CONSTRUCTION OF NORTHWEST SEAL ROCK (ST. GEORGE REEF) LIGHT-HOUSE, SEACOAST OF CALIFORNIA.

OFFICE OF THE U. S. LIGHT-HOUSE ENGINEER, TWELFTH DISTRICT,
San Francisco, Cal., January 1, 1892.

Maj. W. H. HEUER,
Corps of Engineers, U. S. Army, Light-House Engineer, Twelfth District:

SIR: I have the honor of reporting the successful completion of Northwest Seal Rock light-station early in November, 1891.

The site of this station is on Northwest Seal Rock, being the outermost danger of St. George Reef, a cluster of rocky islets and sunken rocks projecting in a westerly direction from Point St. George about 6½ nautical miles long and from 1 to 1½ miles wide.

Inside the reef, close under Point St. George, is a deep wide channel used by northbound steamers, but only in daylight and clear weather.

The position of Point St. George, midway between Capes Mendocino and Blanco, would naturally suggest it as a suitable location for a first-class light, and the present site being about 6 miles outside of the headland gives it a decided preference over the mainland.

The superficial area of the rock above low-water line is about 40,000 square feet, of an oval form, with a ridge running from east to west, the highest point being about 54 feet.

On April 3, 1883, a working party left San Francisco in the schooner *La Ninfa*, a vessel of 137 tons register, chartered for use as a workmen's quarters at the rock. The party, numbering twenty-five, consisting of crew, quarrymen, stonecutters, and blacksmith, with an outfit of provisions, fresh water, and the necessary tools, were towed by the wrecking steamer *Whitelaw*, having on board four sets of moorings, consisting of one 12,000 pounds mushroom sinker and three of 8,000 pounds, four spar buoys, some 200 fathoms of chain 2¼ inches for bottom lengths and 1¾ inches for upper lengths. After a stormy passage, the steamer having put back twice, with her tow, to San Francisco, she succeeded in making Northwest Seal Rock on the morning of April 9, and laid the big 12,000 pounds mooring and made the schooner fast in spite of a heavy sea which was running at the time.

Concerning the depth of water in which the moorings would be placed there was unfortunately some doubt, the only data available being some soundings taken by the light-house tender's boat in 1881. The depth assumed from this being about 18 fathoms, and as it turned out 30 fathoms, our spar buoys were far too light. Our only resource was to get larger ones. The steamer at once proceeded to Humboldt Bay, the nearest point where such sticks could be procured. None suitable being found on hand, it was necessary to have them brought from the woods. This delayed the steamer until April 27, on which date she left Humboldt, arriving at Northwest Seal Rock on the 28th, to find the schooner gone and no trace left of our big moorings.

The weather being fine we laid the other three moorings with the new buoys, the steamer cruised in the vicinity of the rock, awaiting the reappearance of the schooner until May 3, when we again went to Humboldt Bay to communicate with Capt. Payson, the light-house engineer.

On our arrival in Humboldt Bay we learned from the brig *Josephine* that she had sighted and spoken the *La Ninfa* during a gale off Cape Mendocino on April 30. After coaling the *Whitelaw* we immediately put to sea in search and fell in with the missing schooner on the morning of May 6. We then learned she had first been driven north, then south, in her endeavors to hold in the vicinity of the rock, having parted an 8-inch hawser during a gale on the night of April 22, leaving about 50 fathoms attached to the spar buoy, the weight of which and the strong current running carried the stick to the bottom. The *Whitelaw*, although provided with special appliances for dragging, failed to pick up the lost mooring. She was discharged after two days' unsuccessful work.

Arrangements for supply and communication were then made with the coasting steamer *Crescent City*, making trips about once every ten days.

On May 9 we made the first landing on the rock, got in ringbolts, rang spring lines, and made the schooner fast; on the 10th we got our powder ashore and began drilling on the north side for preparation of the site of the pier. The weather continuing fine until the 12th, we rigged a traveler of 2½-inch wire rope, made fast to a ringbolt on the top of the rock and passed between the masts of the schooner to a spar buoy moored on the outer side of the vessel, the fore and main throat halyards being hooked onto the wire so as to take out the sag, a traveler block with endless line being used in taking men and tools on and off, and thus making landings when too rough for a surf boat.

The wire was raised and lowered as desired on board and the surging motion of the vessel allowed by the oscillation of the halyard tackles, the hooks of which were made fast to the wire by a strap; this prevented undue wear on the rope by permitting it to render through a block.

On June 9 the *Whitelaw* came and replaced the head mooring; after this was done the schooner was hauled in close to the rock permanently for the season, making the distance from the vessel to the top of the rock about 300 feet. The wire cable worked excellently, only parting once as the men were getting into the cage on the rock, letting them fall a few feet, but doing little damage except a few bruises.

The southerly winds, accompanied by heavy seas, which prevailed during April and May, changed early in June to violent northwesters, so that little progress was made until the 1st of July. By the end of August the benches, 10 feet wide around the outline of the pier, were roughly formed by blasting, and only needed the finishing off by stonecutters to complete them. In addition space was blasted for water supply allowing a storage capacity of 77,000 gallons of fresh water.

On September 28 the entire work of preparation of the site was completed and ready to receive the masonry. All tools and men were taken aboard. The weather, which had been fine for a few days, changed to a strong southerly gale. The steamer *Crescent City* came on October 2 and took the workmen to San Francisco. The *La Ninfa* left under sail, having a sufficient crew aboard. This concluded the first season's work on the rock. The working force was then disbanded in San Francisco and the tools stored on Yerba Buena Island.

In the fall of 1883 drawings and specifications were prepared for a wharf, workmen's quarters, and stonecutters' shed on the North Spit, Humboldt Bay, for use in accurately dressing the stone before shipping it to the rock. Bids were invited for the erection of these structures, and the contract let to the lowest bidder, Mr. James Simpson, of Eureka. Work was commenced during December.

While in Humboldt, on business connected with the construction of the depot, Mr. Simpson, the contractor, called my attention to a deposit of granite just discovered on Mad River, about 5 miles north of Humboldt Bay. I at once visited the location and found a deposit of granite bowlders of a good quality, and making a careful estimate of the quantity in sight I thought we possibly might get enough for the completion of the light-house. I at once communicated the information to the light-house engineer, who secured the stone at a royalty of 4 cents per cubic foot, and entered into a contract with the owner of the railroad for transportation

Specifications were also prepared under which it was proposed to advertise for bids for transporting the building materials from the depot at Humboldt Bay to the rock.

At the quarry the winter rains had washed down an immense quantity of earth encumbering the railroad tracks, derricks, and stone partly quarried. The main pile of dressed rubble (about 1,500 tons) left on the hill side convenient for shipment, slid bodily and embedded itself in the soft soil at the base of the hill.

At the stoneyard the piles supporting the wharf were completely destroyed by teredo so that it was necessary to practically rebuild it. Work was pushed to the utmost at the two points during March and April, getting affairs in shape, in the preparation of spar buoys, derricks, etc., and in overhauling and renewal of rigging and plant deteriorated or destroyed during two years disuse.

The *Sparrow*, a schooner of 200 tons, was chartered in Humboldt Bay and fitted up with eating and sleeping quarters for 50 men. A large assortment of tools, rope, blocks, chain and ironwork, together with a powerful steam winch for handling material, were shipped by the steamer *Santa Maria*, from San Francisco, on April 5, arriving at Humboldt on the 7th. Owing to continued bad weather and the unfinished state of the wharf at the stoneyard the steamer was delayed until the 18th, when she left for the rock with a load of moorings and men. All the moorings on board were set and the steamer returned on May 1, taking on board more moorings, which she was unable to carry on the first trip. She again sailed on May 10, with the schooner *Sparrow* in tow, arriving at the rock on the 11th. By the 18th we had six sets of moorings finished. The balance of the month was spent in erecting four boom derricks and a large hoisting engine, and in building a wharf or landing for receiving materials at the rock.

The mast of the big derrick, which had been left on the rock, we found had been cracked by a blow from a sea some 40 feet above high water, and had to be fished with heavy iron bands.

In the meantime bids had been received for the transportation from the stoneyard to the rock. Two bids were received, viz, the steamers *Santa Maria* and *Alliance*. The *Alliance* being the lower by $10,000, she was employed.

The *Alliance* arrived at Northwest Seal Rock with her first cargo of building materials and stonemasons on June 4. I found she was not properly rigged for handling the heavy stone and at once put our own riggers aboard and had her suitably rigged for the service.

I also reported to the light-house engineer that the steamer was unfit to carry out her contract, as she neither had the power nor carrying capacity to complete the work during the season available. The steamer *Santa Maria* was then rechartered for $7,000 per month and both vessels were kept on for the season ending October 3.

This season (1887) was remarkable for the prevalence of strong northwest winds, the whole summer being a succession of heavy gales, making construction difficult and dangerous, as the workmen had to be taken on and off daily between the schooner and the rock, but no accident happened to the men nor was any material lost.

During a gale in the month of June a stone weighing 3½ tons was torn from its bed some 30 feet above sea level and thrown on a bench above; the stone was solidly set in cement mortar for twelve hours, but the men were unable to put in the dowel, having to leave the rock in consequence of the heavy sea.

At the close of the season's work, on October 3, we had raised the pier to a height of 18 feet, being eight courses of stone exclusive of the zero course, which was 4 feet high, making a total of 22 feet in height.

The small force of men which had been employed at the quarry and stoneyard in getting out and dressing stone during the fall of 1887 and the spring of 1888 were discharged in March of the latter year, and the work entirely suspended for lack of funds.

An appropriation made March 30, 1888, becoming available in April, two vessels

from the quarry to the stoneyard at the rate of $2 per ton, and also made a contract with Mr. Simpson to build quarters at the quarry for $700.

During the spring of 1884 work was pushed at the quarry and stoneyard so as to have a few cargoes of cut stone ready for shipment to the rock. About the 1st of May the steamer *Whitelaw* was chartered and sent to Humboldt Bay, with heavy backing anchors, and took aboard a large boom derrick. She proceeded to the rock and set the moorings, and, taking advantage of the fine weather on July 2, we got the derrick placed in position and secured. The dimensions of this derrick were as follows: Mast, 20 by 20 inches by 50 feet long; boom, 20 inches diameter in the slings by 90 feet long, with two stiff legs 78 feet long. At the same time the schooner *American Boy*, a vessel of 178 tons, was chartered and fitted up in Humboldt Bay, to be used for workmen's quarters at the rock.

As the appropriation act of July 7, 1884, contained only $30,000 for Northwest Seal Rock work was at once suspended and both vessels discharged, as work on the rock could not be carried on advantageously at a less expenditure than $15,000 per month, or say $75,000 for the season. A force of from 12 to 20 quarrymen and laborers and from 8 to 10 stonecutters were employed at the quarry and stoneyard until October 31, 1885, when they were discharged and the property placed in charge of a watchman.

To provide against further deterioration of plant and the possible loss of the big derrick, a working force was sent from Humboldt Bay, and a steamer chartered which spent the month of June, 1885, in raising all the moorings except one, which was replaced and rebuoyed, the big derrick was also secured against possible loss from its exposure to the heavy seas. During the time the vessel was thus engaged the outline of the pier was marked off with brass brads placed at the center of each stone, header and stretcher.

An appropriation of only $40,000 being made for the work by the act of March 3, 1885, the idea of running work at the rock in the spring of 1886 was abandoned, and as no appropriation was made in 1886 no work was planned with the available funds other than the necessary care of property.

On the closing of the work in the fall of 1885 the result of what had been done at the quarry and stoneyard were as follows:

Dimension stone quarried	cubic feet..	5,439
Backing quarried	do....	4,450
Dimension cut (220 blocks)	do....	5,994
Backing cut	do....	9,006
Total dimension stone on hand	do....	15,052
Total backing on hand	do....	23,138
Total dimension stone on hand, cut	blocks..	419
Number of dimension stone on hand, uncut	do....	133
Rough backing quarried on hand	cubic feet..	6,000

Thus far but one season's work had been done at the rock in preparing the site during the summer of 1883, at a cost of $46,009.17. During 1884 the sum of $9,500 was spent in laying moorings and preparing for the season's work, which was worse than useless, as it cost about $6,000 in 1885 to lift these moorings and taking precautions for the safety of the plant erected the season before.

In four years only one working season of about one hundred working days was utilized advantageously on the rock. During a part of this four years other attempts were made to work on the rock, but on account of small and insufficient appropriations expensive plant had to be hired, property and plant which we had and which for lack of appropriations could not be used, deteriorated by exposure, rot, and rust, all of which combined to make the first four years of the work unduly expensive.

An appropriation of $120,000 having become available March 4, 1887, authority was given for preparing and laying stone by hired labor, for the purchase of plant in open market, and charter of vessels necessary on the best terms obtainable.

were chartered, namely, the wrecking steamer *Whitelaw* and the steam schooner *Del Norte*. The *Whitelaw*, being required first, sailed from San Francisco on April 19, with men, chain for moorings, rigging, tools, etc., arriving in Humboldt Bay on the 22d, making a poor passage owing to strong head winds. After taking aboard lumber for landing and men's quarters on the rock, riggers and carpenters at Humboldt, we sailed for Northwest Seal Rock on April 26.

The weather being favorable we finished the wharf, with quarters under it to accommodate 50 men, erected derricks and large hoisting engine, and reset the moorings, all being ready when the *Del Norte* arrived with the first cargo of building material on May 26, when mason work was at once resumed and prosecuted vigorously until the *Del Norte* was discharged and work suspended for the season. The *Whitelaw* was discharged on July 1, as we found the *Del Norte* quite capable of supplying material as fast as we could use it.

At the closing up of the work the thirteenth course of masonry was laid, five courses being built during the season, bringing the pier to a height of 28 feet, excluding zero course, or a total of 32 feet from the bottom bed of zero.

The weather during this short working season was very favorable, and having the workmen's quarters on the rock a vast amount of time was saved daily getting on and off. The work was prosecuted rapidly without accident or delay.

An appropriation of $200,000 having been made and approved March 2, 1889, bids for the supply of a steamer were invited. They were opened in April, when the steamer *Del Norte*, being the lowest offered, was chartered for $5,000 per month. She sailed for Humboldt Bay on April 11, where she took on board men and material and proceeded to the rock. Upon arriving we at once repaired moorings, rigged derricks, and began setting stone on the fourteenth course April 30.

The heavy timber dwelling used for workmen's quarters, which was built the previous season, had been badly damaged by the sea during the eight months' interval. Work was pushed with a force of about 50 men, being the utmost which could be employed profitably.

The weather this season was more severe than in 1888, but rather an improvement over 1887. The men's quarters, although strongly built, were smashed in during a gale about 2 o'clock one morning in May. No one was injured, but some of the men were washed out of their bunks.

By October the pier was finished, eight courses being laid during the season, the walls of boiler room, coal rooms, and storerooms built up and arched over, and the paving of pier laid, with the exception of a small portion. The season of favorable weather being now over it was decided to stop the work, measures were taken to secure the property to be left on the rock from damage from winter storms, and the men and steamer were discharged.

Work was continued at the stoneyard and the quarry, preparing stone for the tower, all of which was completed by July 1, 1890, when all the workmen were discharged and the stoneyard placed in charge of a watchman.

No attempt was made to work at the rock during the season of 1890, as the available funds would not warrant it, and no further appropriation was made until September 30, 1890, when $81,000 became available. This made a total of $721,000 appropriated, which was the estimated cost of the structure.

Early in 1891 preparations were commenced for the completion of the station, and on March 28, 1891, bids were opened for a supply steamer. The steam schooner *Sunol* being the lowest offered in terms of the specifications, she was accepted at $4,000 per month; she left San Francisco April 10, with men and supplies, arriving at Humboldt Bay on the 11th, got her cargo of moorings, derricks, lumber, rope, tackle, stone, sand, cement, fresh water, and a working force of 50 men aboard by the 17th, but was delayed by rough weather until the 21st, when she crossed the bar at 10 o'clock a. m., arriving at Seal Rock on the evening of the same day.

We found our quarters on the rock badly wrecked and no mooring buoys in sight;

by the 29th we got all moorings set. Two of our former moorings were recovered by dragging, the other two could not be found, and we had to replace them with new.

By May 1 we got our quarters repaired and the big derrick rigged and commenced setting flagging on top of the pier. The weather during April and the early part of May was rainy, with strong southerly winds and heavy seas most of the time. From the middle of May until October the weather was very mild and favorable for working. We set the first stone of the tower on May 13 and the last on August 23.

A four-boom derrick was rigged inside of the tower for supplying masons with material; it also served for an inside scaffold; a double hoist was also erected for mortar supply, and the falls of both hoists were carried to steam winches.

Only one serious accident happened during the construction of the tower; on June 16, one of the riggers, while letting go a tag line of the big derrick boom was carried over the pier and killed.

From August 23 to October 29 the time was occupied in taking down scaffolding, erecting ironwork, pointing stonework, putting in concrete arches in tower, laying concrete floors in rooms in pier and upper hallways, leveling platform for landings, derrick seat and hoisting-engine bed, building donkey-engine house, plastering rooms in tower, carpenter work, painting metal work, and varnishing all woodwork, and in setting up the fog-signal boilers and machinery. All work was finished by the end of October, but we were unable to get the men from the rock until November 8, owing to the heavy sea. This completed the work with the exception of the lens, which had not arrived from Europe.

The station was left in charge of three keepers, and all men, tools, and rigging put aboard the steamer; all the moorings were lifted and the steamer sailed for San Francisco. The tools were stored in Yerba Buena Island storehouse and the men and steamer discharged November 18, 1891.

DESCRIPTION OF THE WORK.

The outline of the pier being blasted off, the outer base ring 10 feet wide was accurately finished with patent hammers, the center cone was roughly stepped to receive the masonwork, provision being made for storing 77,000 gallons of water in the base.

The outside courses of pier are 2 feet and 2 feet 6 inches high, built in Flemish bond, headers 5 feet deep on bed by 2 feet 6 inches wide on face, the stretchers 2 feet 6 inches on bed by 5 feet 8 inches on face. All the horizontal beds are connected by a 2-inch diameter dowel of gun metal in each block and projecting half its length into the course below except the upper course, in which the dowels were omitted all vertical joints of outside stones were dovetailed or joggled into each other. All the outside joints were three-sixteenths of inch wide; the faces of pier stones were pointed off fine with 2-inch margins cut on joints. The top of pier is laid with stone flagging 12 inches thick, finished with 8-cut patent hammers. This serves as a watershed with a fall of 3 inches from center to gutters cut in the stone at the outer rim, and from thence the water is carried in a 4-inch diameter pipe to the cisterns in the base of the pier. For the prevention of leakage, all the joints in the top of the pier were cleaned out to the depth of 2 inches and then thoroughly calked with sand and cement slightly moistened with boiled linseed oil. All walls of rooms inside of pier—namely, fog-signal room, coal rooms, storerooms, hallway, etc.—are of square rubble laid with one-quarter inch joints and faces finished with point and pointed with round jointer, leaving a concave joint.

The corners, jambs, lintels, and sills of tower are natural face with 2-inch margin joints, the corner belt courses and porch are 8-cut patent hammer work, and all the outside joints of the tower are calked the same as top of pier and finished with key jointer.

The brick inside of air spaces is laid in cement mortar, the brickwork in staircases and lower entrance hall is laid in black mortar and finished with raised bead joints.

All outside of pier and tower is laid in mortar composed of one part of Port-

land cement to one part of sand; all inside filling and backing stone is laid in one part of Portland cement to two parts of sand; all the concrete roof arches in pier and the floor arches in tower are composed of one part of Portland cement to one and a half parts of sand and three parts of gravel; the concrete under the fog-signal floors, landings, engine bed, and base of derrick is one part of Portland cement to two parts of sand and four parts of gravel or granite chips.

The woodwork is as follows: The floors in keeper's quarters are of seasoned Humboldt pine 1½ by 3 inches, vertical grain, tongued and grooved, laid on joists beveled on upper side and let into concrete arches; all surfaces of floors are polished and varnished. The inside doors, wainscoting, etc., are of Port Orford cedar with redwood panels; all other trimmings are redwood; the outside doors and windows are oak, all polished and varnished. The keeper's rooms are finished with three coats of plaster, sand finished.

All the metal work received four coats of paint.

Three tables are inclosed: No. 1 gives the cost of the various items of expenditure and the percentages of each on the entire cost; table No. 2 divides the cost of the labor among the various items, and table No. 3 shows the cost of transportation from the stoneyard to the rock and the amount carried.

Respectfully submitted,

A. BALLANTYNE,
Superintendent of Construction.

TABLE No. 1.—*Expenditures incurred in construction of Light-House and Fog-Signal Station on Northwest Seal Rock, St. George Reef, California.*

Items of expenditure.	Rock.	Stoneyard.	Stone quarry.	Totals.	Per cent.
Labor	$123,578.47	$78,045.62	$100,751.86	$302,375.95	42.9132
Superintendence	15,587.00	18,168.68	8,877.90	42,633.58	6.00
Fuel	2,343.03	1,535.74	926.68	4,805.45	.6820
Cement	15,773.00	.....	.....	15,773.00	2.2330
Buildings and plant	45,167.43	13,040.66	8,419.11	66,627.20	9.4560
Transportation	123,496.47	807.90	*30,041.39	154,345.76	21.9050
Bricks and lime	1,247.87	.....	.....	1,247.87	.1776
Office expenses	611.80	559.77	560.23	1,731.80	.2460
Powder	917.22	.....	719.96	1,637.18	.2323
Oil and waste	399.12	86.62	63.40	549.14	.0780
Plate glass and metal work	12,322.76	.....	.....	12,322.76	1.7490
Lens, etc	15,491.00	.....	.....	15,491.00	2.1990
Fog-signal apparatus	3,439.11	.....	.....	3,439.11	.4880
Plumbers' materials	748.75	.....	.....	748.75	.1062
Carpenter work, hardware, paint	1,084.56	.....	.....	1,084.56	.1540
Moorings	57,002.41	.....	.....	57,002.41	8.0900
Vessels for quarters	11,144.41	.....	.....	11,144.41	1.5820
Bronze dowels	2,599.92	.....	.....	2,599.92	.3700
Gravel	680.00	.....	.....	680.00	.0970
Drugs	49.77	.....	13.13	62.90	.0090
Adorite	92.81	.....	.....	92.81	.0132
Royalty on stone	.....	.....	6,841.49	6,841.49	.9710
Plugs and feathers	.....	.....	438.73	438.73	.0622
Right of way to quarry	.....	.....	300.00	300.00	.0430
Boats	658.00	.....	.....	658.00	.0933
Total	434,434.91	112,244.99	157,953.88	704,633.78	100.0000

* This item includes transportation of stone from quarry to yard.

TABLE NO. 2.—*Cost of labor on different items.*

175,260 cubic feet of stone (granite), quarried at 42.26 cents per foot	$75,067.21
Cutting broken ashlar, 13,091 cubic feet, at 45 cents per foot	5,890.95
Cutting backing (rough squared), 109,965 feet, at 18 cents per foot	19,793.70
Cutting dimension stones, 52,204 cubic feet, at $1.766	92,220.22
Handling material at yard, 19,610 tons	11,524.45
Preparing site	17,500.00
Plumber	480.00
Carpenters	750.00
Setting up metal work, stairs, railing, etc	890.00
Laying concrete arches, 2,922 cubic yards	2,766.00
Laying concrete floors, 3,340 square feet 2 inches thick	668.00
Erecting engine, engine-house, and derrick	460.00
Painting	360.00
Plastering	480.00
Bricklaying (94,000)	840.00
Setting 175,260 cubic feet of granite, at 41.47 cents per foot	72,685.42
Total	302,375.95

Table No. 3.—Quantities of material transported to rock from stoneyard.

	Tons.
Stone	14,307
Sand	1,439
Wood and metal	160
Cement	915
Fresh water	1,787
Coal	220
Provisions	90
Brick	335
Tools, derricks, rope, chain, etc	85
Gravel	272
Total	19,610

At $6.296 per ton, $123,496.47.