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SELSEY SEA-DEFENCE SCHEME

Under the terms of the Coast Protection Act, Chichester Rural District Council became the responsible authority for the maintenance and protection of some l6 ½ miles of coast between Chichester Harbour and Littlehampton. This includes Selsey, which has had the dubious distinction, since the turn of the century, of having lost moreland for every yard of frontage than any other place in the British Isles. The problem, as elsewhere, arises largely as a result of the seaside "ribbon" development which has proceeded in the past with an entire disregard of the associated problems of erosion and inundation. Some of the frontagers have spent considerable sums of money on sea walls to protect their properties but isolated works of sea defence are rarely successful for long. To resist the sea successfully it is essential that works should form part of a properly co-ordinated scheme for the protection of the frontage as a whole.

A scheme promoted under the Coast Protection Act of 1949 is now under way for the protection of the eroding coast line over a length of 1½ miles east and west of Selsey Bill. The land mass at Selsey Bill is composed of beds of brick-earth, gravel and sand up to 30 ft. deep — known collectively as "drift " — overlying beds of grey, yellow and green sandy clay and shelly sands comprising the "Bracklesham Beds" which themselves overlie London clay at depths exceeding 350 ft. below the surface and therefore of no especial interest as far as the erosion problem is concerned.

The open-textured friable silty clay of which brick-earth is composed and the gravel and sand beds which corn p rise the underlying "Raised Beach " offer little resistance to the waves and the erosion of the shingle, gravel and sand beds exposed in the low cliffs which border the coastline, and on the foreshore, provides most of the shingle and sand of which the Wittering, Selsey and Pagham beaches are composed. The supply, however, is insufficient to provide a natural protection to the coast without the help of artificial defences. The Bracklesham Beds consist of a dark grey-green compact medium to fine glauconitic sand containing patches and lenticles of clay and silt and are subject to the same process of denudation whenever the sea comes into contact with them, although the rate of wastage by wave action is slower. Their wastage when exposed is accelerated by boring mollusca by which they are freely attacked. The sea bed beyond low water is also subject to erosion and is progressively lowered as the land mass recedes.

The maintenance since 1923 of a lifeboat station on the east beach at Selsey, Fig. 8, has afforded a unique opportunity of observing the behaviour of the sea bed during the past 30 years. Periodic soundings and diving inspections have shown that the rate of erosion slows down as the depth increases, until the sea bed is eroded to a depth of about 2.5 fathoms below low water, beyond which very little change seems to take place, the sea bed being covered with marine growth. This state of affairs is, in fact, what one would expect as the scouring action of storm waves progressively diminishes with the depth of water, and is borne out by a comparison of the off-shore contours shown on 1885 and 1946 editions of the Admiralty Chart which show an appreciable recession of the one-fathom contour, some recession of the two-fathom contour, and scarcely any change at three fathoms.

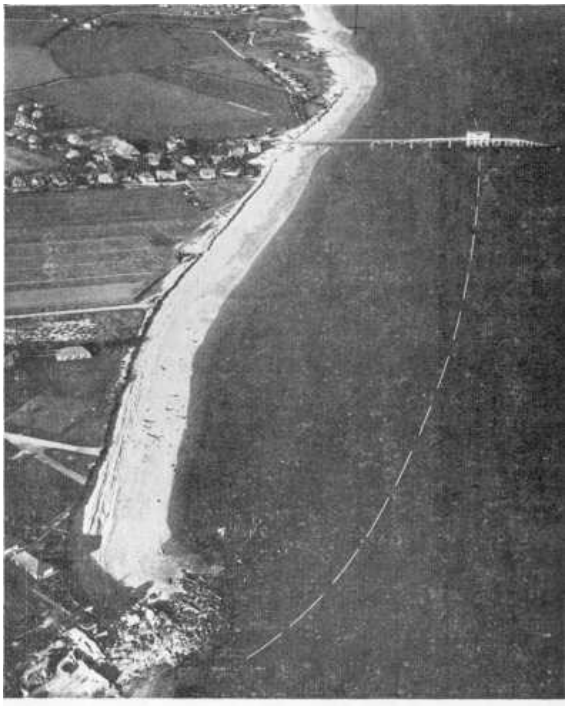

Fig. 8 East Selsey, Sussex, 1949. Broken line indicates position of coastline in 1922

The sea bed is shallow to a distance of nearly four miles south of Selsey Bill, the area being encircled by a line of banks known by the general name of "The Owers". An inner shoal, known as the "Mixon" is uncovered at low tide and is said to consist of limestone rocks formed of the shells of certain Foraminifera. It is recorded (Heron-Allen) that rock was at one time extensively quarried from this reef and used for building purposes until the Admiralty put a stop to it on the entirely justifiable grounds that these rocks served as a defence against the rapid encroachment of the sea. The word "quarried" is perhaps an exaggeration, and the large-scale removal of stones from the Mix on must have been a costly undertaking at the best of times.

The prevailing drift of shingle along the Sussex coast is from west to east, but an inspection of the coast from Chichester Harbour to Pagham showed that the drift divided at Selsey Bill. West of the Bill the drift is westward towards Wittering, whereas east of the Bill the drift is eastward towards Bognor. Selsey Bill therefore receives

no fresh supplies of shingle by littoral drift to make up for periodical losses by scour. The reversal of drift to the west of Selsey Bill was investigated by preparing a wind diagram showing the prevalence and force of winds from various points of the compass over several years. Off-shore winds were disregarded, allowance was made for the sheltering effect of the Isle of Wight and a vector diagram was drawn to represent, in force and direction, all other winds of strong to gale force during the year. The direction of the resultant or average wind was found to be approximately S.S.W., as shown in Fig. 9. This is also roughly the orientation of the coast-line east of Selsey Bill, with the result that east of the Bill the shingle is moved rapidly in a north-easterly direction towards Pagham.

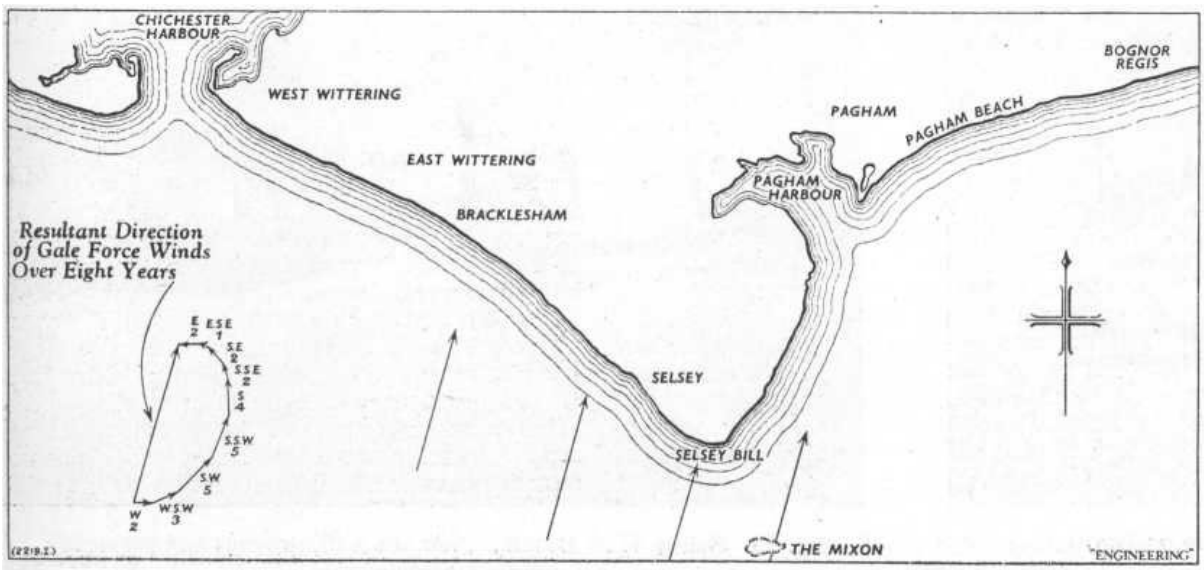

Fig. 9 Selsey sea-defence scheme. Resultant wind direction

The speed at which this material is scoured and driven along the east beach is far in excess of the speed at which the beach is replenished by fresh material moving in from the west, particularly so in view of the very short length of coast from which an eastward-moving supply of fresh shingle can be derived and the very small quantity which is therefore available. Conditions east of Selsey Bill are therefore naturally conducive towards a rapid rate of erosion which, at the site of the lifeboat station, has averaged 25 ft. a year since the station was built in 1923 necessitating a successive lengthening of the approach gangway from the shore and considerable expenditure on underpinning the piled trestles which support the boathouse and slipway Several houses have been destroyed by the sea and the two houses in the cluster at the end of the lifeboat gangway which can be seen in Fig. S have been destroyed during the past two years.

It will be seen from Fig. 9 that west of Selsey Bill the average wind is from a quarter south of the perpendicular to the coastline. The waves produced by it are laso predominantly from a direction south of the perpendicular and the alongshore movement of shingle west of Selsey Bill is therefore, on balance, north-west towards Wittering. The inclination of the average or "resultant“ wind to the general line of the foreshore in this case, however, is very much greater than in the case of the east beach and the rate of erosion west of Selsey Bill is therefore appreciably less than to the east of it and has averaged 4 to 5 ft. per annum since 1875.

In preparing a comprehensive scheme of defence for the Selsey peninsula it was therefore necessary to take into consideration the fact that as the drift divides at the Bill, once the erosion of the cliffs has been stopped by the construction of a sea wall or breastwork no fresh supplies of shingle will become available from the cliffs for the replenishment of the beaches on either side. It followed from this that in any new scheme of defence the utmost regard must be had to the importance of holding such shingle as then existed and preventing it from being swept away in a north-easterly or north-westerly direction, a state of affairs which could only be achieved by means of groynes in conjunction with a sea wall.

A scheme was prepared in 1950 for the protection of the Selsey peninsula for a distance of a mile and a half each side of the Bill by means of sea walls, breastworks and groynes at an estimated cost of approximately half a million pounds. It was suggested in due course by the sponsoring Ministry that in view of the restriction on capital expenditure and the shortage of steel which prevailed early in 1952 the cost of the scheme should be reduced to approximately a quarter of a million pounds spread over three or four years, and that the quantity of steel should be reduced from the 2,500 tons required to carry out the original scheme to something less than 50 tons a year.

These somewhat drastic requirements were met in two ways, by reducing the length of coastline to be protected and by reducing the standard of protection. The Ministry's requirement in the matter of steel was met by redesigning the works to make use of alternative materials such as imported hardwoods, and by substituting mass concrete for reinforced concrete wherever possible. Here again it was realised that some sacrifice in the standard of protection was inevitable. A modified scheme was duly prepared and the Selsey Works Scheme was promoted under the terms of the Coast Protection Act (1949). The Ministry of Housing and Local Government in due course approved the execution of the first stage of the Works Scheme at an estimated cost of approximately £100,000.

During the time which elapsed between the preparation of a modified scheme and the completion of the formalities entailed in the promotion of a works scheme under the Coast Protection Act, steel had ceased to be one of the rare metals, and it was possible to design the works without having recourse to interlocking timber sheet piles and other expedients; the engineer's task was thereby greatly facilitated and the local authority's future liability for maintenance of the work was correspondingly reduced. The first contract comprised mainly the construction of works for the protection of residential property on the West Beach, but it also included a number of ancillary works at the point of the Bill and at parts of the East Beach.

Fig. 10 shows all that remained in 1950 of the sea defences of Selsey Bill which had been carried out some years before the war by private owners, and by June, 1953, when the Selsey Coast Protection Scheme was commenced, further lengths of these old concrete defences had been destroyed. It was considered essential to the scheme of defence as a whole that every effort should be made to preserve what remained of Selsey Bill. The alternative policy of abandoning the tip of the peninsula and rounding off the Bill by constructing a new sea wall some distance landward of the cliff, although easier from the point of view of construction, would have weakened the coast line to the west and exposed a particularly vulnerable part of the East Beach to the scouring action of westerly gales from which it is sheltered by the point of the Bill. Provision was therefore made under the contract for stabilising the short remaining length of sea wall by encircling it with a continuous line of interlocking steel sheet piling driven to a substantial depth below beach level, and by constructing a heavy articulated concrete groyne of a new and experimental design just east of the Bill.

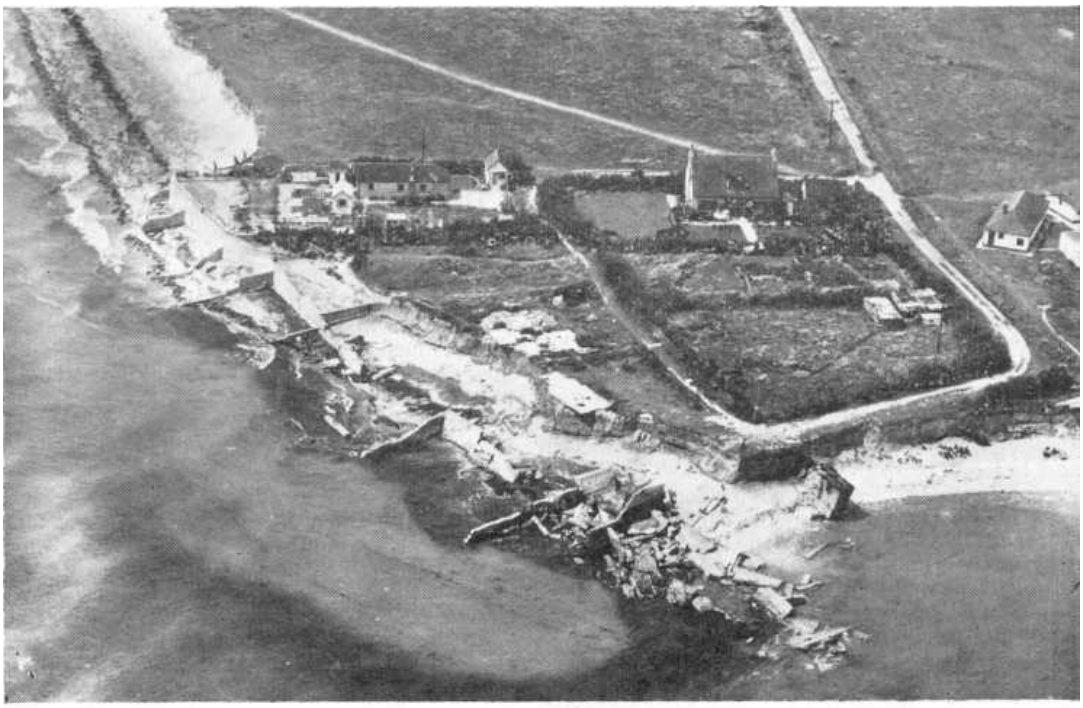

Fig. 10 Selsey Bill. Destruction of old defences

This groyne, which is shown in Fig. 11 consists of two parallel rows of heavy concrete blocks which are free to settle independently of one another, being held together below beach level by a flexible linkwork made up from lengths of old rails. The space between the two rows of blocks was filled with heavy rubble, while the western row was pinned to the underlying beach by pairs of steel rails driven through holes cast in the blocks. The rails were left projecting above the tops of the blocks to allow for the future heightening of the groyne if this is found to be necessary. It will be seen that an even beach has been held along both sides of this groyne, which has been

free to adapt itself, without fracture of its component parts, to changes which have taken place in the configuration of the foreshore in the process of stabilisation.

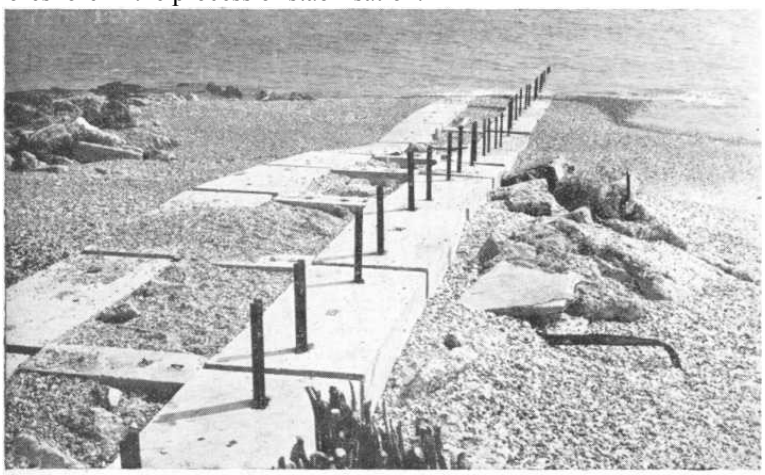

Fig. 11 Selsey Bill. Articulated concrete groyne

Fig. 12 is a type section of the recently completed sea wall on the West Beach. This wall is founded throughout its length on silty sand and the load was spread over a wide area; the wall was secured against undermining by means of a wide sloping concrete apron, terminating in a row of interlocking steel sheet piles. The crest of the wall has been provided with a bull-nosed coping to protect the land behind against being scoured by spray thrown up by the impact of storm waves. With a view to economy the top of the wall was made 2 ft. lower than in the original design, and the coping is at a height of approximately 8 ft. 3 in. above M.H.W.S.T. This height, which is 2 to 3 ft. less than in the case of most sea walls on the South Coast, is sufficient provided the waves break on the beach and do not expend the bulk of their energy on the wall, but if the shingle beach falls below the level of the apron, as it may well do at times, water will be flung to a considerable height when a gale coincides with a period of high spring tides and a certain amount will be blown over the wall on to the land behind. This will not be a serious matter on the West Beach where the land behind is higher than on the east side of Selsey Bill. Moreover, it was considered that the frontagers might well be prepared, in consideration of a cheaper scheme and proportionately lower contributory charges, to provide their own flood works landward of the main sea wall.

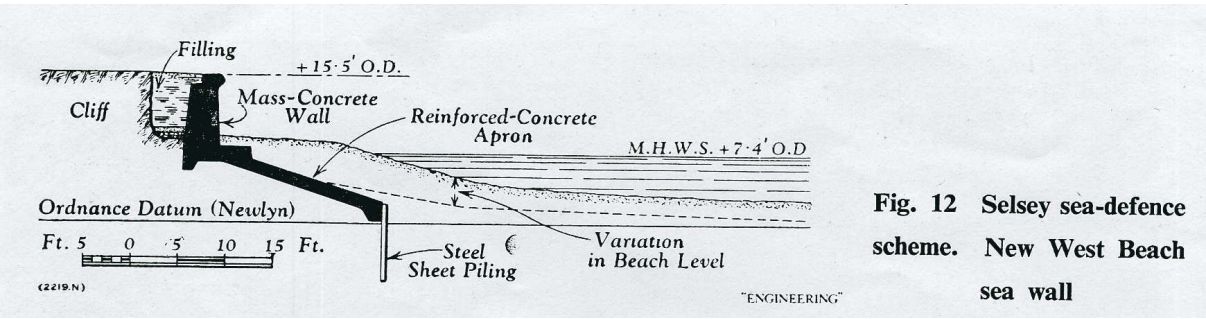

Fig. 12 Selsey sea-defence scheme. New West Beach sea wall

Fig. 13 shows the eastern end of the recently completed West Beach wall and part of a permeable timber breastwork 150 ft. long which was designed to check the scour from spreading eastward and outflanking the new sea wall. The top of the planking is only 2 ft. above the level of high spring tides and the space between the planking and the cliff behind has been filled with rubble. The force of the waves is expended in running up the rubble slope and the water is free to drain back into the sea through open joints between the planks. This breastwork, which was built in conjunction with two short groynes, has served its purpose well so far and no extension beyond 150 ft. has been found necessary; it is appreciated, however, that a prolonged spell of westerly winds of strong to gale force may disturb the equilibrium of this beach and necessitate a further extension of the breastwork. Fig. 13 also shows one of the groynes which have been constructed along the West Beach wall with a view to distributing the somewhat meagre supply of shingle as evenly as possible along the frontage. The piles are steel rails bolted together in pairs, while the planking consists partly of Ekki and partly of greenheart, both

imported hardwoods which are not affected by marine organisms such as the limnoria or the teredo to nearly the same extent as is the case with softwoods such as elm or Douglas fir.

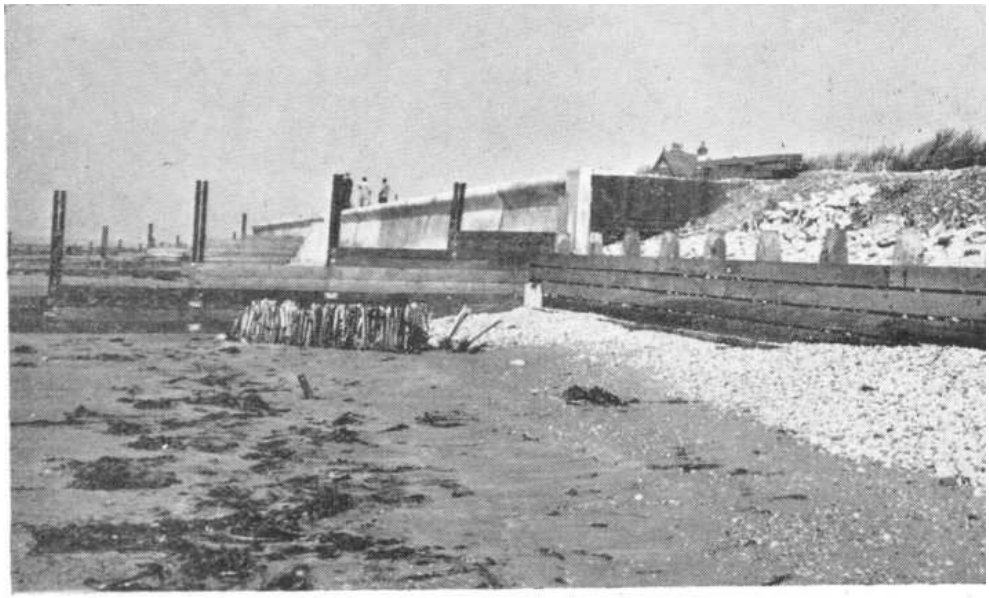

Fig. 13 Selsey West Beach. New sea wall, groynes and permeable timber breastwork

The protection of the East Beach at Selsey is a very much more difficult problem. partly because the rate of erosion is so high and partly because of the soft erodible nature of the subsoil which was shown by a geological survey carried out during 1953 to consist mainly of silty sand and silty clay down to a considerable depth, while the whole of the Fisherman's beach area was shown to consist of alluvium extending to such a depth that its base was not exposed by boreholes sunk to a depth of 30 ft. The geologist's report stated that this area coincided with some low-lying ground which must represent the silted-up outlet of a former stream, possibly dammed by a shingle spit. All the strata bored through were composed of soft or loose materials which are easily eroded and redistributed by wave action when the waves reach them. No tough resistant strata such as one would have expected to find in view of the hard pile driving conditions experienced during the construction and maintenance of Selsey Lifeboat Station were encountered within the range of materials bored through, with the exception of one or two isolated deposits which are exposed at low water of spring tides.

An unknown but undoubtedly substantial proportion of the fine, silty and sandy deposits will be carried out to sea in suspension and eventually deposited on the sea bed beyond the range of submarine wave action. The coarser parts, however, may lie within the range of granular material that is normally encountered on beaches between the levels of low and high water, in which case they may be depended upon in due course to augment the supply of littoral drift. The present slope of the East Beach varies between I in 4.5 and 1 in 10, and these slopes are far too steep to allow fine or even coarse sand to remain within the range of the tide for any length of time unless there is enough shingle mixed with it to give it the characteristic properties and greater stability of a gravel beach. Even so, it will not stand at I in 4 or anything approaching that slope. Samples of sand, clay and silt extracted from the bore holes have been analysed in a laboratory to enable a rough estimate to be formed of the proportion which falls within the range of sizes of which beach material is composed, but the analysis will not indicate what the ultimate beach slope will be, and it is important that this should be established as it will obviously have an important bearing upon the design of the sea wall.

The reaction of a beach to the construction of a scheme of sea defence comprising a sea wall or breastwork and groynes depends to a large extent upon the nature of the material of which the foreshore is composed, that is to say, thtal com

to cover the clay during storms, neither was it found possible to gather and retain enough shingle or gravel by means of groynes to serve as a protective covering to the clay. At Selsey, the clay varies both in level and in character, and the protection of the East Beach frontage and the promotion of safe and stable conditions is a complex problem. The scheme which has been devised for the protection of this side of the peninsula comprises in the first instance the construction of a steel sheet-piled breastwork. just over 4.000 ft. long and a large number of steel grovnes.

The object in using steel piling for the first stage in the construction of the sea wall and the groynes has been to provide full protection to the most vulnerable and unprotected parts of the coast line in the shortest time. Steel sheet piling fulfils this requirement and it is fortunate that as much of this material can now be obtained as is required. Apart from the initial advantage of speed of construction, steel sheet piling has the further advantage of being readily adaptable to changed conditions and can be re-driven to a greater depth or extracted and re-used.

The Selsey scheme should be well advanced towards completion by the end of 1955, but some years may elapse before the coast line settles down to the new regime. The groynes and breastwork will require to be carefully nursed while the settling-down process takes place, and the design has therefore been phased to allow for the changes that are likely to take place in the level and character of the foreshore.