

down this channel, would ever cause it to return to its former north western direction, so as to disembody itself, at a place considerably more west than the present outfall.

I do not however mean to say that it *cannot return*, but that if it does, it must be in virtue of causes operating in a contrary way to those which have brought the mouth of the channel from the westward towards the east, and not in virtue of any change that can be expected to be wrought simply by an increase of back water; for that would be to make a more rapid stream have a tendency to go a longer journey to sea in preference to a shorter.

It is alledged indeed, that, from a general increase of the breadth of sands upon the coast, it is now further from the north end of the pool to sea than it used formerly to be, but this must be understood of the straight line from the said point to low water, without regard to the direction of the channel. For though the present channel should be as long from the pool to the sea, or longer than formerly; yet from the general increase of the breadth of the sands, were the channel to go much further westward than at present, it would have a longer course to sea at low water.

What may have been the particular causes that have brought the mouth of the channel more to the east than formerly, does not appear material to the present question; but to give satisfaction as far as I am able, I will hazard the following conjecture: It is an observation universally agreed upon, that the N. W. winds make the highest tides in the whole German Ocean; the N. W. winds, then, accompanied by *higher* tides will produce more agitation, and consequently carry the sands from the N. W. eastward, in a greater degree than that in which equal winds from the south-east accompanied by lesser tides will bring them back; and according to the local direction of the coast here, they directly tend to accumulate them upon the shore toward the N. E. If this is a true solution, as I apprehended it to be, there seems not the least likelihood that the direction of the channel should ever be permanently removed to the west, but rather that it should be carried further to the eastward than it now is; and what gives strength to the above conjecture is, an observation I had the opportunity of making upon my view, viz. that the outfall channel of the harbour of Blakeney (a few miles eastward of Wells, and situated in a similar manner, in regard to the course of its outfall channel through the broad sands) has shifted also more to the eastward than it was, by above half a mile in the last seven years, as appeared from the marks I was shewn for its entry at that period, compared with its present place; notwithstanding that Blakeney Channel has two large fresh water rivulets that make their way together through this channel to its no small advantage towards keeping it open. The place also of the outfall at low water of the east discharge from the salt water creeks called Wareham Deepes, I was shewn to have removed its place further eastward, than it was at Michaelmas last, by several

several hundred yards, and that chiefly within the compass of the preceding three weeks to my view, during which very strong north westerly winds had prevailed. Wareham Deepes lie betwixt Blakeney Outfall Channel, and that of Wells.

There is one thing more respecting the outfall channel of Wells Harbour that it may be proper to touch upon, and that is, the bar that is described in Beiderman's map to lie across the mouth of the channel so as to be prejudicial to the entry of vessels; but after what has been said, be the impediment arising from hence greater or less, it cannot be imputed to the imbankment of marshes; but to the sport of winds and seas at the place, which will further appear from this circumstance; that when I was examining this place at dead low water of a spring tide, viz. the 15th of March last, I did not observe there was any appearance of a bar, the course of the channel being right out to sea, at N. E. by N. by the compass, yet in another season it may probably return.

Hence, from the above premises, I must entirely acquit the whole of the imbankments, from having been in any degree contributory to the disagreeable effects arising from the change of the outfall channel of Wells Harbour.

What I have further to say, will come most naturally under the third and last question proposed.

Question the 3d, Whether the removal of the imbankment of the Slade Marshes will contribute to any material amendment of Wells Harbour?

It appears clearly from what has preceded, that the progressional operation of nature, which originally formed the harbour of Wells and brought it to maturity, has also occasioned it to grow more and more into a state of decay; and will finally close it up, and convert into firm ground, fit for arable purposes, and those of pasturage, the very spot where ships have rode at anchor; and that this being the progression of nature cannot be countervailed in any degree, but by the industry, art, and hand of man.

It is a fact well established by evidence, that, previous to the erection of Freestone's Sluice in 1749, the upper parts of the harbour, as far down as the pool, had got landed up to that degree, that the shipping, which chiefly laid in the pool, were obliged to have a great part of their loadings brought and carried to and from the town by lighters. That upon the erection of Freestone's Sluice (which as far as appears was the very first attempt in this harbour to counteract the operations of nature by art) this

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rude and simple piece of art succeeded so far as in a very great measure if not effectually to relieve the distress that they then laboured under; viz. that of the quays being in great measure inaccessible to shipping; a construction so rude, that though bearing the *name* of a *sluice*, it would seem as if it had been one of the first attempts to obtain relief by art, before sluices had been invented; and hence we may infer, that if this did so much, what might have been effected by a *real sluice*, built upon a proper and regular construction. This sluice however was attended with a beneficial effect so long as it lasted; and when it went to decay, the part of the harbour affected by it reverted to its former state.

In the year 1765 they again set about to relieve themselves, not by building a sluice upon a better plan, but by erecting a new one upon the same plan, upon fresh ground, with better, and as they expected more durable materials: And this sluice reproduced afresh the effect of the former, which has indeed continued to this day. But in the year 1777 it was discovered to be defective and liable to fail on account of the timber wherewith it was built being eaten with a sea worm, unknown in these parts before, that had attacked it. On this occasion Mr. Wooler, an ingenious engineer, very competent to the business, was called in, who very judiciously advised, not only to build a new sluice upon a new foundation, and of more durable materials, but of a different construction, so as to give a better effect to the issuing waters, as the best means for preventing the harbour going to decay. This salutary advice however appears to have been rejected by the commissioners of the harbour, on account of the expense; in lieu thereof, they adopted another expedient, which, as they thought, was liable to be attended with less expense, and quite as effectual. Having observed, on popular grounds, that many things had gone wrong with the harbour since the last imbankment in 1758, they supposed that they were the effects of that measure; and inferred that by removing the cause, the effects would cease, and every thing come right again. It shall therefore now be my business fairly and fully to examine what foundation there was, or may be, for such a supposition.

As the commissioners of the harbour I presume did not pretend to professional skill in *civil engineering*, they could be no otherways blameable for misjudging in a matter dependent on that art, than that had they fully examined the question upon the like popular grounds, which are alike intelligible to all men, they would have seen there was no just foundation for their expectations. For in the year 1749 the waters of the Slade Marshes had not been interrupted in their operation, and yet this harbour was become choaked, and had got into so bad a state, as to call aloud for immediate relief; what reason then had they to expect it in the year 1778, when, according to the natural progression, every thing had got worse?

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In 1758 Freestone's Sluice had gone to decay, and the harbour was speedily reverting to the state in which it had been before the year 1749. Now had the operation of the Slade Marsh waters been observed to have been of any material consequence, the imbankment of 1758 would have been opposed and objected to at the time, which yet does not appear; and had any bad effects appeared to have arisen from the imbankment in the year 1768, that is ten years after the imbankment, and three years after the rebuilding of the sluice, when an application to Parliament was necessary to get fresh powers to defray the expenses incurred by that erection, &c., it would have been natural to endeavour to get some equivalent for the damage, or at least, as sluice-building must then appear to be the best expedient, to have got powers over the grounds in the unimbanked marshes to enable them to erect such proper additional works, as might from time to time be necessary; and which might have been expected upon easy terms, and without depending on leave being always given in case any damage to the harbour had been felt or apprehended from the imbankment, because the more amicable terms subsisted at that time between Sir John Turner and the commissioners, the less he could have opposed or denied so reasonable a request. But yet nothing of this appears, or indeed any other, till after the year 1777, when Mr. Wooler had reported that a proper sluice was "of the utmost importance towards keeping the channel of the harbour open, and clear of the sands that are constantly brought in by the tides;" and that such a work would probably cost the sum of £2,000. These I say are popular arguments, which as every one can equally see the force of them, ought to have induced the commissioners to seek relief, by pursuing means of reducing Mr. Wooler's advice to execution, rather than deliver the Slade Marshes once more to the empire of the salt waters: but as a professional man, I conceive it will be expected from me to give a direct proof of the efficacy of this idea; of this I shall therefore endeavour to acquit myself in the clearest manner possible.

Respecting that part of the last imbanked marshes that lies west of the ancient imbankments, comprehending 16 acres, it is evidently of no more account than any other 16 acres that lie immediately upon the haven creek, and whose waters immediately ebb within the tide, without passing through the sluice; that is, they would have no other effect in scouring than as making a part of 1778 acres, the water from which makes its way to sea by the Pool; but with respect to the forty-seven acres that lie eastward of the ancient imbankment, and are called the Slade, or Slade Marshes, they appear to me to have a different import.

The reason why the waters passing the sluice have a greater effect in scouring than those which return to sea without passing the sluice, is, because by the contracted opening of the passage of the sluice, the waters that lie in the creeks behind it are detained from ebbing so quickly as they otherwise would have done; that is, their numerous mouths when always open,

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reduced the level of the water contained therein, to nearly the same level as that of the water in the main channel of the harbour, being stopped by dams made across and united by cross passages into one, and the mouth of this being contracted by the work called the sluice, a body of water is held back in these creeks, as reservoirs, which not being able to escape so fast as the tide ebbs in the main channel, it follows, that a body of water by these means is vended upon, and after the half ebb, which discharging itself into the harbour's creek, forms a scour when the depth is so much lessened as to operate with power in grinding the bottom, which otherwise would have been so languid as not to have stirred a grain of sand or mud, in which case its effect would be little or nothing. This artificial scour thus procured, in some degree imitates the effect of a fresh water river, which in these situations is very greatly beneficial, not from any virtue there is in fresh water preferable to salt in these cases (if any thing rather less on account of its less specific weight), but from its having a fall from the land, and proceeding therefrom continually it not only strengthens the ebb, but running to sea at low water when the fall being greatest, and the sandy bottom exposed to its action, it continues to work at a time when it can operate to the best advantage; and when the ordinary current of a river is assisted by extraordinary land floods and freshes from downfalls of rain and snow, and this operating at low water, when, as just remarked, the fall is the greatest, in such cases it is capable of producing extraordinary effects, and of keeping a harbour continually open with a channel of a given magnitude, though loaded with sands in any possible degree: for a fresh water river has this peculiar advantage, that at the same time that it strengthens the scouring power of the ebb, it operates most forcibly at low water, when there is the least to obstruct its operation; it opposes the tide of flood from the sea, and thereby prevents its bringing so much sand and silt into the harbour as otherwise it would.

The defect therefore of this sluice of Wells is, that though it retains the waters so as to be behind the general ebb, and thereby strengthens the latter part of it considerably; yet being at low water all spent, when the greatest good might otherwise be obtained, it loses that good effect which would be had from a fresh water river, or from a proper sluice; that is, one that will retain the water wholly till a proper time of tide, and then being let go in one collected body, is capable in a short space of time of producing marvellous effects; and yet I should not expect such a sluice either to clear the Pool to the depth it had fifty years since, or to carry the outfall channel to the Northwest.

By sluices of this kind, which are the only expedients art has found that is comparable to a river, the greatest part of the sea ports in Flanders and Holland are kept open, and under

under circumstances more unfavourable than the port of Wells, many of which are built not only with great expense, as to the useful part, but with much magnificence, as relying upon the durable utility of their construction. Those of the Wells traders who have occasion to visit the port of Ostend, so much resorted to at the present time, will see a remarkable example thereof in the grand Sluice of Ostend re-erected in the year 1755.

The Slade then consisting of 47 acres (or somewhat less, on account of the high grounds inclosed therewith), it appears to me might derive some occasional advantage in respect of scouring, from the very circumstance of their situation lying behind the ancient imbankment; inasmuch that what is alledged by some of the witnesses may at some particular time or times be true; videlicet, that when the tide was spent at the town, it came down from the Slade.

It seems well attested, and from the nature of the thing (as it appeared on my view) must be the case, that the surface of the Slade never used to be overflowed, but in extreme spring tides, here called *rages*, and the condition of it in growing rushes and other vegetables peculiar to fenny fresh waters before its imbankment, shews this to be the general case; and this would naturally and necessarily arise from the very contracted channel and opening left between the N. E. bank of the ancient imbankment and the high land so narrow, that it does not appear, except in such cases, that there would be a sufficiency of time at high water for the whole surface of the Slade, considered as a pond, to fill any thing near the utmost height of the sea; but yet whatever water was at such times brought upon it, would, upon the same principles as the sluice, be left behind, and retained by the same narrow passages, so as to require possibly the whole of the succeeding low water entirely to vend it; but then it will follow, that by how much it was the longer in vending, it would come down the more leisurely, and toward the latter part of it the more dribbling, in proportion as its channel to let it out grew more contracted by the surface of the water being lower therein: so that although it might at those times come down in good quantity in the first quarter's ebb, where meeting the remains of the waters from the 16 acres of Slade Marsh, and other waters from the unimbanked marshes, that still fall into the haven creek without passing the sluice, and might make a sensible increase of the current; yet as this must greatly fall off after the top waters were gone, and give but little aid in the latter part of the ebb, when it was most wanted, must equally appear plain and clear. But yet whatever good effect might be ascribed to the water from the Slade, or in reality it might have, when it could operate in the manner I have pointed out, yet as it appears from equal testimony that those rages happen but seldom (four or five times in a year), they could be of no material benefit, because their power of scouring and grinding the bottom,



bottom, inasmuch as the sea is incessantly bringing in a fresh accession of sand, silt, and mud, must be in proportion to their frequency, so that if it were to be supposed (what it does not appear to me reasonable to admit), that the effect of the Slade waters was when they happened even equal with that of the sluice, yet the sluice, if we put the neap tides out of the account, operating 365 good tides in a year, and those but five, the benefit could only be as 70 to 1; an effect so small, that, when mixed with many others, could not be perceived; and though in the eye of reason every thing that operates at all must have an effect, yet it clearly appears to me that the effect to be expected either by the shutting up or opening those marshes in the manner they were before the imbankments in 1758\*, could procure no such beneficial effect upon the harbour as to prevent the necessity of supporting and continuing the sluice, or even to be of any measurable or estimable degree or value; and that this explanation of the small utility to be derived or expected from the Slade marsh waters, is in reality the true one, is proved by the facts already stated; viz. that before the year 1749 they had proved *totally ineffectual*, and had always proved so ever since when the sluice was out of order. I must therefore conclude in the sentiment of Mr. Mylne, that whoever would find a cause for the alteration of the course of the out-channel, for the filling up of the Pool, for the landing up of the harbour, channel, or creek, and in general the decaying state of the harbour of Wells, must seek some cause far more extensive than the imbankment of the Slade marshes in the year 1758, and the remedy from human industry and art in something more powerful and better adapted than any of the sluices there applied appears to have been.

London,  
4th May 1782.

J. SMEATON.

\* I say in the manner they were before the year 1758, that is, when there was no bank at all; because if a partial breach was made in the bank, the waters issuing through this breach would have an effect similar to the sluice, till worn by the entering and issuing waters too wide to produce the effect, as was the case when Free-stone's Sluice was worn too wide, it ceased to do its duty.

#### REFERENCES

#### REFERENCES to the Plan of Wells Harbour.

Plate 1. Fig. 2.

	A.	R.	P.
1 Holkham Marsh, imbanked about the year 1719, by the late Lord Leicester, including creeks	560	0	0
2 Wells West Marsh, imbanked 1719, by Sir Charles Turner, including creeks	108	2	12
			668 2 12
3 West Salt Marsh	588	2	0
4 Lodge Marsh	266	2	35
5 North, or Out Salt Marsh	717	2	25
Channels and creeks	146	1	12
			1,719 0 32
6 East, or Church Marsh, exclusive of the ancient creeks	106	3	2
Creeks in ditto	4	0	0
			110 3 2
7 Warham Slade, exclusive of the ancient channel and creeks	59	1	36
The channel and creeks in ditto	7	0	32
			66 2 28
			Acres 2,565 0 34
A A The present entrance into the harbour.			
B The course of the Old Channel by the Scolph.			
C C The west side of the antient entrance into the harbour.			
D Friston's Jurties.			
E E The arrows shewing the set of tide over the sands on this coast, for the last three hours of flood and the first three hours of ebb.			
F The place of the second buoy at the turn by Broom's wreck.			
G The present navigable channel at the Scolph, since the imbankment made by Sir John Turner.			
H The present Pool.			
I The Quay.			
K The bank made by Sir John Turner in 1758.			
L The place to which the water used to flow before the imbankment made at K.			
M N The places where the waters from the west marshes empty themselves into the main channel			
P P The line from which it is supposed the water has drained towards Wells Harbour.			



# ABERDEEN HARBOUR.

The REPORT of JOHN SMEATON, Engineer, upon the Harbour of the City of Aberdeen.

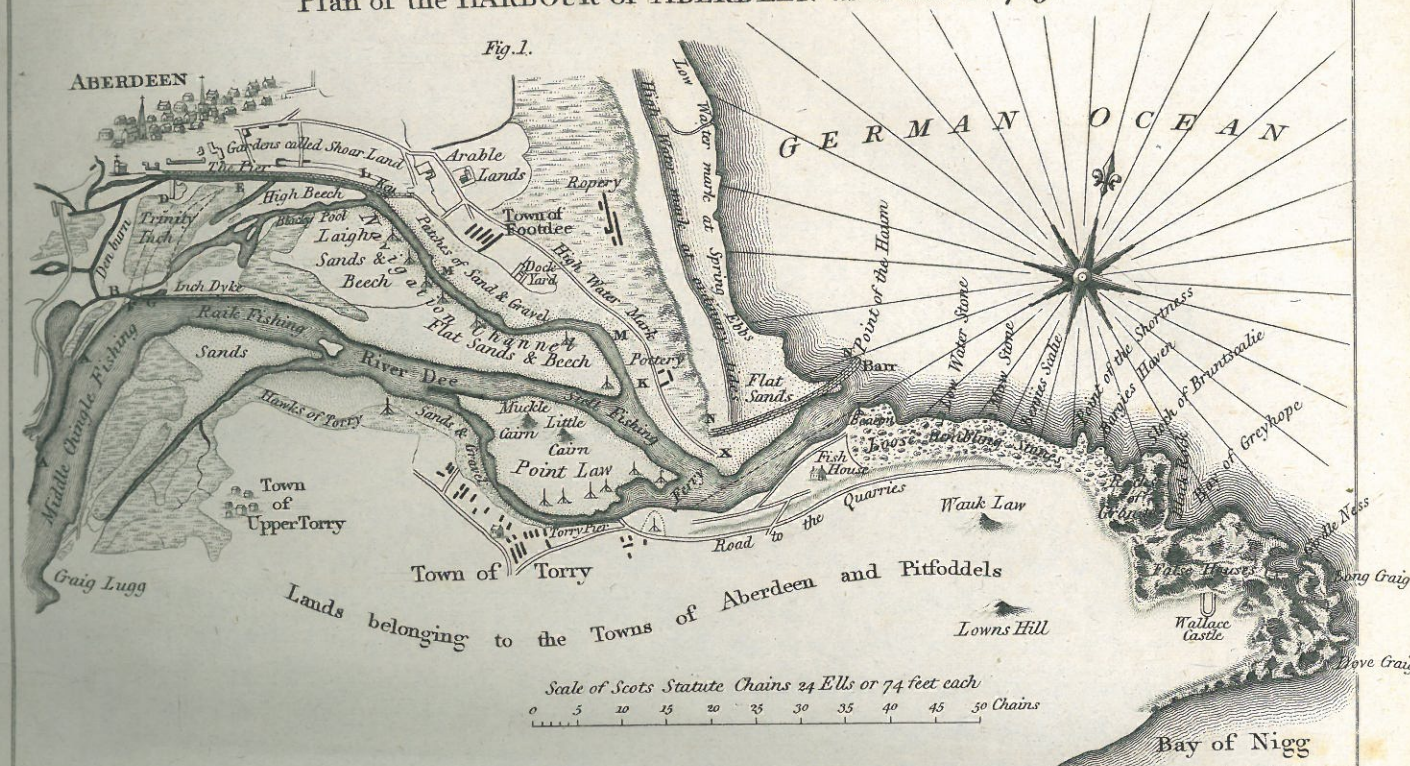
(See a Plan, Fig. 1. Plate 2.)

THE principal complaint attending this harbour is the difficulty of entry, occasioned by a barr a little without the harbour's mouth, and a shifting bed of sand, gravel, and shingle on the north side of the entry, which, by the action of the seas, when the wind is in the north easterly quarter, drives into the main channel, choaking it up in different degrees, according to the violence of the sea, the state of the tides, and of the land speats, floods, or freshes in the river Dee, which here falls into the sea.

When I was there, which was in the month of August 1769, the entry was then said to be in a good state; and on sounding it upon the 7th of that month, which was the 6th day after the new moon, (and consequently the tides in a mean state between spring and neap), I found full four feet of water upon the bar at low water, and at high water the same day full fourteen feet; but it is said that the ordinary spring tides make but much about the same depth upon the bar at high water, and that at low water the barr is left with only the run of the river over it. The neap tides it is said usually make ten feet water upon the bar, but this is to be understood (I suppose) at such times as the entry is in a good state. On sounding at low water, I found the body of the bar to be composed of loose stones of different sizes, and the whole intermixed and compacted together with gravel, over which was a layer of sand from six inches to a foot in thickness, which after great land freshes is said to be quite swept away, and the stones and gravel left bare, which is its best state. The bar is but of short extent, and both within and without we quickly get more water by three feet. Without the bar the water gradually deepens and forms a very good road for ships to ride at low water, and is naturally protected from all winds except the north easterly and easterly, which blow right into the harbour's mouth, so that were there a little more depth of water over the bar, and this certain, this harbour would be capable of affording very good protection to merchant ships trading into these seas.

The

Plan of the HARBOUR of ABERDEEN as it was in 1769.



Plan of the HARBOUR with its Alterations, as proposed 1787 by J. Smeaton.

