 18, when, the upper river having fallen to 5 feet above low-water, disclosing many new obstructions brought down by the recent freshets, it was ordered back. On the 18th of April, the boat requiring repairs, principally to the hull and derrick, both of which had suffered considerably during the rough work of the last winter, was brought down to Oregon City and placed in the dry-dock belonging to the Oregon Railway and Navigation Company, which had been kindly placed at the disposal of this office. New timbers were put into the hull where needed, the forward rake rebuilt, the derrick repaired, and the hull recalked and painted. At the same time such portions of her appliances as were found to be unserviceable were condemned and replaced by new. May 3 the boat was in good working order again and returned to her work up the river. It was found necessary at this time to pull out a portion of the wing-dam at Lone Tree Bar built, in 1873, through which a breach 100 feet wide had been made by the freshet of January last, diverting the greater part of the low-water volume from the boat channel and shoaling the bar below to the extent of making passage there impossible, forcing steamboats to pass through the dam.

As has been shown in former reports, the peculiar shape of the river bed here makes the maintenance of a sufficient channel on the track heretofore followed extremely difficult and expensive; and as the breach in the dam furnished a fair channel, although somewhat narrow for easy passage, it was thought best to widen it by removing 100 feet of the old dam on the lower side of the breach, which was accordingly done. From that time to the close of the fiscal year the boat has been employed, moving from place to place as required, above Yamhill Bar, extending its operations as far as Harrisburg, 149 miles above Portland.

The aggregate of the snag-boat's work during the year is—

On the Upper Willamette:

Number of snags removed	1,021
Number of trees cut from the banks	374

And on the Lower Willamette:

Number of snags removed	100
Number of trees cut from the banks	8
Total snags removed from channel	1,121
Total trees cut from banks	382
Total days of 10 hours worked	184
Total days lost repairing and moving	65
Total miles traversed	2,013¼

exclusive of the operations on Cowlitz River. This is the best year's work yet recorded for the boat, and reflects credit on the energy and industry of the master.

Navigation on the upper river has been carried on actively throughout the year, except during very low-water, when boats did not run regularly above Salem, although trips to Corvallis and intermediate points were made when necessities of traffic demanded. During the winter frequent trips were made to Harrisburg. The completion of the western division of the Oregon and California Railroad has relieved the population of that portion of the valley from absolute dependence on river transportation.

The snag-boat will be kept very busy during the rest of the season, as the bed of the river is still full of drift, and more is constantly coming in, from the caving of the banks during last winter's high-water.

Respectfully submitted.

ROBT. A. HABERSHAM,
Assistant Engineer.

Col. G. L. GILLESPIE,
Major of Engineers, U. S. A.

OO 3.

IMPROVEMENT OF THE UPPER COLUMBIA AND SNAKE RIVERS, OREGON AND WASHINGTON TERRITORY.

At the beginning of the fiscal year the amount available for continuing the work of improvement of the several rapids in the two rivers begun in 1872 was $31,505.18, of which sum $16,505.18 remained to be expended under the contract with Mr. George J. Ainsworth, dated September 25, 1879.

During July and August the rivers were too high to admit of any work, but in September the contractor under instructions from this office transferred his plant to Texas Rapids, Snake River, and began work on the 12th of that month. By the terms of the original articles of agreement this contract should have terminated October 15, but believing that Mr. Ainsworth had not wasted any time and that his contract price was reasonable, I felt authorized in recommending that the contract be extended one month. This extension was granted by department telegram of August 28. September, October, and November were very favorable months for operations; the contractor worked diligently and faithfully with a large, well-selected force, and on the 15th of November had completed his contract. After the contractor had removed his plant, a careful and minute survey was made, and it was found that at Monumental and Homly rapids the contractor had reduced the rocks so as to give full 4½ feet in the channel at low stage; as the usual draught of the boats navigating this river does not exceed 30 to 33 inches, this grade was deemed ample and was accepted. At Texas Rapids, ten of the designated rocks had been removed to the depth of 4½ feet extreme low-water,

corresponding to 5½ feet at ordinary low stage, but at Eddy Rock, No. 10 of the chart, on the north side of the ripple called Upper Bucking Place, and near the lower end of the rapids, it was discovered that owing either to an oversight on the part of the contractor's superintendent or to the exhaustion of the powder, the top surface of the rock had not been reduced in many places below the level of 3 feet lowest stage. The plan called for 1 foot more over the entire rock. The season was late and the weather was severely cold, rendering it impossible to get additional powder from Walla Walla, and in consequence no further work could be done. A careful and minute survey of all work done showed that the contractor had removed under his contract 1,036 cubic yards of solid rock after the reduction of the points named to the required grade.

The projecting points have not yet been removed. The contractor has been paid for 900 cubic yards, and the remaining amount due him, including retained percentage, will not be paid until he has fully complied with the terms of his contract. It has been endeavored, in the execution of this contract, to distribute the work over the entire length of the rapid, removing first those rocks which have heretofore caused the steamboats to keep out in the swift water away from the natural channel. Rock No. 1, at the head, was a large one, and has been entirely removed. The nest of eight rocks in the central section was a great obstruction, not by increasing the currents particularly, but by dividing an otherwise wide channel into a number of small ones, each too narrow and too dangerous for descending boats. The Eddy Rock, No. 10, was the most important one in the whole rapid. It lay directly in the channel, which ascending boats would naturally take in order to get the benefit of the eddies created by the group of rocks just above, called Roll Rock, thereby forcing them to stem the current at its swiftest point. Its removal has greatly lessened the time of passage by ascending boats.

The improvement may well be extended by widening the channel at the point called "Lower Bucking Place." There are no rocks in the navigable channel. The trouble arises simply from the swiftness of the current, which may be lessened by giving the channel a greater cross-section.

After public advertisement in the usual way, sealed proposals for continuing the improvement, under the act of June 14, 1880, appropriating $15,000, were opened in this office September 20, 1880; and with the approval of the department a contract was made November 15 with Mr. J. B. Montgomery, Portland, Oreg., for removing 100 cubic yards solid rock from the Columbia River, at Umatilla Rapids, at $25 per cubic yard, and 650 cubic yards solid rock from the Snake River at Texas, Palouse, and False Palouse Rapids, at $17 per cubic yard. Quantities at the designated places to be determined by the engineer in charge.

The contract contained the proviso that the officer in charge had the reserved right of wholly omitting the improvement of Umatilla Rapids. The proviso was inserted for the reason that it might appear from a detailed survey of those Snake River Rapids, which had never been improved, that the navigation of the two rivers would be more benefitted, at lowest stage, by expending all the appropriation in the Snake River. At the time the contract was made the plant of the contractor, which had been hastily improvised out of material, engines, and steam drills on hand, was at Ainsworth, at the mouth of the Snake River. After receiving instructions to begin at Palouse Rapids, he promised to start at once for the site, and to be ready to enter upon his work

within twenty days. As the season was getting late, it was expected that he would charter a river boat to assist him in getting his plant up the river. Instead of this he relied upon the individual efforts of the crew, which, in a river with such a swift current, proved in the end more expensive than if he had paid towage to a river boat; and besides he was so delayed in his movements that he did not reach Palouse until the first week in December, at which time the weather was bitterly cold. Snow lay upon the ground several inches in thickness, and the river was jammed with ice at many points. The river at Palouse Rapids is 260 feet wide from bank to bank at low stage, and the bed of the stream is filled with large masses of solid rock of such sizes and so located that there are different channels over and past them at different stages of water. At lowest stage the channel is directly through the center, where the width barely exceeds 56 feet, and the current exceedingly swift and turbulent. At 10-foot stage the channel passes to the north side with a group of many small rocks to render it of difficult and dangerous navigation; and for the higher stages the channel is on the south side, where it is entirely obstructed, the swift current constituting the only difficulty.

The contractor was not ready to begin operations till January. The ice had then lodged in large masses, forming a jam over the high walls of the central channel, and the water had backed up and risen several feet. The orders for the conduct of the work required him to work at low stage in the central channel, then only 56 feet wide, and to increase the width 33 feet by cutting the north wall down to 5 feet below low-water for a length of 154 feet and width of 16 feet, and the south wall for a distance of 212 feet and width of 17 feet. When the water rose to 10 feet his plant was required to go into the north channel and cut out to the general depth of the bed of the stream at that point all the group of rocks marked three. His work, therefore, in accordance with these instructions, began in the north channel and was continued, with many interrruptions and under many trials, during the greater part of January. On the night of the 9th of February the river suddenly rose to 20 feet in the gauge, and the contractor's scows containing his drill, implements, tools, &c., and which had been carelessly left at anchor over night, were dragged from their moorings by floating drift and totally wrecked. Since that time the stage has been too high for economical work, and the contractor has not resumed operations. Bad management and want of judgment on the part of the contractor were the cause of the loss of the plant and the delay in the execution of the contract. He gave me his pledge that the superintendent placed in charge should be a competent and skillful man, well known to this office, and that he would be on the grounds in time to do good work before the extreme cold weather came in. Instead of this, he sent up an inexperienced man as foreman, who did not reach the rapids until it was too late to do any effective work.

He promises now to have everything in readiness for a vigorous prosecution of the work just as soon as the next freshet recedes, and to complete his contract before the date given in his contract.

Texas Rapid has now a free channel, nowhere less than 60 feet wide, with 5½ feet depth at extreme low stage. The current, however, is very swift, and the future improvement should have for its object the reduction of the slope by widening the cross-section in the central section and at the lower bucking-place. This will require the removal for present purposes of 500 cubic yards of solid rock.

The improvement made at Umatilla during the year was very limited,

but as it is now universally conceded to be the most rapid, either in the Snake or Columbia River, it would be well to concentrate a large proportion of the next appropriation upon it. As was said in the last annual report, the most important objection to the use of the improved governmental channel arises from the swiftness of the current through it and the narrow width at the upper entrance. It is easy to correct the latter, but the former gives more trouble. At low stage the two channels should be so improved that the old channel can be conveniently and safely used by ascending boats and the governmental channel by descending boats. The improvement in the old channel which seems proper to be made to effect the plan proposed will include the removal of rock, thirty-five in the upper pool, and the widening of the entrance on the upper side by cutting off Roll Rock on the south side and Black Rock on the north side, each for a width of 50 feet. The government channel can be greatly improved for descending boats at low stage by widening the entrace on the upper side to give a full and unobstructed width at the throat of 100 feet, and cutting the south wall back for 30 or 40 feet, so that boats can get well in on that side before making the entrance.

The channel at Homly Rapids was worked slightly down stream during the year, and at low stage the bowlders between Gravel Island and Sand Island, mentioned in last year's report, are now a great obstruction and should be removed. They will aggregate probably 200 cubic yards. The three rapids then which most require immediate improvement are Texas Rapids in the Snake, and Homly and Umatilla rapids in the Columbia, and the amount of solid rock which can be profitably removed in the interest of the navigation of the streams will aggregate 1,000 cubic yards. The railroad constructions mentioned in last report have been vigorously pushed during the year.

The Northern Pacific Railroad with its western terminus at Ainsworth has now been extended nearly to Spokane Falls, a distance of 150 miles, with a westward connection in operation from Ainsworth to Wallula.

The Oregon Railway and Navigation Company has a standard gauge line in operation from the Dalles to Walla Walla, and a large working force is upon the section between the Dalles and the lower cascades with the prospect of opening this section to travel by the close of the calendar year. Extensions of the main line are being graded from Walla Walla into the Palouse country with a railroad bridge across the Snake near Grange City, and from Umatilla via Pendleton to Baker City, where connection will be made with the Union Pacific Railroad extension from Granger.

These connections will necessarily by their disbursements add much to the wealth and growth of the sections penetrated, and the facilities for travel will induce the immigration of large numbers of agriculturists from the east who have only been deterred heretofore from coming to the rich lands of Eastern Oregon by the long overland journey, or the no less disagreeable passage by sea. The greater the population the more important become the navigable rivers as corrections to excessive transportation rates. This fact causes me to urge the appropriation of $20,000 for continuing the improvement of the upper rivers.

In compliance with act of June 23, 1866, I respectfully state that—

The amounts appropriated for this work from act of June 10, 1872, to act of June 14, 1880, both inclusive, were	$175,000 00
By act approved March 3, 1881	15,000 00
Were appropriated, making the total appropriations to date	190,000 00

Of this amount $158,774.70 have been expended to date.

These rivers are in the collection district of the Willamette. Portland, Oreg., is the nearest port of entry. The nearest light-houses and works of defense are at the mouth of the Columbia River, but troops garrison the posts of Walla Walla, Lapwai, Colville, and Spokane Falls.

The amount of revenue collected at Portland during the eleven months ending May 31, 1881, was	$392,891 53
Value of imports	566,021 00
Value of exports	2,701,003 00
Foreign vessels entering from foreign countries	58
With an aggregate tonnage of	40,113
Foreign vessels clearing for foreign countries	54
With an aggregate tonnage of	44,338
American vessels entering from foreign countries	10
With an aggregate tonnage of	8,238
American vessels clearing for foreign countries	25
With an aggregate tonnage of	22,857
Coastwise vessels entering	135
With an aggregate tonnage of	219,910
Coastwise vessels clearing	89
With an aggregate tonnage of	181,333

It is impossible to state the amount of commerce which will be benefited by the continuance of this improvement, but it will be greatly in excess of that of former years when it was more difficult for the farmers to reach the sea ports with the products of their labor.

Abstracts of proposals and contract, a statement of funds, and charts of Texas and Palouse Rapids, Snake River, accompany this report. It is requested that the charts be printed.

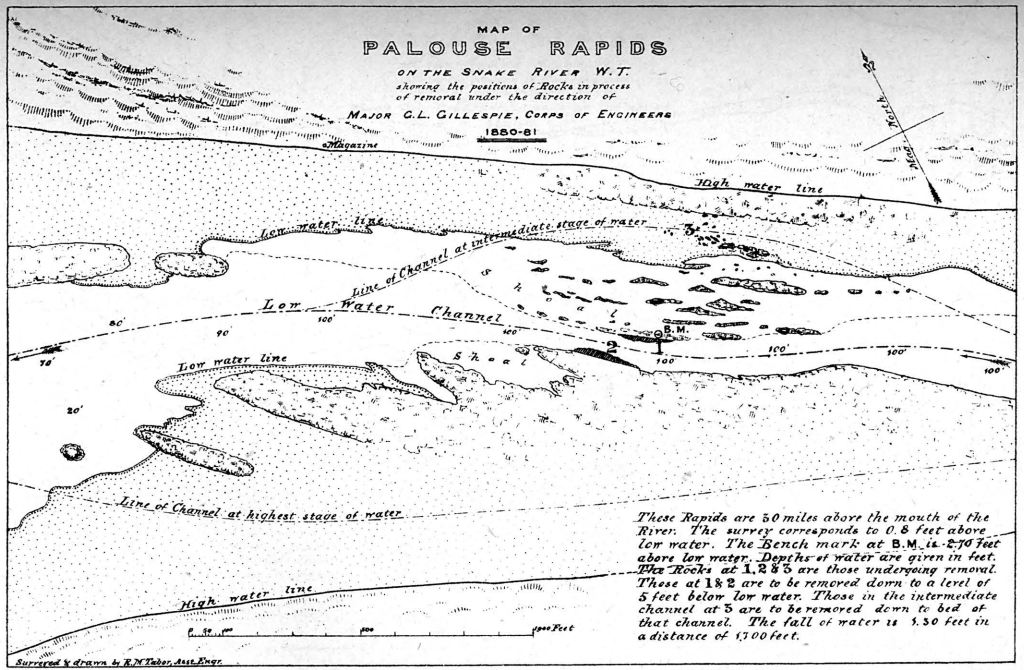
This improvement has been under the immediate charge of Assistant Engineer R. M. Tabor, to whom I am indebted for a faithful and intelligent discharge of the duties confided to him.

Money statement.

July 1, 1880, amount available	$31,955 18	
Amount appropriated by act approved March 3, 1881	15,000 00	
		$46,955 18
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	13,819 86	
July 1, 1881, outstanding liabilities	1,710 00	
		15,529 86
July 1, 1881, amount available		31,425 32
Amount (estimated) required for completion of existing project		62,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1883		20,000 00

Abstract of proposals for removing solid rock in the Upper Columbia and Snake rivers, opened by Maj. G. L. Gillespie, Corps of Engineers, September 20, 1880.

Number.	Names and residences of bidders.	Removal of solid rock.		Total.	Remarks.
		Cubic yards.	Price per cubic yard.		
1	George J. Ainsworth, Portland, Oreg..	1,000	$25 00	$25.000 00	
2	J. B. Montgomery, Portland, Oreg.....	200	25 00	18,600 00	Contract awarded.
		800	17 00		



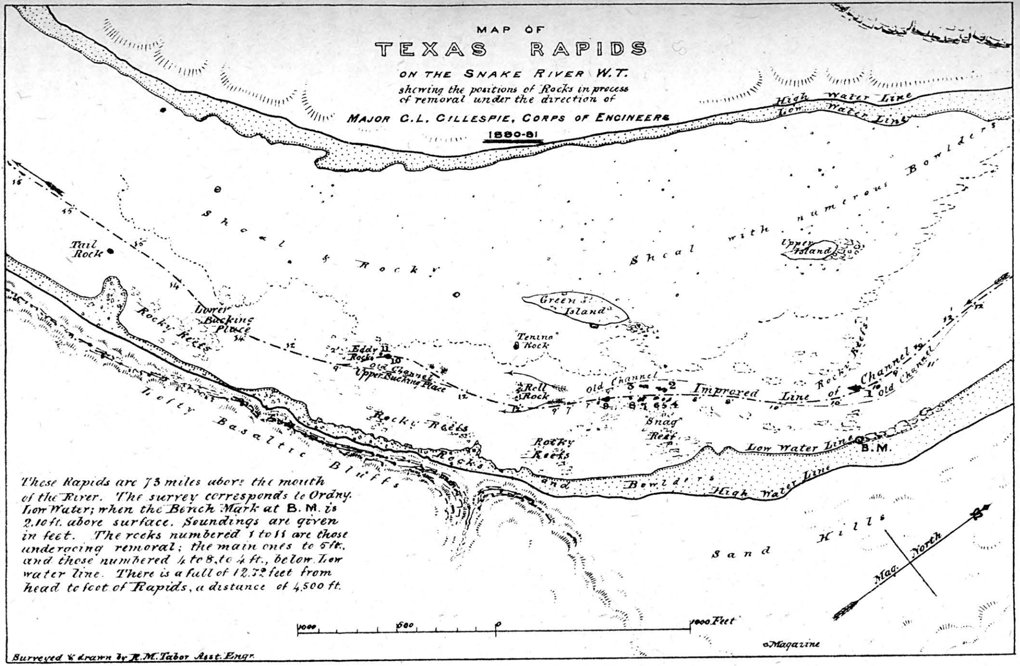
These Rapids are 30 miles above the mouth of the River. The survey corresponds to 0.8 feet above low water. The Bench mark at B.M. is 2.70 feet above low water. Depths of water are given in feet. The Rocks at 1, 2 & 5 are those undergoing removal. Those at 1 & 2 are to be removed down to a level of 5 feet below low water. Those in the intermediate channel at 5 are to be removed down to bed of that channel. The fall of water is 1.30 feet in a distance of 1,100 feet.

U.S. ENGINEER OFFICE, PORTLAND, OREGON

To accompany annual Report June 30th 1881

G. L. Gillespie

Major of Engineers Brt. Lt. Col. U.S.A.



U.S. ENGINEER OFFICE, PORTLAND, OREGON.

To accompany annual Report June 30th 1881.

G. L. Gillespie

Major of Engineers, Brt. Lt. Col. U.S.A.

Abstract of contracts for improving the Upper Columbia and Snake rivers, in force during the fiscal year ending June 30, 1881.

No.	Names and residences of contractors.	Date of contract.	Subject of contract, removal of rock.	Price per cubic yard.	Remarks.
1	George J. Ainsworth, Portland, Oreg.	Sept. 25, 1879	1,600 cubic yards .	$18 00	Contract expires November 15, 1880.
2	J. B. Montgomery, Portland, Oreg.	Nov. 15, 1880	100 cubic yards ..	25 00	Contract expires December 31, 1881.
			650 cubic yards ..	17 00	

O O 4.

CONSTRUCTION OF CANAL AROUND THE CASCADES OF THE COLUMBIA RIVER, OREGON.

At the opening of the fiscal year the amount available for continuing the improvement was $117,116.60. The water in the Columbia River was in freshet at the time and reached its highest stage on the 3d of July, when the gauge at the head of the canal read 137.9 or 41.9 feet above low-water.

The freshet of 1876 which did so much damage all along the Columbia, and in the city of Portland, had a highest gauge reading of 139.4 or 1.5 feet above that of 1880. Notwithstanding the high stage of water and the newness of the embankment protecting the canal excavation, the work sustained no damage from the floods. The water began to recede on the 4th of July, and by the 15th had fallen 5.5 feet, and as the canal bottom became uncovered, there being no caisson at the lower end, working parties for excavation commenced operations at station 7, and followed the receding waters to station 26.

The report of the Board of Engineers dated August 19, 1879, which recommended the low-water system in connection with the river improvement called for detailed surveys of the river at low stage from the canal site to the foot of Bradford's Island with observations for river phenomena. These surveys, which were in progress at the date of the last annual report, were completed in August, and were submitted to the Board of Engineers convened for their consideration November 10, 1880.

Before the deliberations of the Board began, a practical test of the navigation of the river at a 7-foot stage, gauge No. 2, was made by taking the members of the Board from the lower landing of the Oregon Railway and Navigation Company to the site of the locks, by the "Willamette Chief," a staunch steamboat of good power, draught 2½ feet, which runs habitually in the Upper Willamette River, but neither so large nor so powerful as the regular boats on the line of the Middle Columbia.

The time of passage from the foot of Bradford's Island, to the foot of the Main Rapids, a distance of 4 miles of the river which embraces the worst reefs, was thirty minutes. The descent over the same distance was made in 9 minutes. The Board confirmed in general, in its report of November 12, the conclusions reached by the previous Board, as to the proper method of conducting the improvement, and recommended that there should be but a single lock at the foot of the Cascades Canal to accommodate the low-water system of improvement. The arrangement of this lock with its adjacent guard gates, and the guard gate at the head is fully described by the following extract from their report:

Its capacity should be 462 by 90 feet, to accommodate one tow-boat and three barges. It should have a lift of about 24 feet. The clear gate openings should be reduced to 70 feet, so as to diminish the weight of the gates. It should be provided with a guard

gate at its head and foot, so that it may readily be pumped out in case of needed repairs, or vessels being wrecked in it.

There should be a guard gate at the head of the canal, the top of which should be at least 2 feet higher than the highest water. In case the high-water system is hereafter introduced, this guard gate will form the upper gates of a lift and guard lock which must then be constructed at the head of the canal.

The prism of the canal should be 90 feet wide at bottom. The sides should be carried up vertically to within 1 foot of low-water by strong timber cribs filled with stone and then to a height of 11 feet by a dry stone wall.

Here there should be a berm at least 15 feet wide, and then there should be a paved slope of 1 upon 1, leading up to the top of the canal embankment, which should be on a level with the top of the guard gate at the head of the canal.

The following is a summary of the recommendations of the Board:

1st. Improvement of the river with a single lock near the foot of the main rapids for navigation up to 20 feet above low-water, gauge No. 2, and a guard gate at head of canal to exclude high-water.

2d. Should it be found that this method of improvement will not give the desired navigation up to a stage of 20 feet, gauge No. 2, at an admissible cost, the next step would be the construction of a lock behind Bradford's Island, and a dam across the the river from the island to the right bank.

The Board remark in conclusion that the construction of these works will admit of this easy adaptation to an all-the-year-round navigation, should it be required in future. It would necessitate the construction of a guard lock at the upper end of the canal, involving but an additional set of gates.

The approval by the honorable the Secretary of War of the recommendations of the Board of Engineers was communicated to the officer in charge by department letter of December 22, 1880, and measures were taken at once for the execution of the adopted plans. The several abnormal winter freshets which took place in the Columbia River have prevented any work of river improvement to date; and the only steps taken so far have been limited to public advertisement calling for sealed proposals for the removal of 10,000 cubic yards of solid rock and bowlders, to be opened August 6; and to circular letters to resident manufacturers, for the building of the tow-boat which is to tend the drill scows.

It is proposed also to prepare, during the summer, a complete plant for conducting the river improvement, to enable the government to control the prices bid, or to take advantage of all the low-water season in case the proposals presented are exorbitant.

Owing to the absence of a bulkhead at the lower end of the canal, at the opening of the low-water season, to keep out back water, and to the many unusual rises of the river during the winter, the work of excavation of the canal prism has been slow and irregular. Commencing at Station 7, it has been carried to an average depth of 8 feet above grade for a width of 50 feet with side slopes of 1 on 1, and the lock pits to a depth of 16 feet above bottom for a width of 125 feet.

From Station 6 to Station 20, the canal prism is protected against high-water by an embankment made out of the spoils of excavation, with a puddle core in the center. The reference at the top is 2 to 3 feet above that of the highest water in 1876.

From Station 20 to 28 the embankment has been prolonged by a dry stone-wall, with a concrete hearting carried to bed-rock, in order to contract as little as possible the water-way at the lower end of the canal. This wall from Station 20 to Station 25 + 18 is stepped down on the top from reference 134 to reference 126.

The reference of the top of the concrete core is likewise stepped down, from reference 119 to reference 117.6.

In the trench from Station 26 + 60 to Station 27 + 80, concrete has been laid to the surface of the ground and a low section of wall erected above

it. Between Station 25 + 40 and Station 26 + 60, the trench is excavated to a depth of 20 feet; it had to be abandoned on account of the rising river, but was previously covered with timber weighted with stone to prevent its filling with sand and deposit material during high stage.

At Station 28 the canal has been closed by a timber bulkhead ballasted with stone, which extends to the right one-half the distance between the concrete core of the dry stone protective wall and the lock-pit. It is 158 feet long, top measurement, 10 feet wide, and has been carried to reference 94, or 20.6 feet above low-water. It is built of 12-inch square timber. The side timbers are laid close and connected at intervals of 10 feet between center by open walls of cross-ties, dovetailed at the ends. There is an intermediate tie on the bottom course, and a middle longitudinal course carried to reference 83.

The reference of the lowest course is 71, and the average reference of the foundation course is 76. The bottom course is laid in cement and bolted to the rock underneath; the sides are covered to a height of 2 feet with a concrete backing 8 inches thick. The upper courses are bolted and pinned, and the joints of the lower face are caulked with oakum and pitched. A small framed timber dam is also placed across the canal at Station 18 + 75 to completely inclose the lock site; the water collecting in the prism above the dam will be pumped into a flume and conveyed into the river beyond the lower bulkhead, or will flow over a weir directly into the flume.

The outer abutment of the right wing wall of the lock has been built to a proper union with the embankment and dry stone wall, and its face has been stepped for an easy continuation of the wall to the lock chamber. Its top reference has been carried to reference 128½.

The surface of the rocky point exterior to the embankment on the north side which was covered with large masses of conglomerate bowlders, has been greatly reduced, by blasting, to correct the currents over it, to let the water out more freely at the higher stages, and to give a more direct flow to the currents after the water has passed the main rapids.

The left bank of the river below the canal has been much changed during the year by extensive land slides, aggravated to a certain extent by the building of a railroad near and along its crest. To give a limited protection to the road-bed against these slides, the company has in places put in large masses of riprapping. Where the road runs behind the government land purchased for improvement, I have prevented any stone being piled which might, in the process of construction of an artificial channel at the foot of the slope, be required to be removed, but after passing the government line, this protective construction has been liberally used and may interfere materially with the execution of a plan which has for its object the construction of an artificial channel to connect the terminus of the breakwater in the original project with Bradford's Island.

The use of the bank for railroad purposes will always keep the slopes in a state of change and degradation. The soil is very unstable, and the constant sliding to which it is subject from natural causes will assuredly carry all temporary surface protections, which are disconnected in their construction, eventually into the river. It might be possible, if the railway were located some distance back from the crest of the bank, to place on the lower slopes some means of protection which would in a certain degree restrict the evil tendencies of the slides; but with the railway directly along the crest, the vibrations due to frequent passings

of the cars will certainly result in continual and unremitting degradation of the slopes.

I respectfully invite attention to the carefully prepared report of Capt. Charles F. Powell, Corps of Engineers, in local charge, which gives a concise statement of the details of construction during the year.

By act of March 3, 1881, the sum of $100,000 was appropriated for continuing the improvement, which will be applied in the purchase and manufacture of plant for conducting the river improvement, and in the probable removal of ten or more thousand cubic yards of rock and bowlders from the Big Eddy and Middle Block House Rapids.

The appropriations for this work have been as follows:

From act August 14, 1876, to act June 14, 1880, both inclusive	$440,000 00
Act March 3, 1881	100,000 00
Total amount appropriated	540,000 00

The estimated cost of the existing project is $1,290,666.92.

The sum of $750,000 can be profitably expended during the next fiscal year in continuing the excavation of the canal; the building of the protective wall and embankment; the building of part of the masonry of the locks; and in continuing the river improvement.

There is transmitted a chart of water-curves at the several gauges.

COMMERCIAL STATISTICS.

The Cascades of the Columbia River are in the collection district of the Willamette. The nearest port of entry is Portland, Oreg., 65 miles distant; the nearest light-houses and works of defense are at the mouth of the Columbia about 160 miles distant.

The amount of revenue collected at the port of Portland, Oreg., from July 1, 1880 to May 31, 1881, was	$392,891 53
Value of imports from foreign countries	566,021 00
Value of exports to foreign countries	2,701,003 00

	Tonnage.
Number of foreign vessels entered from foreign countries, 58	40,113
Number of American vessels entered from foreign countries, 10	8,238
Number of foreign vessels cleared to foreign countries, 54	44,338
Number of American vessels cleared to foreign countries, 25	22,857
Number of coastwise entrances, 135	319,910
Number of coastwise clearances, 89	181,333

By the construction of the Cascades Canal, free navigation of the Columbia River will be opened to the Dalles, a distance of 230 miles, approximately, above its mouth.

No official statement of the tonnage which has passed the portage during the year has been obtainable from the company which does the carrying trade, but the railroad constructions beyond the Cascades have been so great that it is probable the tonnage has increased to over 200,000 tons. Every one who has given this improvement careful consideration feels that the passage of the Cascades by a canal and an improved river will be of inestimable benefit to the entire country embracing the headwaters of the Columbia, and the Snake and their several tributaries. The head of navigation should be extended to the Dalles on the border of that most productive area from which so much is expected in the near future, so that the producers may find themselves independent of any one corporation which may attempt to control freight rates up and down the river by a fixed occupancy of the portage at the Cascades against all rivals. The improvement will in time extend to the passage of the Dalles portage, but before this is accomplished in its entirety the country must have a great increase in its population and wealth.

of the cars will certainly result in continual and unremitting degradation of the slopes.

I respectfully invite attention to the carefully prepared report of Capt. Charles F. Powell, Corps of Engineers, in local charge, which gives a concise statement of the details of construction during the year.

By act of March 3, 1881, the sum of $100,000 was appropriated for continuing the improvement, which will be applied in the purchase and manufacture of plant for conducting the river improvement, and in the probable removal of ten or more thousand cubic yards of rock and bowlders from the Big Eddy and Middle Block House Rapids.

The appropriations for this work have been as follows:

From act August 14, 1876, to act June 14, 1880, both inclusive	$440,000 00
Act March 3, 1881	100,000 00
Total amount appropriated	540,000 00

The estimated cost of the existing project is $1,290,666.92.

The sum of $750,000 can be profitably expended during the next fiscal year in continuing the excavation of the canal; the building of the protective wall and embankment; the building of part of the masonry of the locks; and in continuing the river improvement.

There is transmitted a chart of water-curves at the several gauges.

COMMERCIAL STATISTICS.

The Cascades of the Columbia River are in the collection district of the Willamette. The nearest port of entry is Portland, Oreg., 65 miles distant; the nearest light-houses and works of defense are at the mouth of the Columbia about 160 miles distant.

The amount of revenue collected at the port of Portland, Oreg., from July 1, 1880 to May 31, 1881, was	$392,891 53
Value of imports from foreign countries	566,021 00
Value of exports to foreign countries	2,701,003 00

	Tonnage.
Number of foreign vessels entered from foreign countries, 58	40,113
Number of American vessels entered from foreign countries, 10	8,238
Number of foreign vessels cleared to foreign countries, 54	44,338
Number of American vessels cleared to foreign countries, 25	22,857
Number of coastwise entrances, 135	319,910
Number of coastwise clearances, 89	181,333

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Money statement.

July 1, 1880, amount available	$117,116 60	
Amount appropriated by act approved March 3, 1881	100,000 00	
		$217,116 60
July 1, 1881, amount expended during fiscal year, exclusive of outstanding liabilities July 1, 1880	75,990 55	
July 1, 1881, outstanding liabilities	7,278 88	
		83,269 43
July 1, 1881, amount available		133,847 17
Amount (estimated) required for completion of existing project		1,224,337 70
Amount that can be profitably expended in fiscal year ending June 30, 1883		750,000 00

REPORT OF CAPTAIN CHARLES F. POWELL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Portland, Oreg., June 30, 1881.

COLONEL: I have the honor to submit the following report of operations upon the construction of the Cascades Canal for the year ending this date:

The great flood of 1880 did not reach a higher stage than that occurring on June 30, as noted in the last annual report. The river remained at a threatening stand-still until July 4. Work in strengthening the canal embankment was suspended a few days thereafter, when it became certain that a further rise was improbable.

The protective embankment, made with haste, incomplete and new, was tested by a river stage of 42 feet, measured at the head of the canal; this stage is only 1.5 feet below the highest one known to white inhabitants on the Columbia.

While we have not ceased to congratulate ourselves on the beneficial result in the protection of the canal prism, the floating property, and nearly all of the plant, we regret that a similar protection had not been secured for the lock pits.

The project under which construction was commenced did not contemplate such protection, but required that the coping of the low-water lock walls should be above the slope of extreme high river.

The shortness of the working season, the necessity for disposing of spoil material on the river side, and the hope that the yearly rise would not exceed the average one, strengthened the controlling reason named in the last annual report for not constructing some kind of breakwater on the river side of the lock location.

The lower end of the embankment rested on a rocky ridge nearly as long as the lock pits, and about parallel to them, and whose crest was above ordinary high-water. As far as known great floods had occurred at long intervals, and not until the spring of 1880 was it considered at all probable that another flood would so soon follow that of 1876.

The high-water flowed over the ridge in large volume, carrying much material, which was deposited in the lock pits, and by infringing against the land bank caused caving and a flattened slope. The ridge was washed clean, as if by powerful sluicing. Large cut stones were moved several feet in a surface only slightly inclined, and the corners of squared pieces smoothly rounded by attrition. The pits were partly filled with gravel and small bowlders, causing additional work, and by its necessity a vexatious delay, during good weather, in recommencing excavation proper of the lock pits.

During July and August a force of quarrymen and stone cutters was engaged in preparing building stone from bowlders on the high ground of the land side of the canals and locks. Roads were made to unsurveyed government land on the mountain slope, a large supply of fuel cut, charcoal burned, and timbers for derricks gotten out.

A good blacksmith shop was built above high-water. The frail buildings erected by the contractors for lodging and messing of employés were thoroughly repaired, the interior arrangements remodeled for health and comfort, and the mess-house changed for a second lodging-house. A neat, substantial, new mess-house, to accommodate three hundred men, with kitchen, bake-house, cellar, and store-room, was built at a cost of very nearly $1,800.

The mapping of the survey of the minor rapids made during the previous low-water season was completed. By the end of September, sketches, profiles, plots, tables of data, and estimates of proposed projects were in presentable shape, leaving nothing omitted, it is believed, for a satisfactory consideration of the difficult problems connected with an improvement at the Cascades.

The slow subsidence of the flood stage did not permit the resumption of any work

of excavation until the middle of August. Spoil materials from the canal prism were worked into the embankment or used as filling on the opposite side to make working ground and good roads. As the lower levels were uncovered the force was increased and concentrated there; excavation was continued with some interruption by freshets until the latter part of March, when an early rising river again forced an evacuation of the pits.

Commencing at Station 7, or 700 feet from deep water of the river above the canal, the prism is now excavated to an average depth of 8 feet above grade, for a width of 50 feet, with side slopes of 1 on 1; the lock pits are made to an average depth of 16 feet above bottom, and for a width of 125 feet.

A test pit and drill hole in a lock pit were driven to a depth of 29 feet below extreme low-water. The underlying conglomerate did not show any material change in character.

Experience of a year on this work proved the necessity of preparatory structures to permit satisfactory progress, which can only be made at reasonable expense during the moderately favorable times of spring and autumn. On account of the absence of an elevated rock formation, contrary to expectations at the commencement of the work, or of any tight bank, there must be avoided on the one hand, for active operations, the low-water season with its accompanying severity of weather, and on the other the middle of the dry season, when high-water obtains. To accomplish this object there was planned, by your approval, a capacious water-tight compartment enclosing the entire lock site. The compartment was arranged in this way: At the down-stream end, a timber bulkhead tied into the high bank on the land side; on the river side, a concrete core in a trench cut to the underlying conglomerate, connected by a similar core to the solid end of the bulkhead; at the upper end, a plank bulkhead and dam to receive on their face the mountain water which flows freely into the canal. A flume was arranged to carry the waste water around the lock pit.

The approved report of the Board of Engineers for the Pacific Coast of 1880, in their investigations concerning the canal, furnished a definite project of the improvement from which a protective structure on the river side of the lock site could be located and combined with the arrangement for tightening the bank. A rough, dry-stone wall surmounts the concrete core and receives the latter, with gravel packing, as a hearting to a height of 1 foot above average high-water slope. For the concrete is then substituted a double thickness of horizontal sheeting of 1 by 12-inch boards with the lower course imbedded in the concrete. The junction between the canal embankment and the dry-stone wall is formed by the outer end of the wing wall of the lock on the river side. The wing wall is of hammered rubble in the faces, and of rubble, bowlders, and concrete in the body; 177 cubic yards, completing the junction, were laid, at a cost, including expense of foundation, of $9.45 per yard.

In the excavation for the concrete core the conglomerate was reached on a length of 715 feet, leaving two gaps at the lower end aggregating 159 feet long. The lowest reference of the bed-rock found is 67.5, or 5.9 feet below extreme low-water at the foot of the lock. A trench was cut in the rock, for foundation, more or less shallow according to its character. The concrete is 2 feet thick for an average height of a little over 3 feet and then decreased to 1 foot; 542 cubic yards were laid at a cost, for the whole hearting, of $15.47 per yard of concrete, including expense of excavation, gravel backing, and 500 running feet of sheeting two courses high. The average quality of the concrete is according to the following proportions by measure: one Portland cement, one slacked lime, five sand, seven broken rock, and nine gravel.

When the concrete core was brought to the firm surface of the ground at reference 100, the dry wall was commenced and the core continued. Founding the wall on the conglomerate bed-rock was out of the question. Its base of bowlders and gravel required more spread and a stepping back from each side of the core of nearly 3 feet. At two places where rock foundation was conveniently reached the opening was choked, as it were, to join the concrete or sheeting. The gravel backing of the core was rammed in layers. The outer faces of the wall have a *batie* of 0.5; the inner faces are vertical; the body of the two parts is formed without bond. A row of 3 feet slab-wood sheeting was driven along the inner toe; transverse zigzag rows were placed in the base; the sheeting projects 4 inches; 15,190 cubic yards of wall were laid at a cost of $1.21 per yard. Commencing at the lower end of the canal embankment the protection wall carried to the flood line extends now 526 feet. Its direction inclines from the prolongation of the embankment, towards the lock, at an angle of nearly 2°. From the unfinished end to beyond the timber bulkhead and around the detached parts of the concrete core and wall a pile of loose stone was dumped for temporary use as a breakwater during this year's high-water and for convenient handling in continuing the permanent wall next season. Besides the definite purpose of the wall, two objects during its construction were kept in view: to use the spoil material of lock excavation, and open an unobstructed high-water channel on the outside of the embankment and wall.

The timber bulkhead is 10 feet thick and ballasted with earthy gravel rammed,

First quarter 1881:		
Hired labor	$23,281 94	
Materials	2,549 80	
Transportation	808 69	
Telegrams, traveling expenses, &c	101 69	
		$26,742 12
Second quarter 1881:		
Hired labor	23,966 46	
Materials	2,144 38	
Transportation	199 73	
Telegrams, traveling expenses, &c	141 34	
		26,451 91
Total amount expended to June 30, 1881		398,873 95
Total amount of appropriations to June 30, 1882		540,000 00
Total amount available July 1, 1881		141,126 05
Outstanding liabilities July 1, 1881		7,278 88

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, D. C., December 15, 1880.

SIR: I have the honor to submit herewith a report to this office of November 13, 1880, with accompanying papers from the Board of Engineers for the Pacific coast, being the results of its investigations on the subject of the construction of the canal around the Cascades of the Columbia River, and containing suggestions and recommendations with regard to the further prosecution of that work.

The observations for low-water stage, which had been made prior to the preparation of the original project for this work, having been necessarily limited for want of time, it was subsequently found that the low-water height adopted for the sill of the lower lock of the canal was too great. This and other matters connected with the original project demanded that before any masonry construction was commenced the whole plan of improvement should be reconsidered.

The Board of Engineers for the Pacific coast was accordingly instructed to take the subject under consideration, and after careful investigation made a report August 19, 1879, in which a low-water system and the improvement of the river below the proposed locks for low-water navigation were recommended. But in order to be prepared to report in detail upon all points connected with the improvement, and to decide upon the project best suited to meet future wants of the navigation of the river, the Board recommended such detailed surveys to be made of the river and all the reefs for 6 miles below the Cascades as would supply the necessary facts and conditions.

These surveys having been completed, the Board was directed to reconvene in October last, for the purpose of continuing their investigations, and Majors Weitzel and Houston, of the Corps of Engineers, were assigned as additional members of the Board during the consideration of this subject, these officers having had large experience in lock and canal construction which it was important should be availed in this connection.

This Board confirms the previous opinion that the actual construc-

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This Board confirms the previous opinion that the actual construc-

tion of the canal ought to await the improvement of the river below, since the effect of removing the rocks and reefs in the bed of the river will be to lower the water surface at low stage, and the amount of this lowering cannot be calculated beforehand, but must be determined practically.

In the mean time the excavation of the canal may be continued; the stone for the locks prepared; the timber for the gates and other material accumulated, so that when the construction is actually begun, it may go on without interruption, and the final completion of the work will not be delayed.

The Board is also of opinion that the river navigation at the main rapids can be greatly improved, and important benefit to navigation secured, anterior to the completion of the locks, by the removal of reefs and projecting points so that boats can ascend (with assistance if necessary) to the foot of the main rapids during low and medium stages of water, and recommends for that purpose the expenditure of about $100,000.

Further, as experience in this country in the construction of canals around obstructions in navigable streams points to an increase of the size of lock chambers and to higher lifts, the Board is of opinion that the dimensions adopted for this canal should be increased to a capacity of 462 by 90 feet, with a lift of about 24 feet.

Major Gillespie, Corps of Engineers, the officer in charge of this improvement, submits to the Board estimates, among others, of the cost of a practicable low-water system by use of the river to the main rapid, as follows:

Completion of the excavation now in progress and construction of one lock 300 by 90 feet (C^1)	$966,901 75	
Improvement of the river to foot of main rapid, for temporary low-water navigation (C^2)	43,128 25	
	1,010,030 00	
Addition for lock 458 by 90 feet	107,910 20	
	1,117,940 20	

The report of the Board concludes with the following summary of its recommendations:

1st. Improvement of the river with a single lock near the foot of the main rapids for navigation up to 20 feet above low-water, and a guard-gate at head of canal to exclude high-water.

2d. Should it be found that this method of improvement will not give the desired navigation up to a stage of 20 feet at an admissible cost, the next step would be the construction of a lock behind Bradford's Island and a dam across the river from the island to the right bank.

The Board remarks, in conclusion, that the construction of these works will admit of their easy adaptation to an all-the-year-round navigation, should it be required in future. It would necessitate the construction of a guard-lock at the upper end of the canal, involving but an additional set of gates.

Upon careful consideration of all matters presented in this report, I beg leave to recommend the views of the Board for your approval.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers,
Brig. and Bvt. Maj. Gen.

Hon. ALEXANDER RAMSEY,
Secretary of War.

[First indorsement.]

Respectfully returned to the Chief of Engineers, approved.
By order of the Secretary of War.

H. T. CROSBY,
Chief Clerk.

WAR DEPARTMENT,
December 18, 1880.

REPORT OF THE BOARD OF ENGINEERS FOR THE PACIFIC COAST

PORTLAND, OREG., *November* 13, 1880.

GENERAL: The Board convened at the Cascades on the 10th of November, 1880; all the members present.

The two associated members of the Board arrived at the Cascades on November 6 and devoted the interval prior to the meeting of the Board to an examination of the locality and a study of the various surveys and projects.

The Board of Engineers for the Pacific Coast in its last report on the Cascades Canal, dated August 19, 1879, arrived at the following conclusions:

1st. That the medium and high-water navigation of the portion of the river just below the canal is, under present conditions, impracticable.

2d. That the low-water navigation of this portion of the river is, under present conditions, practicable, but not convenient, and not such as ought to exist in the approaches to a canal of the magnitude and importance which this must always be as the outlet of an extensive agricultural country.

3d. That the low-water navigation can be improved, and ought to be improved, by the excavation of the reefs which contract the low-water section.

4th. That the excavation of these reefs will, according to the extent of their removal, tend to lower the level of low-water at the foot of the breakwater, and also to equalize the high-water slopes and velocities.

5th. That inasmuch as the reference of the sills, the aggregate lift of the locks, and the height of the breakwater are dependent upon the regimen of the river, as it will be established by the removal of the reefs, it is a logical sequence that the construction of the masonry of the locks and of the artificial channel ought not to be commenced until the reefs are removed.

The Board awaits the survey and estimates for the removal of these reefs, and the results of the study of the cross-sections of the river at different points and at different stages, before expressing an opinion as to the extent of excavation that ought to be undertaken.

In the mean time, and during the time occupied by the removal of the reefs, the systematic observations of the heights of water and velocities will be a valuable element in any further consideration of the subject.

The Board sees its way with tolerable clearness, through the processes which have been indicated, to the successful accomplishment of low-water navigation which may be expected to obtain for six months in the year. This result is not, however, without its difficulties and its serious contingencies, and one of the great advantages of the course proposed by Major Gillespie and approved by the Board is, that time will be gained for careful observation and study of what can be done and of what must not be attempted.

Some of the points which we think require study and involve difficulty will be mentioned in what follows.

Having reached the conclusion that actual construction ought to await the improvement of the navigation of the river proper, it seems hardly necessary at the present time for the Board to express an opinion as to the practicability or advisability of providing for high-water navigation. We are convinced, with the information before us, that high-water navigation will require the constructions spoken of as possibilities in our report of September 24, 1877, namely, that the breakwater will have to be extended to Bradford's Island, the channel behind the island excavated, and additional lockage provided at the foot.

We believe that the cost of these works have never been carefully estimated, and

we recommend that this be done at some time in the future and before the high-water system shall be again considered.

This high-water system involves one difficulty which is peculiar to itself, and another which it shares with the low-water navigation, both of which appear to the Board to be serious. We merely indicate them for the purpose of commending the study of them.

The first is found in the following circumstances:

About 2,000 feet below the lower end of the breakwater, as now projected, the river at its low stage is only 400 feet in width.

The base of the breakwater added to the 70 or 80 feet of channel inside of it will take up about one-third of the cross-section of the river, when it is already too small.

Whether or not it may be necessary to make some compensation for this contraction by cutting away the northern shore and what may be expected to be the effect of the contraction in low or high stages, are questions of difficulty and importance.

The second difficulty is due to the sliding of the hills on the southern shore. The effect of this on the proper position of the breakwater is direct.

Indeed this final position will result from a balancing and a compromise of evils.

On one side there is a sliding mountain, which threatens at any moment to fill the canal, and which ought not really to be touched in excavation. On the other side is a river channel too narrow to be encroached upon. Yet the channel must be narrowed or the mountain cut. One or both of these courses must of necessity be followed.

The circumstances of this work, as they now appear, impress the Board with a sense of difficulty and expensiveness of construction even for low-water navigation, and much more for a high-water system.

Under existing circumstances, with the information before the Board, we are of the opinion that operations ought to be directed to securing for the present merely the low-water navigation, including the medium stage of navigation, if this shall appear practicable during the excavation of the reefs. The additional information that will be obtained from observations of river phenomena during the interval, and a careful estimate of cost, will, in due time, justify an expression of opinion whether or no the high-water system is practicable or advisable.

The surveys and observations of river phenomena recommended by the Board have been completed and estimates submitted for a river improvement and different plans of canal improvement. Nothing further has been done in the direction of river improvement.

A complete topographical and hydrographic survey has been made from the foot of the main rapids to the lower steamboat landing, and plotted on a scale of 1 inch to 50 feet. The surveys and other observations of river phenomena are described in the accompanying letter of Col. G. L. Gillespie* submitting estimates as follows:

Completion of excavation, construction of one lock, chamber 300 by 90 feet in the clear with high guard-gate and wing-walls	$966,901 75
For harbor near head of canal and additional lock	444,984 25
Additional to make lock 458 by 90 feet in the clear	107,910 20
Improvement of river to foot of main rapid for temporary low-water navigation	43,128 25
Construction of artificial high-water channel to Bradford's Island and improvement of chute, on a grade of $\frac{1}{1000}$ from reference (66) at head of channel	6,360,687 88
Construction of artificial high-water channel on level (66)	4,119,421 71
Construction of walls and concrete bottom covering for artificial high-water channel on level of (86)	3,431,970 00
Low dam on river opposite Bradford's Island	119,025 00
Single lock chamber 300 by 90 feet in the clear in island chute	540,000 00
Thus making the cost of a practicable low-water system by use of river to main rapid	1,010,030 00
Of an easy low-water navigation to foot of main rapid, for longer period, by lock and dam improvement at Bradford's Island	880,384 50
For its extension for high-water navigation by artificial channel on level (66.0) and additional lock	4,659,421 71
Total of a high and low water navigation by use of an artificial channel on a grade bottom	7,676,688 63

After careful examination, this Board agree with the opinion expressed by the Board of Engineers for the Pacific Coast, in the report above refer-

*Not printed.

red to, "that actual construction ought to await the improvement of the river from the foot of the main rapids to the lower steamboat landing," and for the reasons stated.

The effect of removing the rocks and reefs in the bed of the river will be to lower the water surface at a low stage, and the removal of the projecting points above low-water will increase the cross-section of discharge and reduce the velocities at higher stages.

The amount of this lowering of the water surface can only be determined practically, as it is absolutely impossible to calculate it with any degree of accuracy.

The date of final completion of the work for navigation at a low and medium stage need not be deferred by the improvement of the river or lower approach to the canal.

The excavation of the canal prism may be continued. The stone for the locks can be prepared, the timber for the gates purchased and seasoned, and other materials accumulated so that when construction is actually begun it may go forward with the greatest practicable rapidity.

It appears to the Board that an important benefit to navigation may be secured after some improvement of the river has been accomplished and anterior to the completion of the locks by the establishing of a portage across the government lands adjacent to the locks. The land owned by the government is, however, limited to a narrow strip, and the establishment of a thoroughfare might interfere with the construction of the locks. On this account the Board refrain from making a positive recommendation in regard to this matter, but suggest it for the future consideration of the local engineer.

The Board are of the opinion that the river navigation at the main rapids can be greatly improved by the removal of reefs and projecting points so that boats can ascend to the foot of the main rapids with perhaps some assistance during low and medium stages of the river; but the extent and cost of such improvement cannot be determined, except by actual trial, and would therefore recommend the expenditure of not to exceed $100,000 in improving the river, which would give a better navigation, and determine the extent and cost of further improvements.

Lieut. C. F. Powell, Corps of Engineers, in immediate charge, has proposed to obtain navigation at low and medium stages by the construction of a dam across the river at Bradford's Island, and a lock behind the island, included in the above estimates. This would doubtless accomplish the object, but it would be very expensive, and, in the opinion of the Board, should follow the improvement of the river if done at all. Its necessity would depend on the extent to which the river admits of improvement. The advantages of an open river navigation over locks are so great as only to need mention.

The construction of this lock and dam, without the river improvement, would greatly postpone the time when improvements now in progress could be made available. The demands of commerce for relief are such that the plan adopted should be the one which can be executed in the shortest time. This can be done by improving the river channel, and, if necessary, providing a tug to assist vessels in ascending. Such a tug will, in any case, be required for operating the canal.

Papers giving the character of the navigation of the Columbia River, past and present, between and below portages, and examples of special navigation of the river up to the foot of the main rapids at the Cascades, accompany this report, marked respectively D and E.

This Board of Engineers made a practicable test of the facilities of navigation of the lower river at a stage of 7 feet rise at gauge No. 2 by

steaming from the lower landing (6 miles below main rapids) up through the minor rapids to the foot of the main rapids. The steamer was the Willamette Chief, 18-inch cylinder by 7½-foot stroke, 110 to 124 pounds steam, and 2½-feet draught. The time occupied in passing from the foot of Bradford's Island to the foot of the main rapids, a distance of 4 miles, was 30 minutes. The descent to the lower landing was made in 9 minutes. The boat had, at the time of ascent, not to exceed 10 tons freight. The trip, as indicated by the time of passage, was made without difficulty, the steamer appearing to struggle only in passing the Big Eddy Rapids, and then only for a moment. It is probable that with a little more draught less difficulty would have been experienced. The result of the passage served to confirm the previous estimate of the practicability of improving the river navigation up to the foot of the main rapids.

In order to obtain an all-the-year-round navigation it has been proposed to excavate a channel next to the left bank, and to build a breakwater on the river side of this from the foot of the main rapids to Bradford's Island chute, a distance of about 13,000 feet.

The original plan was to build this breakwater of crib-work filled with stone. This mode of construction is not permanent, and if built at all the construction ought to be of rubble masonry, for which there is an abundance of material in the immediate vicinity. The top of this breakwater should be at least 2 feet higher than the highest stage of the water contiguous to it, and should be stepped off to accommodate these various heights. This wall would rest almost entirely upon an artificial foundation composed of riprap and crib-work, the latter, for the sake of permanency, not being carried up any higher than to within 1 foot of the low-water stage.

It is clear that the construction of this artificial channel with breakwater will be very expensive, very difficult, and will require a long time for its execution. It will, moreover, seriously diminish the cross-section of discharge of the river, now already too small, will require constant dredging to remove the material which will be deposited in it by the continued degradation of the adjacent mountains, and it will not be susceptible of enlargement in the future.

On the contrary, if the system to accommodate the greatest part of and most useful navigation, *i. e.*, for all stages up to 20 feet above low-water at the foot of the main rapids, be adopted, it will be far less expensive, can be ready for commerce within a reasonable time if adequate appropriations for it are regularly made, will suffer little from the degradation of the mountains, and can be readily enlarged in the future by an improvement of the river to diminish the velocities in the lower approach.

In order to provide navigation at higher stages, it seems that a solution of the problem which would really be completely satisfactory, permanent, and free from uncertainties, consists in the construction of a water-tight channel or trunk which shall carry the upper level of the canal—the reference of bottom being 8 feet below low-water above main rapids—to a point opposite the Middle Block House Rapids, and thence to a lower level to Bradford's Island chute, with a reversed arch at bottom and stone wall next to the river, both laid in hydraulic cement.

This outer wall would require a great deal of strength since its upper portions would at times be compelled to resist a strong hydrostatic pressure. A lock with about 18 feet lift should be placed near gauge station No. 8, or abreast of the Middle Block House Rapids, and the top of this wall stepped down about 12 feet below this lock.

This channel or trunk would rest mainly upon an artificial foundation consisting of heavy riprap, which would need time for settlement, and would require its top to be carefully graded to receive the reversed arched bottom.

Such a system would require considerably more time for its execution than the plan last discussed, would be more expensive, and, although not encroaching upon the river to the same degree, it is nevertheless open to the objection of seriously diminishing the high stage water-way.

In determining the dimensions of the locks for the improvement, the following historical facts should be borne in mind, *i. e.:*

The Louisville and Portland Canal was first opened to commerce in 1830. Its locks were combined, three chambers in number, each with a lift of 8$\frac{2}{3}$ feet and a capacity of 185 by 50 feet. It was thought by the projectors that these dimensions would suffice for all time to come. In less than twelve years an enlargement of the canal and locks was demanded. Since that time new combined locks with two chambers, with lifts respectively of 14 and 12 feet and with a capacity of 335 feet by 80 feet have been built. The three chambers of the old locks have been converted into two of the same dimensions and lift, and the main or Indiana chute over the falls has been considerably improved. Yet the officer in charge of this work, who is a member of this Board, states it as his belief that in consequence of the delays which occur when there is a sudden rise in the river in passing the large number of accumulated vessels, there will soon be another movement for a still further enlargement of the canal and increase of lock capacity.

The old canal around the falls of the Saint Mary's River, Michigan, was opened to commerce in 1855. The locks were combined, two chambers, 350 feet by 70 feet and each 9 feet lift. It was also thought by the projectors that these dimensions would suffice for all time to come. At the time they were completed they were the largest canal locks in the world. Fifteen years afterwards, Congress had made an appropriation for commencing its enlargement and for the construction of an enlarged lock, now nearly completed, and which is 515 feet by 80 feet, and has a lift of 18 feet.

It seems that the whole tendency in the construction of ship canals around obstructions in the navigable streams of this country, is in the direction of large lock chambers and higher lifts.

Having these facts in view, it seems that there should be but a single lock at the foot of the Cascades Canal, to accommodate the low-water system of improvement. Its capacity should be 462 feet by 90 feet to accommodate one tow-boat and three barges. It should have a lift of about 24 feet. The clear gate openings should be reduced to 70 feet, so as to diminish the weight of the gates. It should be provided with a guard gate at its head and foot so that it may readily be pumped out in case of needed repairs or vessels being wrecked in it. There should be a guard gate at the head of the canal, the top of which should be at least 2 feet higher than the highest water. In case the high-water system is hereafter introduced, this guard gate will form the upper gates of a lift and guard lock which must then be constructed at the head of the canal.

The prism of the canal should be 90 feet wide at the bottom. The sides should be carried up vertically to within 1 foot of low-water by strong timber cribs filled with stone, and then to a height of 11 feet by a dry stone wall. Here there should be a berm at least 15 feet wide, and then there should be a paved slope of 1 upon 1, leading up to the top of the canal embankment, which should be on a level with the top of the guard gate at the head of the canal.

The following is a summary of the recommendations of the Board:

1st. Improvement of the river with a single lock near the foot of the main rapids for navigation up to 20 feet above low-water gauge No. 2, and a guard gate at the head of canal to exclude high-water.

2d. Should it be found that this method of improvement will not give the desired navigation up to a stage of 20 feet gauge No. 2, at an admissible cost, the next step would be the construction of a lock behind Bradford's Island and a dam across the river from the island to the right bank.

The Board remark in conclusion, that the construction of these works will admit of their easy adaptation to an all-the-year-round navigation, should it be required in future. It would necessitate the construction of a guard lock at the upper end of the canal, involving but an additional set of gates.

All of which is respectfully submitted.

C. SEAFORTH STEWART,
Lieutenant-Colonel of Engineers.
R. S. WILLIAMSON,
Lieutenant-Colonel, U. S. Engineers.
G. H. MENDELL,
Lieutenant-Colonel, Corps of Engineers.
G. WEITZEL,
Major of Engineers, Bvt. Maj., Gen., U. S. A.
D. C. HOUSTON,
Major of Engineers, Bvt. Col.
G. L. GILLESPIE,
Major of Engineers, Bvt. Lieut. Col., U. S. A.

The CHIEF OF ENGINEERS, U. S. A.

D.

LOCK AND CANAL CAPACITY.

Plan prepared by direction of Colonel Wilson gave for locks a width of 46 feet, total length 250 feet, available length 214 feet; for canal prism a bottom width of 50 feet, and low-water surface width of 58 feet; least depth in both 8 feet.

Board of Engineers increased lock width to 50 feet, and total length to 300 feet, making available length 262 feet.

Subsequently, upon recommendation of Colonel Wilson, the Chief of Engineers authorized an increase of lock width to 70 feet, which reduced available length to 256 feet. No change was made in canal prism, but it was intended to widen that when the wants of navigation required it.

The location of the breakwater below the locks has remained unchanged since the time of the first plan, the one which gave a lock width of 46 feet.

The lock width, in each case above, was the same at the gates and in the chamber.

During the progress of the work it was found that the sides of part of the cut for canal prism would not stand the weather and percolating water on a slope of 2 on 1, and it was considered advisable to have a little greater depth in the canal than over the miter-sills. The cut is actually being made with slopes of 1 on 1 and 9 feet deep at low stage, giving a surface width at low stage of 68 feet.

CHARACTER OF PRESENT NAVIGATION.

The river above Celilo is known as the Upper Columbia, between the Cascades and the Dalles as the Middle Columbia or Dalles route, below the Cascades as the Lower Columbia, between Portland and the Cascades as the Cascades route, and between Portland and Astoria as the Astoria route.

Steamers on the Lower and Middle Columbia are at the same time freight and passenger and tow boats. Barges are not used on the Upper River. All steamers are

stern-wheelers except the Idaho, a small old side-wheeler, which has of late years been run on the Middle Columbia as a winter boat.

Barges as well as steamers take their loads on deck entirely. The freight is laid in packages and is moved by hand.

Part of the barges on the Dalles route are provided with sails, and frequently sail up stream.

Numerous scows ply the river below the Dalles. They sail up stream loaded and float down light.

In towing, a steamer takes one barge lashed firmly to her side. The small steamer Hassalo, during high winds, tows with a line. Other steamers are not provided with tow-line supports. Sometimes a second steamer assists the tow-boat, particularly during high stages, in leaving the Upper Cascades. The *Thompson* takes a large loaded barge up stream during ordinary stages, makes landings and reaches the Dalles 50 miles, within one hour and half of her usual running time. Captains McNulty, Wilson, and Wolf say the *Thompson* and *Wide West* could tow two or three barges without difficulty. These boats are used principally for passenger and freight traffic. Assistant Superintendent Dodge states the larger steamers did not take more than one barge at a time for the reason that there was not room for loading and unloading larger tows at the inclines. On the Astoria route there is a considerable towing of ships, and also of rafts and logs up stream.

On the Upper Columbia, seven steamers; on the Middle, four steamers and four barges; on the Cascades route, three steamers and five barges, and at times during the past summer four extra steamers. A few small steamers ply in local trade between Portland, Vancouver, and higher landings.

The Thompson on the Dalles route and the Wide West on the Cascades route are the largest steamers on the river; they measure 246 feet by 47 feet over guards and wheel, the former has a 9-foot hold, the latter 8 feet. These steamers are considered the most efficient ones on the Middle and Lower Columbia.

The Harvest Queen is the largest boat on the Upper River; she is 226 feet by 42 feet; loads from 3½ feet to 6 feet draught, and can carry nearly 500 tons. The draught of the other steamers above Celilo is from 3 feet at low stage to 6 feet 4 inches at high.

The side-wheeler designed in Portland by the Oregon Steam Navigation Company in 1878, but not built, was intended to be 257 feet by 62 feet over guards.

The largest barges, one on the Dalles route and her mate on the Cascades route, are 207, by 47 feet over all. The next sizes of barges are 185 by 40 feet and 103 by 30 feet over all.

The two barges of the first size, one of the second and the steamer Hassalo, were built last spring; the Reed on the Cascade route is one and a half years old. The Harvest Queen on the Upper Columbia is two years old. Other boats were built three or more years ago.

It may be noticed that while the locks are unnecessarily wide for any single craft now on the river, a separate lockage would be required for a tow-boat and each large barge or each pair of the smaller size. The proposed side-wheeler would make too tight a fit in length for passage through the locks. For separate lockages, doubtless machinery for moving barges would be demanded.

Below the Dalles there is a good 8-foot channel; above Celilo not more than 3½ feet can be depended upon during low-water on the rapids.

The current in the whole river is strong, especially at high stages, and also at low stages on part of the rapids.

During the summer and the larger part of the year strong up-stream winds prevail; the wind blows down stream during midwinter. At times the winds blow in gales.

From the Dalles to the Cascades navigation is suspended for two and a half weeks on an average on account of the ice, and during a little shorter time beyond the Cascades; the period of ice blockade on the Upper River is twice as long. Low-water of a season generally coincides with a freeze-up.

The down freight consists of grain, wool, and live stock; the up freight of merchandise, lumber, and wood, and during the past season of railroad supplies. Hay is taken from about the middle of the Cascades route in both directions.

CHARACTER OF FUTURE NAVIGATION.

If the expectations of the production of Eastern Oregon and Washington Territory are one-half realized a very large freight traffic will center in that region, the natural outlet of which is on the line of the Columbia River. The last annual report of the Portland board of trade gives 70,000 tons as the surplus of this year's wheat crop of the Upper Columbia country for export alone.

With a railroad terminating at the Dalles or rival roads leading to that place from the east, or an improvement giving easy navigation at the Dalles, a very large part of the freight traffic will be by water. An overland railroad striking the Columbia would occasion a considerable passenger traffic on the river. Local trade between Portland and the Dalles is increasing, but is not likely to be large enough to pay for any lock construction.

According to experience on older rivers, freight would be carried principally by barges in fleets, and side-wheel steamers would accommodate passenger traffic.

The same experience shows that single lockage of fleets is greatly to the advantage of navigators.

GATE SPAN.

On account of the necessarily great height of gates of the upper lock or locks, the gate span should not be longer than that actually required by the widest crafts or fleets in general use, *whatever may be the width and length of the lock chamber.*

The unavoidable narrowness of the artificial channel would generally necessitate towing astern. A steamer could take through a small barge abreast and drop her behind without delay to enter the locks. At the higher stages one barge, or two barges of the smaller size, could be towed abreast, but this period is of short duration.

In case of an improved river below the locks for temporary use in navigation, a tow-boat could, at the most, take one barge up stream, and then with a line. She might manage two barges lashed to her side, going down stream.

It follows that the gate span is fixed by the widest single craft in general use. *If the locks are to accommodate any considerable passenger traffic,* such a craft would be a side-wheeler. Ordinary river side-wheelers measure from 60 to 80 feet over guards. Somewhat wider boats are used on the Lower Mississippi and Hudson.

Colonel Merrill's letter (copy appended) gives the following mean dimensions of three characteristic Ohio River side-wheelers, viz, 299 feet by 78.3 feet.

The artificial channel would not in general easily pass an 80-foot boat, and the high winds would prevent the general use of excessively large guards.

A gate span of 70 feet seems enough to admit side-wheelers of required size. Mr. Gates, who may be considered an authority on Columbia River navigation, indicates (see copy of his letter appended) such width of locks as desirable, and that the corresponding useful length is 300 feet.

LOCK CAPACITY.

For single lockage this is fixed by size of fleets. Considering the current, wind, and rocky channel, three barges seem a maximum number in a fleet, even with an artificial water-way to Bradford's Island; more might be taken down stream but not up stream. The great width of new, large barges now in use by the Oregon Railway and Navigation Company results from the frequent transfers of freight requiring deck loads. The kind of freight is similar to that on the Mississippi from Saint Louis to New Orleans; the size of barges used there, 225 by 36 feet (see copy of letter from Captain Ernst appended), is a good measure of what will be required on the Columbia. Captains McNulty and Wilson say a large enough barge to handle well is of a size 180 to 200 by 40 feet.

An Ohio River tow-boat is 230 by 48 feet. Captain Ernst gives 200 by 46 feet as size of Saint Louis and New Orleans tow-boats; it is thought that the wheel, which would add some 28 feet, was not included in this size.

An increase of 12 feet in width and of 155 feet in useful length to the dimensions probably required for side-wheelers would admit a tow-boat 230 by 46 feet and three barges, each 225 by 36 feet; to give a little clearance between the parts of the tow and an easy exit from the lock, the chamber should be 458 by 88 feet in the clear.

For a tow-boat and one barge, the length for side-wheelers, 300 feet, and width of 88 feet are ample.

Which size of lock-chamber shall be adopted?

1st. 256 by 70 feet, now authorized.

2d. 300 by 70 feet, needed for probable size side-wheeler.

3d. 458 by 88 feet, for tow-boat and three barges.

4th. 300 by 88 feet, for tow-boat and one barge.

CANAL PRISM CAPACITY.

The upper entrance of the canal is on the lee shore of winter, and at the head of the rapids. There ought to be a harbor and turn-out basin as capacious as the ground reasonably permits. The entrance should be ample, then a narrow throat, and between that and the upper lock the harbor and basin. The contracted part should easily pass a steamer and two barges lashed to her sides. The depth ought to be 1 foot greater than over miter sill.

In the water-way below the locks 80 feet is recommended for the least bottom width, with turn-outs in the bends of the river bank. In the portion of the canal behind Bradford's Island, where there is more latitude for the dimensions, a normal width of 150 feet should be taken. The depth throughout the water-way ought to be 2 feet more than over the miter sill.

LETTER OF MR. JOHN GATES, CHIEF ENGINEER OREGON RAILWAY AND NAVIGATION COMPANY.

OREGON RAILWAY AND NAVIGATION COMPANY,
Portland, August 3, 1880.

DEAR SIR: Yours of July 31 received. The side-wheel steamboat that you refer to is 257 feet long over all and 62 feet beam over all. The largest barge on the river is 206 feet long over all and 47 feet beam over all. The *Wide West* and *Robert R. Thompson* are 246 feet long over all and 47 feet beam over all.

There is no doubt but what side-wheel steamers larger than the ones mentioned above will be used between here and The Dalles in a very few years, if the locks at the Cascades will take them through.

In regard to the barge towing, I suppose barges as large as the largest now in use will be used in the future. Tugs will probably take two or three at a tow. Stern-wheel tugs will be used. Powerful screw-tugs would not have depth of water sufficient to be used on this route.

Respectfully, yours,

JOHN GATES,
Chief Engineer Oregon Railway and Navigation Company.

CHARLES F. POWELL,
First Lieutenant of Engineers.

LETTER OF MR. J. W. TROUP.

STEAMER HARVEST QUEEN,
August 12, 1880.

DEAR SIR: Your communication is at hand, and in reply I would state that the exact dimensions occupied by the Harvest Queen in a lock would be, length 226 feet, beam 42 feet.

In regard to barges, I think a very powerful stern-wheel tow-boat at a good stage of water might get up the river with two barges, say, 220 feet long and 45 feet beam each; to do this it would be necessary to take one at a time in passing either up or down over the worst rapids, but in my opinion it would not be profitable on account of the strong current and high winds, which latter would frequently necessitate laying by.

A steamboat considerably larger than the Harvest Queen could be run successfully at a medium stage of water.

Yours, very truly,

J. W. TROUP.

Lieut. CHARLES F. POWELL.

LETTER OF MAJ. WILLIAM E. MERRILL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, August 14, 1880.

SIR: I take pleasure in replying to your letter of the 31st ultimo.

1st. On the Ohio River, both side and stern-wheelers are constantly being built, the chief noticeable sign of change being the increase of the stern-wheelers.

The following are the dimensions of some recently built boats of each class:

SIDE-WHEELERS.

	When built.	Length.	Beam of hull.	Width over all.
		Ft. in.	*Ft. in.*	*Ft. in*
Bostona	Oct., 1879	302 6	43 6	79 6
Telegraph	——, 1877	289 0	41 6	76 0
Fleetwood	Aug., 1880	305 0	43 6	79 6

STERN-WHEELERS.

	When built.	Length.	Extreme width.
		Ft. in.	*Ft. in.*
Wyoming	——, 1879	257 0	45 6
W. N. Chancellor	Aug., 1879	176 0	35 0
Emma Graham	June, 1877	221 1	42 0
Fashion	Aug., 1877	220 0	41 2

MODEL BARGES.

		Ft. in.	*Ft. in.*
Rubicon	July, 1880	177 6	29 6
Buttercup	July, 1879	177 6	29 6
Barge No. 6	Oct., 1878	121 0	20 4

Coal barges, 130 by 24 feet. Coal boats, 170 by 26 feet.

There are numbers of steamboats in use that are smaller than those given in the above tables, and a very few of both classes that are larger.

2d and 3d. All tows on the Ohio, either ascending or descending, are bound to the steamboat in the firmest possible manner. One or two barges are usually lashed alongside. More than two are always placed in front and are *pushed*. There is absolutely no towing by a line.

For *freight only*, the stern-wheeler is always preferable, because cheaper to run. Less power will do equal work, and they require only half the number of engines.

For *passenger traffic*, the side-wheeler is preferred, but the stern-wheeler is the cheaper and lighter, and on this latter account is the only one that can run in low-water.

For *towing*, none but stern-wheelers are used. In strong water the stern-wheeler is preferable. To make landings the side-wheel is the better.

It should be borne in mind that all our side-wheelers have independent side lever engines.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Lieut. C. F. POWELL,
Corps of Engineers.

LETTER OF MR. JOHN GATES, CHIEF ENGINEER OREGON RAILWAY AND NAVIGATION COMPANY.

OREGON RAILWAY AND NAVIGATION COMPANY,
Portland, August 19, 1880.

DEAR SIR: Yours of August 14th received. The length of the side-wheeler steamboat whose beam over all of 70 feet would be about 300 feet. But there are all sorts of proportions of steamboats. There are side-wheel boats of 36 feet that have a beam over all of 75 feet. Some have a large diameter of wheel and narrow face. Others are built with small diameter and broad face, so that the beam over all is often more than twice the beam of hull.

I should think that locks 300 feet long should be fully 70 feet wide.

Steamer St. Johns, Hudson River, 50 feet beam of hull, 85 feet over all.

Magnolia, Mississippi River, 33 feet, over all 72 feet.

I think that boats as large as would go through locks 70 by 300 feet would load from Lower Columbia to Wallula if there were locks at both portages.

Respectfully, yours,

JOHN GATES,
Chief Engineer Oregon Railway and Navigation Company.

Lieut. CHARLES F. POWELL,
Corps of Engineers.

LETTER OF CAPT. O. H. ERNST, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., September 10, 1880.

SIR: Your letter of the 27th ultimo was duly received.

The dimensions of the tow-boats recently built for the Saint Louis and New Orleans trade are 200 feet in length and 46 feet in width over guards, of barges 225 feet in length and 36 feet in width. The number of barges in a tow is five for both up stream and down stream tows.

The depth of water in the Mississippi at the lower stages being much less than is desired by steamboatmen, I have made inquiry as to how far the foregoing number are the result of necessity, and what changes, if any, would be made if there were a wide and deep channel at all stages.

It appears that the dimensions of the barges would not be changed, but that possibly some of the tow-boats will be built larger.

Very respectfully, your obedient servant,

O. H. ERNST,
Captain of Engineers.

Lieut. CHARLES F. POWELL,
Corps of Engineers.

E.

EXAMPLES OF NAVIGATION AT THE LOWER AND MIDDLE CASCADES OF THE COLUMBIA RIVER.

NAVIGATION OF CASCADES UP TO MAIN RAPID.

Before the time of steamboating, bateaux were run as far as the Big Eddy.

Until 1863, small weak steamers ran to the middle landings, at the Blockhouse on the right bank and at Ruckles on the left bank, for about half the year. It is not known if these boats carried sail. During remainder of the year, when high-water prevailed, freight was taken from the lower to the middle landings in scow-schooners.

The steamer Jury ran to Greenleaf Slough during high-water of 1862 (second highest water record).

In the fall of 1875 steamer Willamette Chief made an experimental trip to the lock location. Copy of certificate concerning trip is attached and marked A.*

During high-water of 1876 (highest known), the present steamer Welcome, the cylinders of which are 4 feet by 16 inches, made regular trips to the Old Garrison.

In April, 1880, the government scow Snow-flake made the passage from the Lower Cascades to the lock location. Statement of the trip is attached and marked B.*

On May 1, 1880, when the river at gauge 2 was 20.7 feet above extreme low-water, steamer Lurline landed at Ruckles.

On June 1, 1880, when the river at gauge 2 was at a stage of 37.6 feet, steamer McCully failed to pass Middle Blockhouse Rapid.

On October 28, 1880, when river at gauge 2 was at stage of 6.7 feet, the McCully reached the lock location. Accounts of the three trips last-named are marked C,* D,* and E.*

During last season and up to a stage of 20.0 feet, our survey parties crossed to and from the Big Eddy with impunity, in ordinary skiffs. An attempt made on May 4, at a stage of 28.5 feet, proved that skiff crossings were not then practicable. Soundings with a 30-foot pole were made through Big Eddy Rapid at the most difficult part, between the mid-channel and Twin Bowlders, at a stage of 6.5 feet.

CONCLUSIONS FROM ABOVE.

1st. That steamers can reach mouth of Bradford's Island Chute opposite Old Garrison all the year around.

2d. That they can reach Ruckles Landing up to a stage of 20 feet on gauge 2 and with some difficulty to a stage of 37 feet.

3d. They can reach lock location at a stage of about 12 feet on gauge 2.

4th. That crossings at the Big Eddy are practicable up to a stage of about 20 feet.

NOTE.

The river was high for a low-water season in 1878–'79, and low in 1879–'80. A mean from the records of these two seasons will probably give average low-water; the mean period taken therefrom of a stage of 20 feet or less on gauge 2, is seven and one-half months, and for a stage of 12 feet or less, six months.

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*Not printed.