

SECT. II.—OTHER SELECTED PAPERS.

No. 1,515.—“The Encroachments of the Sea from Spurn Point to Flamboro’ Head, and the Works executed to prevent the Loss of Land.” By ROBERT PICKWELL, Assoc. Inst. C.E.

THE Author believes that an account of the ceaseless loss of land going on along this part of the coast of Yorkshire, of its geological formation, and of the works constructed as defences, some of which have been carried out under his personal direction, may prove of interest to the Institution. The subject bears, to some extent, upon the vexed question of the source of the enormous amount of alluvium in suspension in the waters of the Humber, which is so great a difficulty in dealing with the improvement of the navigable channels of the estuary. There is another question upon which this subject also bears, namely, the possible ultimate outflanking and destruction of the Spurn neck and lighthouses, and the consequent loss of the great harbour of refuge in the Humber. In order to give reliable facts and data, the Author made a personal survey of the coast from Spurn Point to Flamboro’ Head, examined all the old plans of the district upon which reliance could be placed, and took careful measurements and notes in each parish along the coast.

The communication may be divided as follows:—

1. An account of the loss of land along the coast from early times down to the present from actual admeasurement.
2. An account of the engineering works to resist the inroads of the sea, with their relative cost, &c.
3. The Author’s view of the effect of this waste of coast upon the navigation of the Humber.

1. AN ACCOUNT OF THE LOSS OF LAND ALONG THE COAST FROM
EARLY TIMES TO THE PRESENT. (Plate 4).

This subject has already been alluded to in communications by Mr. Oldham, M. Inst. C.E.,¹ and by Mr. Shelford, M. Inst. C.E.,² Smeaton, in his “Narrative of the Building of the Eddystone

¹ *Vide* Minutes of Proceedings Inst. C.E., vol. xxi., p. 454.

² *Ibid.*, vol. xxviii., p. 472.

Lighthouse," put the loss at 10 yards per annum. Mr. Oldham, in evidence before a Select Committee of the House of Lords on the Holderness Embankment and Reclamation Bill, April 1866, chap. 360, p. 20, reckons it at $2\frac{1}{4}$ yards, Mr. Shelford at $2\frac{1}{4}$ yards per annum, and the "North Sea Pilot" states it to be 10 feet per annum. The Author believes that the loss named in the above papers though correct for a limited locality, and at the time when the measurements were taken, cannot represent the loss along the entire coast.

Although Spurn Point does not strictly come within the subject of the wasting cliffs, it may fairly claim attention. This long, spoon-like neck, projecting from the mainland at Kilnsea for 2 miles southward into the Humber, is entirely formed of shingle and sand, through which the sea percolates freely. About the year 1860 a boring was made in the lighthouse, and nothing but shingle was found at a depth of 50 to 60 feet; the water rose and fell with the tide, and corresponded nearly with the sea both in level and taste. "Ravenser" was situated here and on the mainland; for in Kirby's Inquest, 1295, it is stated that "The heirs of Ingram de Risum hold in Ravenser 2 carucates (240 acres), where 48 carucates make a knight's fee." Mr. Shelford has stated the known movements of Spurn Point southwards and westwards to 1864.³ The Author's measurements in September 1875 show a further southward extension of 60 yards since 1864, or 5.4 yards per annum, while the movement westward has been arrested. Since 1864 there has been a gain of land extending eastward, due to the joint effect of the prohibition by the Board of Trade of the removal of shingle from the beach, and of the groynes built by Sir John Coode, M. Inst. C.E. There has been no waste at the High Lighthouse from 1869-70 to 1875, the gain of land eastward along the entire length of the neck varying from 30 to 80 yards in width, or an average of 6 yards per annum. The material is composed of shingle and drift sand, in many places 8 to 10 feet above high water spring tides, grown over with mat grass.

Proceeding northward, the mainland is first met with at Kilnsea. Here the boulder clay sinks low, and the drift is exposed to the action of the waves. Hence, at this and similar depressed cliffs, the sea has made greater inroads than on higher cliffs, where the boulder clay forms a strong natural revetment wall at their foot. The loss at this point has been great. In Doomsday, 1080, Morcar had $13\frac{1}{2}$ carucates of land to be taxed, or 1,620

³ *Vide Minutes of Proceedings Inst. C.E.*, vol. xxviii., p. 480.

acres. In 1852 the extent of Kilnsea was only 911 acres, giving a total loss of 709 acres since 1080. This, with the present frontage to the sea taken as an average, gives a width of 1,950 yards washed away in seven hundred and seventy-two years, or 2·5 yards per annum. In 1766 the chancel of Kilnsea Church was 95 yards from the cliff; in 1833 only 4 yards of the west end of the church were standing, so that, allowing 30 yards as the length of the church, there had been a waste of 120 yards in sixty-seven years, or 1·8 yard per annum. From 1833 to 1847 the average loss was 5 yards per annum, and the whole of Kilnsea has been destroyed during the last century. The "Blue Bell" in New Kilnsea has a stone built into its east wall, inscribed, "Built in year 1847; distance from sea 534 yards." In September 1876 it was 392 yards from the sea, so that the loss has been 5 yards per annum. At the north end of the parish, Mr. Tennison's farmhouse is 242 yards from the cliff, the loss since 1840 having been 5·3 yards per annum. The parish has lost 220 acres, including the entire village and church, since 1818, which if the land be valued at £50 per acre, gives a loss of £11,000. It has been necessary from time to time to construct at this place embankments across the depression in the cliffs, to prevent the flood tides inundating an extensive area of cultivated land.

The same irregularity in the loss appears at Easington, where the boulder clay sinks below high water. On the Author's recommendation, and for future reference, a stone was built into the east wall of Mount Pleasant Cottage, at the east end of Easington, to indicate that in 1876 the cliff was 616 yards distant due east. In 1771 the same point was 880 yards distant, and up to 1852 the annual loss was 1·8 yard per annum; from 1852 to 1876 it was 5 yards per annum. North of the village another depression occurs in the cliff, and the sea has scooped out a bay 300 yards across the mouth, and 40 to 50 yards broad. Easington Church in 1771 was 1,056 yards from the cliff; in 1833 this distance had been reduced to 968 yards, causing a loss of 1·4 yard per annum; and from that time up to 1852 the loss was 1·4 yard per annum. In 1876 the distance of the church from the cliff was 861 yards, the encroachment having been at the rate of 3·3 yards per annum.

At about 1 mile north of the village is the manor of Dimlington. Here the cliffs rise to a height of 60 feet at the south end. According to Doomsday, "In Dimelton there are 5 carucates of land to be taxed," equal to 600 acres, "value in King Edward's time thirty-two pounds, now eight pounds," or £652, now £163. Here certain monks of Meaux Abbey lost 55 acres between 1291

[1877-78. N.S.]

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and 1396. The waste opposite Dimlington Farmhouse has been as follows:—From 1771 to 1852 it was 1·8 yard per annum. In 1876 the distance from the cliff was 194 yards, giving a loss of 5·1 yards per annum. From this point the cliff rises, and at “Dimlington High Lands” attains an elevation of about 110 feet, with 15 to 20 feet thickness of boulder clay at the base. From here the cliffs gradually become lower, and at Outnewton they are from 60 to 70 feet in height. Near the alleged site of the old manor Garth are the ruins of the old chapel. The loss opposite this ruin from 1771 to 1852 was only 0·8 yard of land per annum. In 1876 the ruin was 60 yards distant from the cliff, the loss since 1852 having been 3 yards per annum. The distance of the north-east wall of the cart shed of this farm is 184 yards from the cliff.

At the gorge, separating the parishes of Outnewton and Holmpton, the rate of encroachment by the sea from 1802 to 1852 was 0·9 yard, and from 1852 to 1876 3·5 yards per annum.

The cliffs at Holmpton are about 30 feet high. From Holmpton Church the distance to the cliff in 1786 was 1,200 yards, the loss up to 1802 being 0·5 yard per annum. From that date up to 1833 the loss was 2 yards per annum; then to 1852 it was 0·3 yard per annum; and in 1876 the distance was 1,050 yards, the loss having been more than 3 yards per annum.

The parish of Withernsea has a sea frontage of $2\frac{1}{2}$ miles, and has suffered much; the cliffs are from 10 to 25 feet in height at the south end of the parish. Opposite “Nevilles” farmhouse, from 1794 to 1852, the waste was 0·7 yard per annum. In 1876 the distance from the cliff was 375 yards, the waste having been 2·3 yards per annum. Half a mile farther north the “Intack” farm in 1876 was 220 yards from the cliff. Between 1833 and 1852 the loss of land was 2·4 yards per annum; and since then it has been at the rate of 2 yards per annum. At the village of Withernsea, where only half-a-dozen of the old cottages remain, opposite the southernmost house of the old village on the east side of the high-road, from 1794 to 1852, the loss was 1·1 yard of land per annum. The distance of the house from the cliff in 1876 was 455 yards, and the loss of land had been 145 yards in the twenty-four years, or at the rate of 6 yards per annum. A little north of this are the poor-houses, standing back to the east of the road. Opposite these, from 1794 to 1852, the loss was only 0·5 yard per annum; but the distance from the cliff in 1876 was only 290 yards, the loss having been 135 yards in twenty-four years, or 5·6 yards per annum. Opposite the church the loss from 1794 to 1833 was 1·15 yard per annum; from 1833 to 1852 it was 2 yards per annum,

and in 1871 the distance from the cliff was 315 yards, the loss having been 3·6 yards per annum. Opposite the east end of the old house close to Queen's Terrace, from 1794 to 1852 the loss was 1·2 yard per annum; and in 1871, when the distance from the cliff was 216 yards, the loss had been 4·2 yards per annum. The present watering-place of Withernsea is situated in both Withernsea and Owthorne parishes, and here the cliff disappears below high-water level.

At Owthorne the loss has been similar to that at Withernsea. In 1786 the sea reached the wall of the churchyard, and in 1816 a storm carried a large part of the edifice down the cliff. Almost the last of the tower was gone in 1822. Taking the church to have been 30 yards in length, the waste from 1786 to 1822 was 1·2 yard per annum. The sea gained 70 yards more up to 1852, or 2·3 yards per annum, and an additional breadth of 48 yards up to 1868, or 3 yards per annum. Opposite the east side of the butcher's shop at the corner of the Hull Road, the loss from 1812 to 1852 was 105 yards, or 2·6 yards per annum. Subsequently, up to 1868, a breadth of 46 yards more was lost, or 3 yards per annum. Near the chapel of ease, opposite the west side of the high-road, the loss from 1812 to 1852 was 2·2 yards per annum; then up to 1868 it was 3·3 yards per annum. The distance of the road from the cliff in 1871 was 78 yards, the loss in the intermediate three years having been 3·3 yards per annum. The loss at the farm just outside the village, at the corner of the Tunstall Road, was from 1812 to 1852 71 yards, or 2 yards per annum. In 1871 the distance of the corner of the road from the cliff was reduced to 30 yards, the loss in the interim having been at the rate of 2 yards per annum.

At Withernsea and Owthorne the degradation of the cliff has been arrested by groyne and other defences, put down by the Author in 1870 for the Withernsea Pier, Promenade, and General Improvement Company. Since that date there has been practically no loss of land.

At Waxholme the cliffs are 30 to 35 feet high. At the northern farm the loss of land from 1844 to 1852 was at the rate of 2·6 yards per annum. In 1876 the distance was 92 yards from the south-east corner of the east barn to the cliff. A breadth of 41 yards has been lost during the last twenty-four years, or 1·7 yard per annum.

At Newsam another manor has been lost in the sea, as from Doomsday, "In Ninuehusum Ernwin had 5 carucates of land and 2 oxgangs to be taxed," or at least 600 acres. There is

nothing of this land left now. The loss at the coastguard station, opposite the east end of the rocket apparatus shed, has been from 1844 to 1852 at the rate of 1·2 yard per annum. In 1876 the cliff was 26 yards distant, showing a further loss of 1·7 yard per annum. North of the station is Sand-le-Mere, a dried fresh-water lake with an embankment constructed on its sea face of sand overgrown with bents.

At the village of Tunstall the cliffs are from 35 to 40 feet high, having a base of 15 feet in height of boulder clay. Opposite the east side of Seaside Lane, running parallel with the cliff, the loss from 1777 to 1852 was 1·1 yard per annum. The distance of the lane from the cliff in 1876 was 145 yards, indicating an encroachment of 1·6 yard per annum. Opposite the church, from 1786 to 1833 the loss was 3·4 yards per annum; then up to 1852 a further loss of 0·7 yard per annum occurred; and in 1876 the distance from the cliff was 710 yards, showing a further loss of 1·7 yard per annum.

Monkewike has been almost all lost in the sea. According to Doomsday it contained "2 carucates of land," or 240 acres; now almost all is gone.

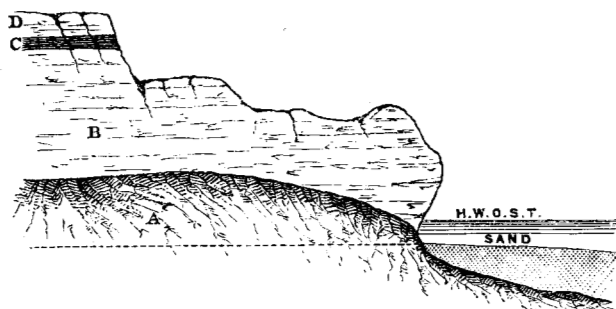
Opposite Hilston Church, from 1777 to 1852 the loss was 1·1 yard per annum. In 1876 the distance of the church from the cliff was 1,073 yards, the loss in the meantime having been 1·4 yard per annum. The cliffs here are about 60 feet high, with a stratum of from 15 to 20 feet of boulder clay at the base. Opposite "Hilston Mount," or "Admiral Storr's Towers," from 1832 to 1852 the loss of land was 1 yard per annum; and in 1876 the distance from the cliff was only 1,140 yards, the loss in the interim having been at the rate of 1·66 yard per annum.

The waste of these cliffs is not by any means regular, or even gradual, but occurs at intervals in huge landslips, 200 to 600 yards long, and from 20 to 50 yards in width; after which there is generally no more loss at these points for three or four years, until the looser material of the slip itself and the base on which it had rested have been washed away, leaving the cliff face proper exposed. In time the waves undermine the foot, and by the aid of frost and land water bring down fresh slips. Figs. 1 and 2 represent two landslips at this point of the cliff. The base A, of boulder clay, stands up as a revetment wall almost perpendicular for 20 feet in height; B is the old drift of sand, gravel, clay, &c.; at C is a fresh-water deposit, 60 to 65 feet above the sea-level, about 5 inches deep; and D is the "new drift," or surface covering.

In Doomsday, Grimston is stated to contain 6 carucates of land,

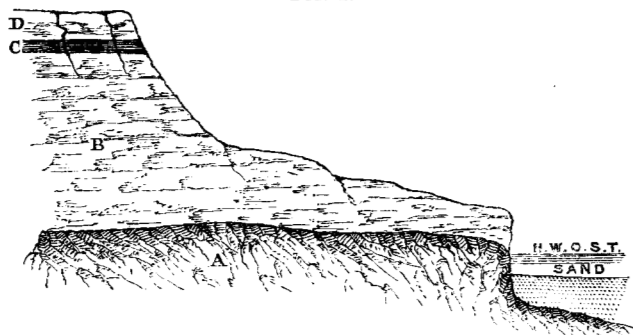
or 720 acres; according to the survey of 1782 it only contained 275 acres, the loss of land having been 445 acres in seven hundred years. Opposite the present Grimston Hall, from 1833 to 1852 the loss was at the rate of 1·3 yard per annum. In 1876 the distance of the hall from the cliff was 675 yards, 25 yards having been lost

FIG. 1.



in twenty-four years. Opposite the farmhouse, on the site of part of the ancient Grimston Garth, the seat of the Grimstons since the Conquest, the loss from 1833 to 1852 was 1·3 yard per annum. In 1876 the distance of the farmhouse from the cliff was 240 yards, the encroachment of the sea in the interval having been 60 yards,

FIG. 2.

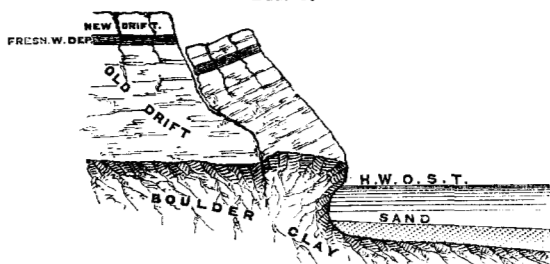


or 2·5 yards per annum. Here, again, the cliffs are about 70 feet in height, and exhibit landslips in different stages of progress. Fig. 3, a sketch of one of the slips in an early stage, shows how the sea, after clearing away all remains of the preceding slip, acts at the foot of the boulder clay base, undermining it until the superincumbent earth eventually breaks away and slides gradually

down to the foot. This description of slip occurs when the beach is unusually low, and admits of deep water at the cliff foot.

"Ringborough," at the south end of the parish of East Newton, has suffered much; the cliffs are about 45 to 50 feet high. Opposite the west end of this farmhouse, from 1833 to 1845 the loss of land was 0·7 yard per annum; from that date up to 1852 the loss

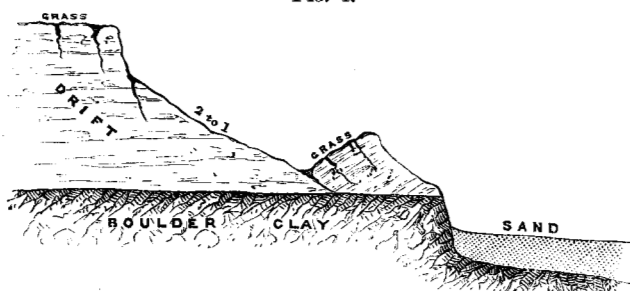
FIG. 3.



was 3 yards per annum; and in 1876, when the distance of the farmhouse from the cliff was 207 yards, a breadth of 70 yards had been lost in twenty-four years.

"Thorp," which according to Domesday contained 5 carucates and 6 oxgangs of land, or 690 acres, is now reduced to about 148 acres, the loss having been 540 acres in seven hundred years. Fig. 4 shows another landslide at this point in a more advanced

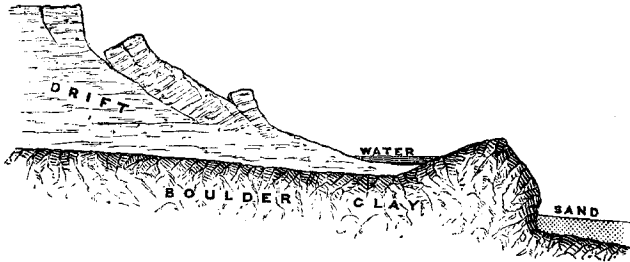
FIG. 4.



stage of progress, with only a small portion of the material of the original slip left upon the ledge of boulder clay. This slip is from 50 to 60 yards long and 30 yards wide. It is probably two or three years old, and will soon be cleared off, to be followed by a steep undermined cliff face and an ultimate heavy slip. At the north end of this parish the cliffs are still about 70 feet high, and

present slips in various stages of progress. Fig. 5 shows one such slip, 300 yards in length and from 40 to 50 yards in width. This

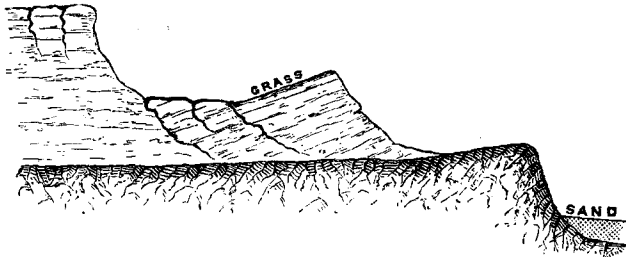
FIG. 5.



is an old slip with a very tough foot of boulder clay. Fig. 6 is a sketch of another slip of more recent occurrence, although not by any means new; this is about 200 yards in length, where the cliff is 70 feet high.

The cliffs at Aldborough are about 70 feet high, and at the present time are suffering very much from landslips. Indeed, almost the whole length of the cliff in this parish may be regarded as one huge landslip from end to end. At the south end of the parish there is a landslip 900 yards in length, and from 50 to 60

FIG. 6.



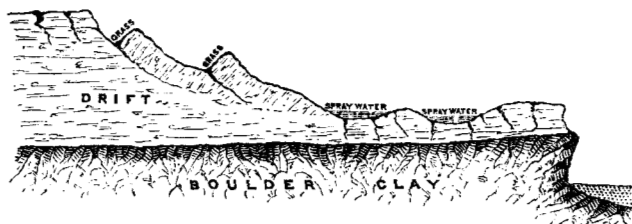
yards in width; and here it will be noticed (Figs. 7 and 8) how the back water of the storm waves, breaking up the foot of the cliff, draws down the slope of the cliff into a succession of slips, which eventually are washed completely off the ledge of boulder clay. The land springs are the chief cause. In this parish the site of the old church is now far out to sea; but the present church, in 1786, was $2,043\frac{3}{4}$ yards distant from the cliff, the loss being, up to 1832, 2 yards per annum; a further loss of 23 yards was incurred up to 1852; and in 1876 the distance was 1,890 yards the rate of degradation having been 1·7 yard per annum.

Great Colden is close to the edge of the cliff, here about 35 feet high. From 1764 to 1833 the loss opposite the nearest farmhouse to the cliff was 1·3 yard per annum. Opposite the old house within the ancient moat, near the Cross Keys public-house, the loss of land since 1852 has been 2·8 yards per annum.

At Mappleton the cliffs are about 50 feet high. The total loss of land from 1786 to 1874 has been 206 yards, or 2·3 yards per annum.

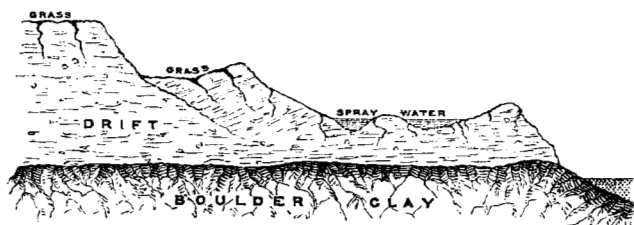
At Hornsea Burton the cliffs are from 30 to 40 feet high. By

FIG. 7.



Kirby's Inquest the "heirs of Gilbert de Mappleton" held here 6 carucates of land, or 720 acres. The area in 1852 was reduced to 409 acres, showing a loss of 311 acres. Taking the present sea frontage of 1,400 yards to be an average of that lost, the above is equal to a screed of land 1,075 yards in breadth lost in five hundred and seventy-one years. By an inquest held in 1400, it appears that

FIG. 8.



between the years 1334 and 1400 the Abbey of Meaux lost 27 acres of land. Opposite the brick-yard cottage at the south end of Hornsea Burton, from 1845 to 1852 the loss was 11 yards; and from 1852 to 1876 it was 1·4 yard per annum. Opposite the east side of Hornsea Burton farmhouse, from 1845 to 1852 the loss of land was 6 yards. In 1876 the distance of the house from the cliff was 208 yards, indicating a loss of 1·3 yard per annum. Oppo-

site Hornsea, another depression in the cliffs is the site of an ancient fresh-water lake. Hornsea Beck, a hamlet anciently close to the present Hornsea, stood about 500 to 600 yards beyond the existing cliff. The loss here and at Hornsea was the subject of early investigation. At an "Inquisition held at Hornsea, on the 28th of April, 1609, 7 James I.," "George Fenwick, Gent., John Goldwell, Gent., and eighteen of the yeomanry made oath to this effect: We find decayed by the flowing of the sea in Hornsea Beck, since the first year of King Edward VI., 1546, thirty-eight houses and as many little closes adjoining. Also we find, since the same time, decayed in ground the breadth of twelve score yards throughout the fields of Hornsea" (or 4 yards per annum). In this inquiry, John Galloway, of Hornsea, said that "there doth usually every year waste the breadth of 40 feet, which is more than heretofore." This statement is referring to the loss after the destruction of the pier at Hornsea. "Ed. Harrison, aged eighty, also said that he has known 300 yards washed away; and that there was a peere at Hornsey Beck, during the continuance whereof the decay was very little." From measurements made by a Mr. John Harrison, in 1757 and 1759, it appears that the loss was 11 yards 4 inches in one year and five months. The house from which the above measurements were taken was washed away in 1785. This house in 1759 was 50 yards distant from the cliff which indicates a loss of 2 yards per annum. Opposite the church, from 1786 to 1836 the loss was 2·7 yards per annum. Then up to 1852 the loss was 2·1 yards per annum; and in 1876 the distance to the then high-water mark was 930 yards, showing a loss of 1·5 yard per annum. These measurements were taken opposite the low lands at Hornsea Gap, there being no cliff, and are consequently only approximate, as the high-water mark varies with the state of weather and amount of beach. Opposite the road running east and west, and immediately south of the Marine Hotel, from the east side of its junction or cross-road with the north and south road, from 1809 to 1852 the loss of ground was 2 yards per annum. In 1876 the same point was only 283 yards from the cliff, the loss having been 1·8 yard per annum. The loss at the boundary of Hornsea Burton and Hornsea close to Stream Dyke running through Hornsea Gap, from 1809 to 1845 was 88 yards, equal to nearly 2·5 yards per annum; and from 1845 to 1876 the loss of ground was 55 yards, or 1·8 yard per annum. At the northern end of Cliff Lane, which runs north of Hornsea nearly up to Atwick parish, opposite the east fence of the lane, from 1809 to 1852 the loss was 2·7 yards

per annum. In 1876 the distance of the fence from the cliff was 167 yards, the loss of land in the interval having been 2.1 yards per annum.

At Atwick the cliffs are from 30 to 35 feet high. At the south end of Long Lane, situated between the village, the cliff, and opposite the east fence of the same, the loss from 1769 to 1852 was 2.1 yards per annum. In 1876 the distance was 242 yards, indicating a loss of 24 yards in twenty-four years. In this parish there is an ancient stone cross on the village green. It is stated in "Pol. Hist. Holderness" that "As lately as the year 1786 the cross was distant from the sea 33 chains 61 links. It is now scarcely half that distance." This statement should be received with caution, and must be incorrect, as the Author found that as lately as 1852 this cross was 37.50 chains, or 825 yards from the cliff, and that in 1769 it was 1,012 yards, showing a loss of 2.25 yards per annum; and in 1876 the distance was 800 yards, or 25 yards lost in twenty-four years.

Skirlington, in Atwick, is a little north of the latter, and is returned in Doomsday as containing 5 carucates of land, or 600 acres. The area in 1756 was 335 acres, and in 1852 only 328 acres. The total loss since 1080 appears to have been 272 acres. Taking the present sea frontage to represent that already washed away, these quantities give a total loss of 2,500 to 3,000 yards in breadth in eight hundred years. The actual loss of land from 1769 to 1852 was 1.9 yard per annum. Between 1852 and 1876 the total loss was 36 yards.

At Skipsea the cliffs are from 30 to 35 feet high, with a fresh-water valley between them running inland. South-east of Skipsea village is the site of the ancient hamlet of Cleton, or Clayton, now lost in the sea. Opposite the east side of Cliff Lane, from 1765 to 1852 the breadth of land lost was 172 yards. In 1876 the distance of Cliff Lane from the cliff was 124 yards, indicating a further loss of 34 yards in twenty-four years. A little farther south is a low fresh-water peat valley, called "Withow Hole," the site of the ancient hamlet of Withow, now lost in the sea. The peat bed is 150 yards long, with fresh-water sediment 5 to 7 inches thick, and peat 1 to 2 feet thick. To the north of this point, and directly east of Skipsea, stood the ancient village of Hyth, or Hyde, also lost in the sea. According to the chronicle of the Abbey of Meaux, it was totally destroyed as early as 1396. Opposite the west end of the cottage in Cliff Lane, situated two fields north of the road from Skipsea to the sea, from 1765 to 1852 the loss of land was 183 yards. In 1876 the distance of the cottage

from the cliff was 165 yards, indicating a further loss of 18 yards in twenty-four years.

Farther north, just within the parish of Ulrome, is a farmhouse south of that known as "Sea Breezes." The loss of land here from 1765 to 1852 was at the rate of 1.3 yard per annum. The distance from the east face of the house to the cliff in 1876 was 153 yards, showing an additional loss of 27 yards in twenty-four years. At Ulrome the cliffs are from 10 to 20 feet high, the boulder clay occasionally disappearing altogether. The loss of land at the coastguard station from 1766 to 1852 was 0.8 yard per annum; from 1852 to 1876 the loss was 1.5 yard per annum. At the north of the parish, near the Barmston Drain, the loss of ground from 1756 to 1766 was 40 yards, or 4 yards per annum; from 1766 to 1852 an additional breadth of 35 yards of land was lost, while from 1852 to 1876 the loss was 2.7 yards per annum. The east side of the wooden horse-bridge across the Barmston Drain being 230 yards distant from the cliff in 1876.

At the south end of the parish of Barmston, the loss from 1756 to 1852 was 87 yards; and from 1852 to 1876 the loss was 2 yards per annum. North of this parish stood the ancient village of Hartburn, now lost in the sea. At this point the loss of land from 1756 to 1852 was 66 yards, and from 1852 to 1876 it was 14 yards.

The township of Auburn has almost all been lost, the ancient village bearing the same name having been entirely washed away.

Wilsthorpe is another small township, of which the village of the same name has also been entirely lost in the sea.

At Hilderthorpe the cliffs are from 25 to 30 feet high, and they contain large quantities of chalk drift. A little north of the village the loss of land from 1805 to 1852 was 2.1 yards per annum. In front of Colonel Rhode's estate the loss from 1852 to 1872 has been computed at 2.2 yards per annum. Immediately to the south of the Bridlington Quay South Pier the loss of ground from 1805 to 1852 was 2 yards per annum, and from 1852 to 1872 it increased to 3.5 yards per annum. Bridlington Quay (of which Hilderthorpe forms part) has suffered little in actual loss since the erection of the harbour and pier works, and the masonry and timber promenades along the edge of the cliff. Immediately to the north of the North Pier, the cliffs have been protected by the pier, causing an accumulation of beach. The loss opposite Fort Hall from 1771 to 1852 was 0.4 yard per annum. The loss of ground at Sands Cut, the boundary of Bridlington and Sewerby parishes, from 1771 to 1852 was only 45 yards.

At the south of the parish of Sewerby, opposite the east end of

Sands Cottage, from 1802 up to 1852 the loss of land was 35 yards. In 1877 the distance of Sands Cottage from the cliff was 14 yards, indicating a loss of more than 0·6 yard per annum. At Potter's Hill the breadth of ground lost from 1802 to 1852 was only 7 yards, and from 1852 to 1877 it was 10 yards. From here the clay cliffs gradually give place to the chalk, and the loss gradually decreases. Opposite the Methodist chapel at Sewerby village, the loss from 1802 to 1852 was only 9 yards, and from 1852 to 1877 only 5 yards. A little to the north of Sewerby Hall, the loss of ground from 1852 to 1877 amounted to 24 yards, doubtless due to a recent fall of the cliff.

From this point the cliffs present such resistance to the waves, that the loss is little more than nominal when compared with that of the cliffs already noticed. The decay that does take place here is principally due to the winter frosts.

2. AN ACCOUNT OF THE ENGINEERING WORKS, &c.

(Plate 4, Figs. 1-11.)

From what has already been stated under the head of loss at Hornsea, it appears that as early as the year 1609 the inhabitants were fully aware of the important part the old "pear" played in protecting the cliffs; not so much, the Author presumes, in the capacity of a breakwater as in that of a huge groyne causing a large accumulation of shingle beach.

According to Dr. Whewell's cotidal chart the tidal wave coming in from the Atlantic runs from the shore of the Firth of Forth to that near the Tees in one hour, and from the Tees to halfway between the Humber and the Wash, a distance of 105 miles, in two hours; so that the scour of this wave along the coast from Flambro' to the Spurn is very powerful, carrying with it in a southerly direction the shingle, sand, and mud from the cliffs, the beach travelling more slowly than the sand. It is upon this law that the most successful protective works are based; and it is evident that any diminution of the beach brings about a corresponding amount of actual damage, while any works which tend to increase the beach will most effectually oppose a resistance to the inroads of the sea.

For many years it had been the practice to remove the shingle for sale for the repairs of the parish roads. This custom grew to such an extent that it was not uncommon to see from twenty to thirty vessels beached between Withernsea and the Spurn, taking from 50 to 80 tons each, in a single tide. On the opening of the Hull

and Holderness railway the gravel trade received a great impetus. In 1868 the Board of Trade, by virtue of the Harbour Transfer Act of 1862, issued an order prohibiting the removal of shingle from any portion of the shore at Spurn for a distance of $2\frac{1}{2}$ statute miles northward from the point. In 1869 the Board of Trade further prohibited the removal of shingle from any portion of the coast between Spurn and the northern boundary of Hornsea parish, and in 1869 and 1870 prosecuted certain persons for violating the law. In the evidence it was stated by Sir John Coode, M. Inst. C.E., in 1869, "that if the shingle continued to be removed the port of Hull would be endangered, and that materially so." Mr. James Oldham, M. Inst. C.E., stated that "the removal of shingle would result in the weakening of Spurn Point;" also, in 1870, that "every ton of shingle taken away resulted in damage to the coast." Capt. Cator, R.N., stated "that before the construction of Mr. Coode's groynes there were only 36 paces between high-water mark on the Humber side and high-water mark on the sea side. Now there is between 400 and 500 yards solid beach." "Taking the quantity at 25,000 tons per annum over a period of twenty years, from near Kilnsea, it represented a bank 3 miles long, 31 yards wide, and 6 feet deep removed." Mr. C. G. Clarke, of Withernsea, stated that from 200,000 tons to 250,000 tons had been removed along a length of 2 miles opposite Withernsea between the years 1854 and 1869, equal to 8,000 tons per mile per annum.¹ It is well worthy of remark that the waste of the cliffs prior to the gravel trade was only from 0·7 yard to 1·4 yard per annum. During the time when this trade was carried on the Author found that the loss had increased to from 3 yards to 6 yards per annum.

¹ "Extract from Report of Capt. Vetch, Engineer to the Lords of the Admiralty, dated the 29th July, 1850.

"I believe it may be safely assumed that during the last ten years it has not been less than 40,000 tons—but say 30,000 cube yards of solid material on the average per annum—and if this removal takes place along a length of 15 miles of shore, as alleged by one of the witnesses, there would still be an abstraction of 2,000 cube yards per mile per annum, which would amount to $11\frac{1}{2}$ cube yards for every yard in length during the period of the last ten years, from which fact the full effect of the removal of stones may be truly appreciated; and from 1845 down to the present time the mischief which has occurred appears to have been but too truly anticipated both by the Tidal Harbours Commissioners and the Harbour Department of the Admiralty, and although, by direction of their Lordships, precautions were at last taken, they proved to be too late to avert the evil."

SPURN GROYNES.

In 1864 six groynes were put down at Spurn Point by Sir John Coode, who has had the maintenance of the Spurn since 1863, with a view of collecting the shingle and increasing the beach on the sea side of the point. These groynes were placed at varying intervals from the extreme southern point to the north of the promontory. At the time of their erection the gravel trade had not been prohibited, yet they were so successful that subsequently other intermediate groynes were erected. In the discussion on Mr. Shelford's paper on the Humber,¹ Sir John Coode stated that his object in erecting them was essentially conservative, but the Author found by recent measurements that a great deal more than this had been accomplished. At the extreme point, and at a groyne a little to the north, the line of bent grass had extended 60 and 80 yards respectively to seaward beyond the original line, and along almost the entire neck this line of bents had travelled to seaward from 20 to 40 yards, covering a sandbank of drift from 6 to 10 feet high; which may be called a gain of land equal to 2 to 4 yards per annum. This accumulation of drift sand has been greatly accelerated by constructing small embankments of sand 6 to 8 feet high, and planting them on the top and sea face with bent grass, which binds the sand and prevents drift. During the last four or five years a plant has sprung up here among the bents called the sea buckthorn, which is of rapid growth and greatly to be recommended for similar situations. The Author estimates that there is an accumulation of bent-covered sand along the Spurn neck for a length of 2 miles, equal to 60 yards in width and 6 feet deep. Two groynes are laid down opposite the High Lighthouse, three opposite the site of the great beach of 1849, and others at different points along the entire neck. The first six that were erected are of Dantzic timber piles 10 inches square, shod with iron shoes and driven various depths into the beach. The planking is 3-inch red wood, secured to the piles by $\frac{3}{4}$ -inch screw bolts and nuts. All butt-joints are made on and secured to the southern piles by $\frac{1}{4}$ -inch wood screws and clip plates. The length of the groynes varies with circumstances, likewise the levels and rake of the pile-heads. When they were erected most of them stood five to seven planks above the sea beach at the land end. In September 1876 five of the groynes were covered with shingle to depths of 3 to 4 feet along most of their length.

¹ *Vide Minutes of Proceedings Inst. C.E., vol. xxviii., p. 503.*

The Author is of opinion that there is now an outer belt of beach, in addition to the high bent-covered sands, at least 100 yards wide, 7 feet in average thickness, and $2\frac{1}{2}$ miles in length, equal to 1,250,000 tons of shingle, entirely due to the construction of the works of Sir John Coode, and the prohibition of the removal of shingle; and that the works have been a great success, and have rapidly reduced the chances of the sea outflanking Spurn Point. The cost of these groynes was about £6 per lineal yard.

WITHERNSEA GROYNES (Plate 4, Figs. 1-8).

In 1870-71 the Author, acting for Mr. C. G. Clarke, the contractor to the Withernsea Improvement Company (Limited), after obtaining a provisional order from the Board of Trade for the erecting of groynes and a promenade pier, now built, put down six groynes and an embankment across the low land from cliff to cliff. Two of these groynes were put down on the foreshore belonging to the North-Eastern Railway Company. Before their erection the beach was very low, and after a north-west gale, not uncommonly, the whole of it was swept away down to the bare clays. On the 8th of February, 1868, an unusually high tide occurred, doing alarming damage along the coast; the high-water mark of this tide (Fig. 1) reached a point about 400 feet to the landward of the present ordinary high-water mark. Groynes Nos. 1, 2, 3, 4, 5, and 6 (Fig. 1) were put down at intervals of 200 yards apart, at right angles to the beach, and varied from 300 to 350 feet in length. Figs. 2 and 3 are the section and plan of groyne No. 2; and Figs. 4 and 5 of groyne No. 4. The top of the groynes at the land end are 12 feet above ordinary high-water spring tides, the outer end being 3 to 4 feet above the beach. They were strutted at the south side to resist the pressure of the accumulating beach to the north; and, to oppose as little resistance to the breakers as possible, the top five rows of planks were only added as the beach accumulated.

The main piles are of Dantzig red wood, 13 inches square, 22 to 24 feet long, and shod with 14-lb. shoes of wrought-iron (Figs. 6, 7, and 8). These piles were driven 11 to 12 feet into the boulder clay below the sand. The strut piles are of red wood, 13 inches square and 12 feet long, driven 8 to 9 feet into the clay. The struts are of red wood, 13 inches wide by $6\frac{1}{2}$ inches thick, dovetailed and halved on to the piles, and secured with $1\frac{1}{4}$ -inch screw bolts and cast-iron washers. The planking is of red wood, 4 inches thick by 11 inches wide, in 20 to 25-foot lengths, secured

to the piles with 1-inch screw bolts passing through every plank and pile. Cast-iron washer plates were used in preference to wrought-iron, as the rust is less in the former than the latter. Every butt-joint, provided with a clip washer, was made on the north side of the south piles.

The breakers exerted the most destructive effect at a point corresponding with one and a half hours before and after high water; the temporary road for constructing the groynes for a length of 30 to 40 feet at this point being torn up, whilst above and below it remained unimpaired. Consequently, along this portion of the groynes, the Author caused 30-foot piles to be driven instead of the ordinary 22-foot piles. The result was that when these groynes were erected, most of them stood 8 to 10 feet above the high beach, and 4 to 6 feet above the outer beach; and when the Author took sections of the beach in June 1876, groynes 3, 4, 5, and 6 were entirely buried, and 1 and 2 were buried for two-thirds of their length. The ordinary high water spring tide mark is from 50 to 80 yards farther seaward now than formerly, and since 1871 there has been no loss of land along the coast thus treated. At less than $\frac{1}{4}$ mile to the southward of the last groyne, the sea at high water still reaches the cliffs, while to the northward the effect of the groynes is felt in keeping the high water from the foot of the cliffs for upwards of 1 mile.

The present beach varies in position with varying gales and seas; but the Author estimates that there is an average constant beach of 1,200 to 1,400 yards in length, by 100 yards broad, and 8 to 10 feet thick, or an accretion of 500,000 tons of shingle and sand, due to the prohibition of its removal by the Board of Trade and the effect of the groynes. In addition to the sea beach proper, there is a large accumulation of drift sand at the foot of the cliffs and the groynes, forming a high and dry beach, in many places covered with vegetable growth.

The cost of the groynes was £3 7s. 6d. per lineal yard. With the exception of No. 1, they have not suffered any material damage since 1871. The Author believes that they might have been placed 300 yards instead of 200 yards apart with equally good results, and at a considerably reduced cost per yard of protected sea frontage.

The effect of a south-east gale is to cliff out the beach 3 to 4 feet deep (Fig. 4), and to draw it down to what is called the outer beach; the shingle, however, soon returns to its original position. In January 1877 an extraordinary tide occurred, rising within 1 inch of the highest on record at Hull, and produced by a strong north-west gale which blew for some hours previously;

the tide caused serious damage to the coast generally. Although the sea rolled higher up the beach than on any previous occasion at Withernsea, no damage whatever was sustained by the protected cliff face or groyned frontage. The same tide caused a breach in Mr. Jackson's pile breastwork at Hornsea (described under head of "Hornsea Groynes") about 15 yards long, and some other minor slips.

HORNSEA GROYNES (Plate 4, Figs. 9-11).

On the foreshore of Hornsea, works comprising groynes and breastwork, &c., have been carried out by private enterprise. The Author has only noticed such as are most important. At the north end of this foreshore Mr. William M. Jackson erected two groynes in the year 1869, the northerly one being 132 feet long and the southerly one 102 feet long, at a distance of 150 yards apart. The piles are of Dantzig red wood, 12 inches square and 14 to 15 feet long, driven in pairs, each pair being 6 feet from centre to centre, with the space between filled with red wood planking, 3 inches thick by 11 inches wide. The land thus protected being composed almost entirely of gravel, Mr. Jackson erected a line of pile breastwork along the entire frontage, of which Fig. 9 represents a section of the south end. The breastwork was backed up with clay, and as it is protected by the groynes no loss has occurred since 1869-70. The cost of the groynes was £1 6s. 6d. per lineal foot, and that of the breastwork £4 per lineal yard.

At the north end of the breastwork a light revetment was constructed. Immediately south of these works are the Marine Hotel and its ruined grounds. When the protective works here adopted were carried out the cliff formed a small promontory of boulder clay about 25 to 30 feet high. The breastwork was about 110 yards long, and was adjusted to the form of the promontory. The piles were 13 inches square, driven 4 feet apart from centre to centre, with back waling 13 inches wide and $6\frac{1}{2}$ inches thick, and planking 3 inches thick and 11 inches broad, all well bolted together, and tied with land-ties and piles. This work in December 1876 was in ruins, all the planks being gone except those buried below the sand, and many of the piles. At the north end (Fig. 10) the sea had encroached from 15 to 16 feet behind the piles; at the middle it had encroached 30 feet behind the piles; and at the south end the encroachments had been 62 feet. A groyne, run out from the most prominent point of this breastwork at a cost of about £3 10s. per lineal foot, was speedily destroyed.

At the southern limit of Hornsea foreshore Mr. Wade has erected
[1877-78. N.S.]

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two groynes of a form new to this coast, being constructed of main and sheet piles. The main piles are 13 inches square, of Dantzig red wood 27 feet long, and are driven in pairs with two walings and a centre row of closely-driven sheet piles, 6 inches thick by 12 inches wide and 20 feet long; at the outer end the sheet piles are 3 inches thick by 11 inches wide, all bolted together. The Author believes that this form is not desirable, inasmuch as it presents too many interruptions on its face to the breakers, and also because the sheet piles being fixed at their ultimate height (about 9 or 10 feet) above the surface of the beach, present too great a resisting surface to the breakers, and are more exposed than that form of groyne which admits of the top planks being added and "built up" as the beach accumulates. The total cost of these groynes was about £600.

The Author's experience of the difficulty which exists in penetrating the wet sand beach down to the clay, in order to fix the bottom planks, leads him to believe that a combination of sheet piles at the bottom and of planks at the top is the most efficient form of groyne, both as regards strength and offering a minimum of useless resistance to the breakers. Fig. 11 is an elevation of this form of groyne, the main piles being driven zigzag with a waling between $6\frac{1}{2}$ inches thick by 13 inches deep, fixed on the present level of the beach, sheet piles 6 inches thick by 12 inches wide driven into the clay on the north side of the waling and bolted to it. The top planking is gradually added as the beach accumulates, and is kept 3 to 4 feet above it. The cost of this form of groyne would be about £4 10s. per lineal yard.

3. THE EFFECT OF THE WASTING COAST UPON THE NAVIGATION OF THE HUMBER.

From what has been stated under the head of "Loss of Land, &c.," it is evident that the material of the wasting cliffs of Holderness ultimately finds its way to the Spurn Point, the lighter material and alluvium being carried into the estuary of the Humber, there to be deposited along its banks and bed. This seriously affects the navigation of the river, and is the cause of enormous expense in dredging at the Grimsby and Hull Docks. It appears to the Author that the chief cause of expense to these two flourishing ports, and the difficulties of the Humber Conservancy Commissioners, is to be found in a great measure outside the estuary rather than in the tributary rivers. Mr. Redman, M. Inst. C.E., in the discussion on the outfall of the Humber, estimates the amount

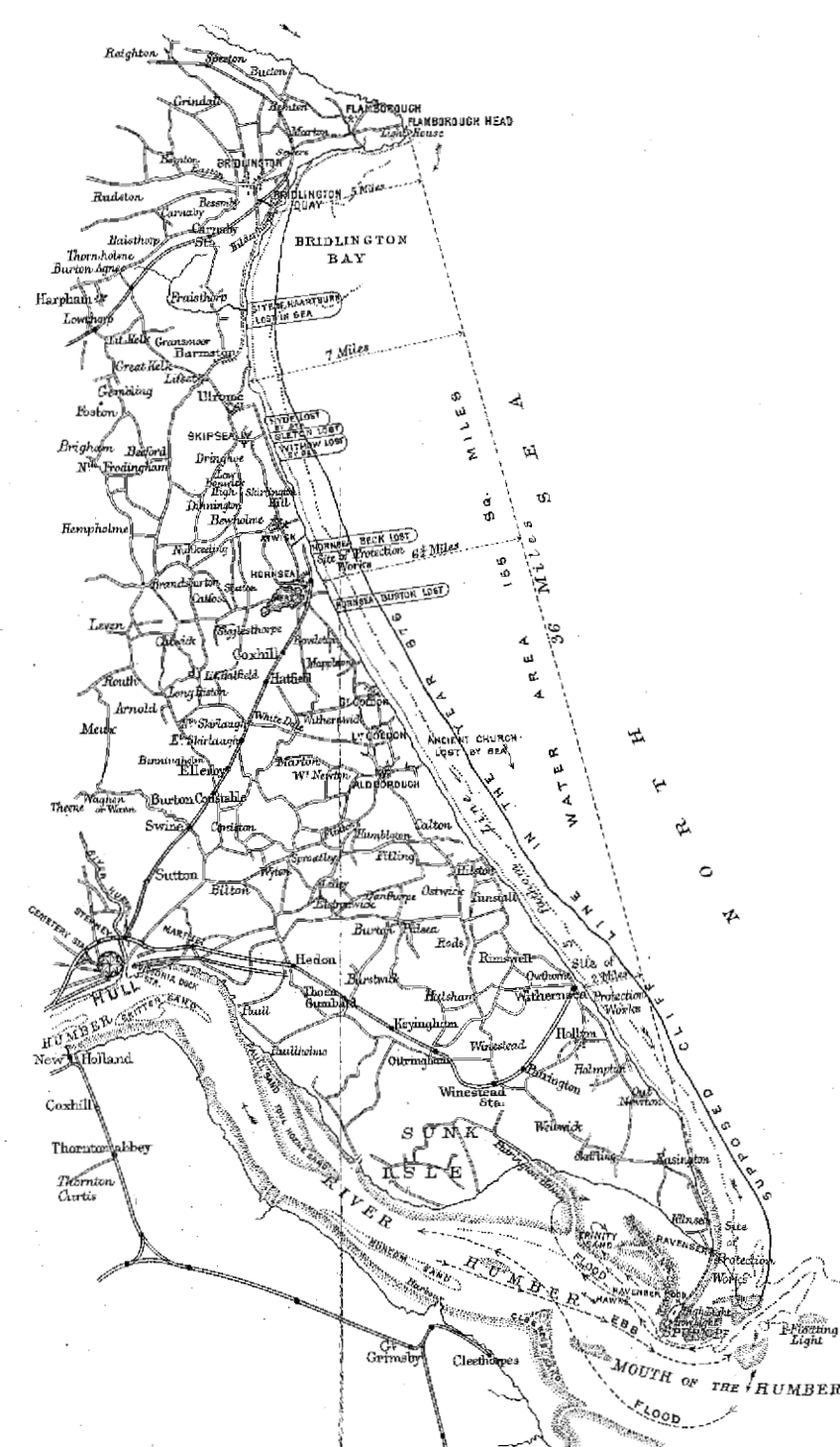
of material thus affecting the Humber at 3,000,000 tons per annum, taking the rate of degradation at 10 feet with a height of cliff of 30 to 40 feet.¹ The Author suggests that this does not adequately represent the actual amount of loss, since the clays below low-water level are eroded as well as the face of the cliff. At 1,000 yards from the shore there is a depth of 30 feet of water below low-water level, at which point, about four hundred years ago, there was a cliff 30 to 40 feet above high-water level; and as the range of the tide here is 18 feet, there is an actual loss at a point 1,000 yards from the shore equal to 90 to 100 feet in depth, the result of the falling of the cliff face and the subsequent abrasion of the submerged clays; this gives an average depth of 70 feet lost for every yard in width. Taking the coast at 40 miles long, and the average loss at a breadth of $2\frac{1}{2}$ yards of land per annum, the amount of material travelling towards the Humber would be about 7,000,000 tons per annum. The Author believes that this plays a far greater part in the present condition of the Humber than the alluvium brought down by the land water of its tributary rivers.

It has been suggested that a pier near Kilnsea would be the best remedy for preventing this enormous amount of material from entering the Humber; but if this were constructed the Author is of opinion that the effect would only be partial; for whilst such a pier would stop the travel of the shingle, and cause it to accumulate for a time locally, its influence would not extend beyond 2 or 3 miles northward, and the great bulk of the coast towards the north would still go on wasting and keep up a constant supply of matter in suspension, and the travelling beach would ultimately round the end of the pier and find its way into the Humber. In the opinion of the Author a thorough system of groynes along the whole of this coast would be the most efficient method of protection, as the groynes would not only intercept the travelling shingle and prevent it finding its way into the Humber, but would effectually cut off the supply of alluvial matter, which is conveyed in suspension into the Humber, by protecting the cliffs from the ravages of the sea. Such a system, if commenced at or near the Spurn and proceeded with towards the north, by erecting groynes at intervals of 300 to 400 yards, would secure for the whole of this exposed coast a permanent and sufficient beach. If these groynes were each 300 to 400 feet in length, the cost would be approximately £1 10s. per lineal yard of protected coast; and, presuming that the whole of the cost fell upon the land (which

¹ *Vide Minutes of Proceedings Inst. C.E.*, vol. xxviii., p. 495.

the Author thinks should not be the case), it might fairly be apportioned by taking four parallel screeds of land along the entire coast, each measuring, say, $\frac{1}{4}$ mile in width, the first screed paying four-tenths, the second three-tenths, the third two-tenths, and the fourth one-tenth; this at 5 per cent. would amount to 7*s.* 4*d.* per acre for land in the first screed, 5*s.* 6*d.* per acre for land in the second, 3*s.* 8*d.* per acre in the third, and 1*s.* 10*d.* per acre for land in the fourth screed. Taking a length of 1,200 yards of coast, and the loss at $2\frac{1}{2}$ yards per annum, there is an actual loss of land of from $\frac{3}{4}$ acre to 1 acre per annum, equal to £35 to £50 per annum. The interest alone on the cost of the protective works, as suggested, for the same length of frontage, would be equal to £90 to £100 per annum at 5 per cent., so that to the landowners as a whole it is cheaper to lose the land than to protect it. But the Author suggests that the owners of the land are by no means the only interested parties; and that beside the Humber Conservancy Commissioners, Trinity House, and the seaports of the Humber, it is a matter for the serious consideration of the Legislature itself.

This communication is accompanied by several maps and drawings, from which Plate 4 and the woodcuts have been compiled.



ENCROACHMENTS OF THE SEA.

