Hydraulics Research
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THE EFFECTIVENESS OF SALTINGS

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This report describes work carried out by Hydraulics Research into a review of the coastline of England and Wales. It has been funded by the Ministry of Agriculture, Fisheries and Food under contract number CSA 1299, the nominated officer being Mr A Allison. At the time of reporting the Hydraulics Research nominated project officer was Dr S W Huntington.

ABSTRACT

This report is an initial definition study into the effectiveness of saltings in the role of sea defence.

The objective has been to identify sites of major saltings and to discuss with the relevant authorities the state of those saltings with the aim of identifying any problems, and if there are, how they are being tackled.

Discussions were held with various representatives from Water Authorities, the Nature Conservancy Council and the Institute of Terrestrial Ecology to determine any parallel research. Relevant literature was also reviewed and information sought as to whether related research is being carried out elsewhere in the United Kingdom.

The areas most troubled by erosion or 'die back' are identified and the attempts at regeneration by the relevant authorities are discussed. Finally, recommendations are made for future research in co-operation with other interested bodies.

This report was prepared for the Ministry of Agriculture, Fisheries and Food, within the research programme commission 14C. The departmental project officer is Mr A J Allison while the company's nominated project officer is Dr S W Huntington.

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1 INTRODUCTION

This review, undertaken for the Ministry of Agriculture, Fisheries and Food, is an initial project definition study into the general condition of coastal saltings with special reference to those which form an integral part of the sea defences around the coast of the United Kingdom.

It has been estimated that almost ten per cent of the coastline of England and Wales is bordered by saltings, thus the choice of sites reviewed has had to be somewhat subjective. A large proportion of saltings front rural, low-lying land. Areas such as these come under the Land Drainage Act of 1976, which is concerned with the protection of low-lying land against flooding by the sea. Responsibility under this Act usually lies with the area Water Authority, although large tracts of low-lying coastal lands are nature reserves and as such are maintained by various authorities including such bodies as the Nature Conservancy Council and the National Trust. Many of the sea defences protecting these low-lying lands comprise nothing more than earth or clay embankments at the coast and rely on the saltings to seaward to reduce the wave action at the main line of sea defence. It is thus most important to maintain healthy coastal saltings.

Major sites were identified, and visits were made to discuss the various areas with the relevant authority engineers. The engineers were asked to identify any vulnerable stretches, what their problems were and how they were being tackled. They were also asked what they thought the priorities should be for further strategic research with regard to the protection of the existing saltings. A visit was made to the offices of the Nature Conservancy Council (N.C.C.) and the Institute of Terrestrial Ecology where the nature

of the study was discussed and mutual problems and parallel research identified. When it was discovered that the N.C.C. were currently researching salt marsh vegetation this review was amended to a brief synopsis of the major saltings in England and Wales with particular reference to reclamation and regeneration in a mainly engineering sense.

In this report, Chapter Two looks at saltings as an engineering medium and their effectiveness as coastline protection, Chapter Three reviews the evolution of saltings, their biological aspects and the stresses imposed by the elements. A review of specific sites around the coasts of England and Wales is given in Chapter Four and this is followed by the observations, conclusions and recommendations. Finally, a bibliography containing some of the currently available material is included as Chapter Six.

2 SALT MARSHES

The most maritime of all marshes are those which develop in coastal areas and are inundated regularly in sea water. In the context of this review, a salting is given to be an expanse of salt marsh with the sea on one side, ie not an enclosed marsh.

In the following sub sections the source of saltings is defined, their biological aspects are commented on and the day to day stresses imposed in a coastal environment are explained.

2.1 Evolution

Saltings are the product of erosion of the land mass and owe their origin to the fine muds, silts and sands which are transported in suspension by the tides and seaward flowing rivers to some sufficiently sheltered spot. During the period over high tide when the currents are relatively still, some of the suspended sediments in these coastal waters settle out and deposition takes place. The foundation on which a salting eventually evolves is often a flat or gently sloping sand floor within the inter tidal zone. As these mud flats build up, algae tend to form on the surface and eventually larger salt and submersion-tolerant plant seeds are distributed, into these coastal areas, usually by the tide. If conditions are favourable they will settle out in the sheltered regions and germinate. This can only occur when the silt has built up to a reasonable level as germination needs a period of several hours of continuous exposure to the air. The vegetation, once it has developed, slows down the water movement thus encouraging the deposition of more silt and raising the level of the mud flats. The vegetation usually canalises the ebbing water, forming low islands, and allowing these relatively stable areas to develop still further.

Once the vegetated flats have been built up, thus decreasing the time of tidal submersion, plants which are less salt- and submersion-tolerant gain a foothold at the higher levels. This cycle continues until the area is inundated only at the highest tide levels with the flows confined in the main to the channels. The growth of a salting can be either seaward from the coast (eg Dengie, Essex), landward from an offshore bar or spit (eg Scolt Head Island, Norfolk) or along the coast as at Stert Flats in the Bristol Channel.

Around the coasts of the United Kingdom, saltings fall naturally into three distinct regional types. This variability is related to the geological, hydrographic and climatic factors, and each regional type has a distinct sequence of vegetation which changes as the salting matures. On the western and north eastern coasts the soil is predominantly of muddy sand and the vegetation is characterised essentially by the dominance of grasses, commonly Pucinellia maritima (salt marsh grass) in the lower marsh and Juncus gerardii (salt marsh rush) in the mid and upper marsh.

The east coast has a firm clayey soil. The vegetation differs from that of the west coast in that the grasses are not so predominant and herbs such as Aster tripolium (sea aster), Limonium spp (sea lavender), Armeria maritima (thrift) and Plantago maritima (sea plantain) are common.

Soil on the south coast is commonly a soft clay or silty mud. The vegetation here is characterised by the dominance of Spartina anglica (cord grass), a vigorous perennial salt marsh grass which forms circular patches or extensive 'meadows'.

Spartina townsendii, the original sterile hybrid, first appeared in Southampton Water in 1870. Since then it has spread either naturally or as transplants. Spartina anglica, a vigorous fertile hybrid has evolved from the original plant and now dominates a large proportion of the coastal saltings and grows down to about mean sea level. Spartina traps sediment and given the right environment, helps build up saltings quite quickly. This can be seen on saltings which are based on sand. Above high water neaps, a layer of silt or clay, caught by the vegetation, is usually found above the sand. There is little doubt that since its introduction, Spartina has changed the character of the majority of our coastal saltings. Tansley (Ref 61) stated in 1939 that no other species of salt marsh plant in north west Europe has anything like so rapid and so great an influence in gaining land from the sea.

The spread of Spartina anglica has been greeted with mixed emotions: naturalists and ecologists would like to curtail its growth to allow other salt marsh communities to flourish and because its prolific spread cuts down the size of the mudflats where wildfowl and waders feed. Others see the spread of vegetation as a means of slowing down the threat of coastal erosion.

Other common salt marsh plants include Eel grass (Zostera marina) which grows mainly near and below the low spring tide mark, and Glasswort (Salicornia).

A study of the physical and sedimentological processes of a salting reveals its complexity. Fundamentally it relies on the transport and deposition of sediment and the abundance of wind or waterborne seedlings, but the range, phase and tidal period together with rainfall and climate all exert an influence in the way a

salting will develop and the type of vegetation that will establish itself.

The most common use of an established salting is probably for grazing, although haymaking is popular on the higher ground of the marshes of the northern coasts of Holland and Germany. A large proportion of saltings around the coast of the United Kingdom are designated nature reserves and are highly valued by both naturalists and bird watchers.

2.2 Imposed stresses

The stresses imposed on a coastal satling are formidable. On the hydraulic side there are forces imposed by tides, waves and the interruption of the sediment supply, eg for a salting to grow and flourish an adequate supply of material from either a fluvial or marine source is essential. Diminution or interruption of supply is often caused by coastal works updrift cutting off the normal littoral supply. Also the removal or deterioration of a sheltering ridge or bar can lead to an increase in wave activity to the detriment of a coastal salting.

Damage to the ecology of a salting can present itself in the form of pollution. This can occur as the result of chemically spraying nearby fields or an increase in the discharge of industrial or domestic sewage or domestic waste. Reclamation, thereby reducing the width of a salting can also, unless carefully assessed, cause deterioration.

The sub-sections below look at both hydraulic and ecological types of stress.

2.2.1 Hydraulic stresses

These can be summed up under the headings tides and waves, which directly influence the coastal processes. Thus the vertical growth of a salting is related to its position on the foreshore, the tidal range (which has a large influence on the type of salt tolerant plant that will establish itself) and the sediment supply.

For example in the Bristol Channel the tidal range can be in excess of twelve metres and here the vertical growth of a salting can exceed four metres. In a small tidal range however, saltings have a much smaller vertical build up. Inequalities in the tidal flood and ebb currents create a residual, and depending on the direction, this can induce either accretion or erosion.

Alongshore sediment transport is also dependent on the approaching wave angle relative to the coast. Landward movement however, is dependent on the wave type, with long period low waves depositing more material than they drag away (constructive) and short period steep waves removing more than they supply (destructive). Wave action of the destructive type can also of course scour the seaward edge of the tidal flats resulting in a vertical "cliff" face.

Coastal saltings are at the whim of the elements, and although they can grow up to accommodate a gradual sea level rise if sediment is available, sea level rise or a long term change in the coastal (wave) climate may well play a large part in their eventual demise, as will a change in sediment supply caused perhaps by the construction updrift of some form of coastal protection cutting off natural erosion and thus downdrift supply.

2.2.2 Ecological

Vegetation, on which saltings rely, is essentially dynamic and as such vulnerable. Pollution is one cause of plant mortality. This comes in many forms and can range from chemical substances used in agriculture or industry to polluted sewage and oil. This has led in some areas to the growth of green algae, to the detriment in some cases of the saltmarsh vegetation. Oil pollution from refinery effluent can also cause the death of salt marsh vegetation although some types of plant can tolerate it to some extent. Unfortunately, emulsifiers used to disperse oil pollution can also kill off salting vegetation.

Die-back along the edge of a salting, and in and around saltpans in the marsh itself, has been the cause of much speculation but currently its cause is not known. One suggestion put forward is that Spartina Anglica, a salt marsh flora that dominates on the south coast has, since the fifties, been in a state of degeneration. It is not known how or why this occurs and the situation could be cyclic. Degeneration due to public access is thought to be minimal because of the saturated nature of the marshlands although trampling can have a marked effect through soil compaction.

3 COASTAL ENGINEERING ASPECTS

It has long been recognised that the existence of saltings seaward of a coastal embankment is beneficial in reducing wave activity at the shoreline. By reducing the depth of water offshore saltings effectively curtail wave heights thus decreasing the impact of wave forces at the coastline. This in turn allows the sea defences to be built to a less robust standard than would otherwise be necessary and thus reduces costs. Indeed the majority of these defences are often clay or earth embankments or sand dunes, in some instances protecting land at a lower level than the saltings.

It is not the purpose of this report to go into quantifying an optimal berm system or define the best width of a salting, not least because it will vary from site to site. It is assumed however that there would be economic justification for the coastal authority to ensure a minimum width based on the calculation of sea wall performance. The importance of this is demonstrated in various reports and previous studies. H.R.L. Report EX 924 demonstrates the importance of a berm fronting a sea wall on the wave overtopping and the required crest height to prevent this. Generally the efficiency of a salting in reducing overtopping increases rapidly with width, depending on the site, until an optimum of 50 to 80m is reached.

Coastal saltings thus play an important role in the sea defence system protecting our coastline. They are however essentially dynamic and vulnerable, and where used as part of a sea defence system, must be protected to ensure that the wave climate at the coastline is not increased. Erosion of the saltings for whatever reason will lead to increased wave

activity at the man-made sea defences. In the case of clay embankments this could lead to the loss of toe loading and subsequent slip failure of the seaward face. In extreme cases, increased permeability, salt water intrusion and possible slip failure of the back face could occur. These problems could of course be alleviated by armouring the front face and increasing the floodbank dimensions but this solution would be expensive.

The pattern of erosion or accretion is complex. Ranwell (Ref 50) found that on a rapidly accreting marsh in Bridgwater Bay it was possible to identify distinct seasonal changes in the pattern of mud supply. In spring and summer, mud is deposited at the seaward edge of the saltings, reaching a peak during the autumn. During the winter months there is either no change or slight erosion. He also suggests that the mud supply to the higher regions of the marsh is derived from those successively lower.

It is important therefore to understand, monitor, promote and reinstate saltings from the outset. Where they are currently in a state of erosion there are various ways in which the problems have and can be tackled. On the engineering side this is usually confined to the development of artificial means to promote their growth, and is achieved by regeneration, stabilisation or some form of offshore protection. Reclamation of healthy areas of saltings is another engineering feature, and examples of these are given in the following sections. The following three sub sections on reclamation, regeneration and stabilisation concentrate on the seaward edge of saltings (and not creek edges within the marsh), because this is thought to be the main problem area.

3.1 Reclamation

Where saltings form an integral part of the sea defences, little reclamation is attempted, unless it is part of an overall scheme to regenerate an eroding area.

However, coastal reclamation of saltings has taken place around our shores since the Roman times. One of the most effective ways is probably to reclaim in strips. In the Wash reclamation has been done in this way for many years. The salting must be ripe for enclosure with an adequate thickness of vegetated silt overlying the sea sand. The natural process of accretion, with vegetation playing a key role, is sometimes artificially speeded up by cutting trenches across the marsh parallel to the shore. Embankments, usually of clay, are then built to enclose the area and seal it off from the sea. The vulnerable seaward side is often faced with stone or turfs cut from the marsh. The area within is then drained, usually by natural leaching, or infilled often by dredged material from an adjacent offshore area, pumping it into the enclosed area as slurry. Another form of infilling can be by the dumping of waste material in the form of domestic or industrial refuse. The area on the seaward side of the floodbank will usually build up again gradually and naturally.

Large scale reclamation does of course take place and schemes under con side ration include areas in the Wash, Morecambe Bay, the Solway Firth and the Ribble Estuary in this country and the Waddensee area of Holland and Germany. Some of these methods are given later and they must be carefully planned so as not to upset the delicate accretion/erosion balance of the area.

3.2 Regeneration

This is a useful way of increasing saltings or recovering those that have been lost. It would depend of course on how they were lost and would be of little use if, for instance, the supply of sediment to the area was cut off. It can be done in several ways but is usually achieved by placing brushwood around a section of saltings to slow down the tidal currents and promoting growth by trapping the sediment.

A development, as yet it is thought untried, is the laying of bio-degradable natural geo-textiles. These products, usually in open mesh form, are made of such materials as jute, hessian or straw and can be impregnated with seedlings. They could thus both stabilise and generate growth at the same time. Taking this theme further, the planting of artificial seaweed could be tried to trap sediment and allow vegetation to gain a foothold.

A method sometimes used is to enclose an area of saltings of several hundred square metres with walls of brushwood fencing (a labour intensive operation). This will tend to accelerate the build up of sediment within the area by trapping silt inside the fencing. A scheme such as this, to regenerate a large section of coastal saltings, is underway on the Essex coast. Known as the Schleswig-Holstein method it is explained in detail in section 4.1.4.

Work on saltings in Holland and Germany has shown that an existing degenerating marsh can be rejuvenated by the cutting of new drainage channels in a uniform pattern in a similar way to those in the enclosures mentioned above.

As part of the regeneration work it might be possible to fill in, artificially, the regenerative compounds.

This would require the right material which may well be dredged from silted up areas in the vicinity. It would however require permission, it is thought, either from M.A.F.F. under the Food and Environmental Protection Act, or the Crown Estate Commissioners. Regeneration, if applied in a National Nature Reserve (NNR) or a Site of Special Scientific Interest (SSSI) (and most salt marshes are) requires permission from the Nature Conservancy Council (NCC).

3.3 Stabilisation

Stabilisation differs from reclamation (which is done to gain land from the sea) and regeneration (which aims to build up ailing saltings) in that its aim is simply to maintain the existing situation.

To deter erosion and to protect and stabilise the mud flats, geo-fabrics in the form of plastic sheeting have been experimented with in the tidal inlets of Holland and Denmark.

On the north bank of the Severn Estuary, where saltings are often found on two distinct levels, rubble is often placed to protect the bank face between the two levels.

Another form of stabilisation yet to be tried is artificial seaweed. This synthetic material is clipped to an open grid mat and can thus be laid on the seaward edge of an eroding salting to any required length. Under water the buoyant strands stand upright thereby reducing the local flow velocities. If successful it could be taken up and used again elsewhere.

Protection of the hinterland, landward of the saltings, is in some areas provided by natural sand dunes. These dunes, at the mercy of the prevailing

dunes. These dunes, at the mercy of the prevailing winds, are often stabilised by kidding (eg brushwood fencing) or gabions or by planting with vegetation such as marram grass.

3.4 Offshore protection

Explained in more detail in section 4.1.4, this is achieved by placing protection seaward of the saltings, either at their seaward face or further offshore. This offshore protection acts as a breakwater to dissipate incoming wave energy and allow sediment to settle out in the quiescent area between the artificial protection and the mudflats fronting the saltings.

Where the face of the saltings is being eroded by wave action, protection in the form of stone filled gabions, rubble or sand bags is sometimes used to deter scour. Artificial seaweed in the form of plastic fronds clipped to a mesh framework, is about to be tried in several test trials on the Essex saltings.

4 REVIEW OF MAJOR SITES

Because of the large acreage of coastal salting, including the bays, inlets and estuaries around our coasts, it was decided to concentrate on three or four of the major sites fringing the east, south and west coasts of England and Wales. This was also dictated by other research currently being carried out.

A five year study of the salt marshes of Great Britain is being undertaken by the Nature Conservancy Council. Although this report, due for publication in 1988, investigates mainly the geographical distribution and vegetation types, it also indicates whether particular areas are in a general state of accretion or erosion.

Symposia to be held in 1987 include those by the Estuarine and Brackish Water Sciences Association on "The Wash" in April and (in conjunction with the Nature Conservancy Council) "Fringing Habitats" in July.

With these studies in mind the following sub-sections concentrate on the views of the relevant regional Water Authority Engineers and, where there are problems, how they are coping. The various sites reviewed are in clockwise order covering England and Wales, and are grouped geographically as east coast, south coast and west coast.

4.1 The East coast

On this coast, fronting the North Sea, the four main areas of coastal saltings reviewed are,

1. the Lindisfarne area, sheltered by Holy Island, on the Northumberland coast,
2. the northeast coast of Lincolnshire which includes the south bank of the Humber Estuary,

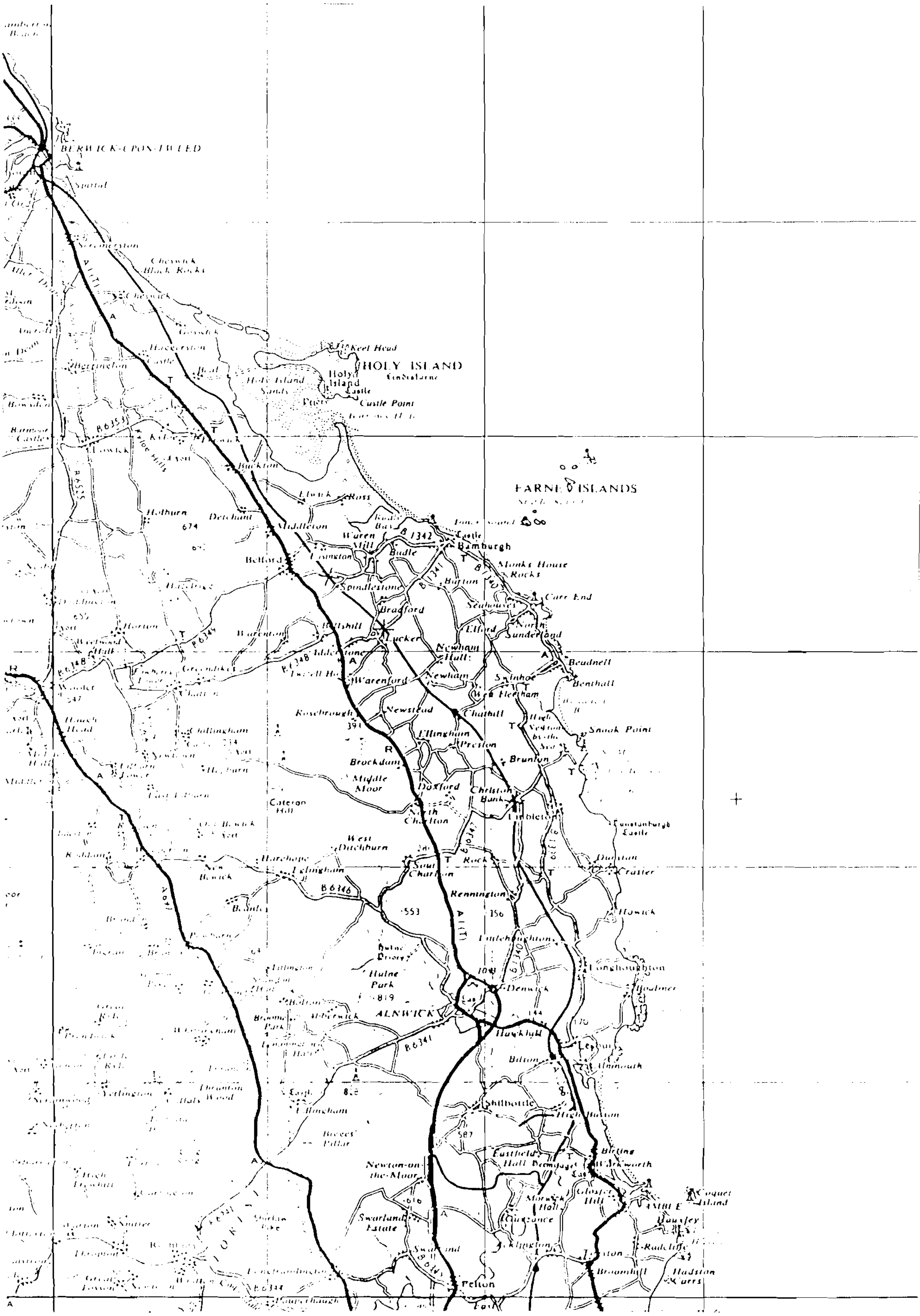
3. North Norfolk from Hunstanton east to Sheringham, and
4. the coast of Essex between Jaywick Sands in the north and Shoeburyness on the Thames Estuary.

Other sites which are largely estuarial such as the Wash and the estuaries of the Kent coast are commented upon briefly.

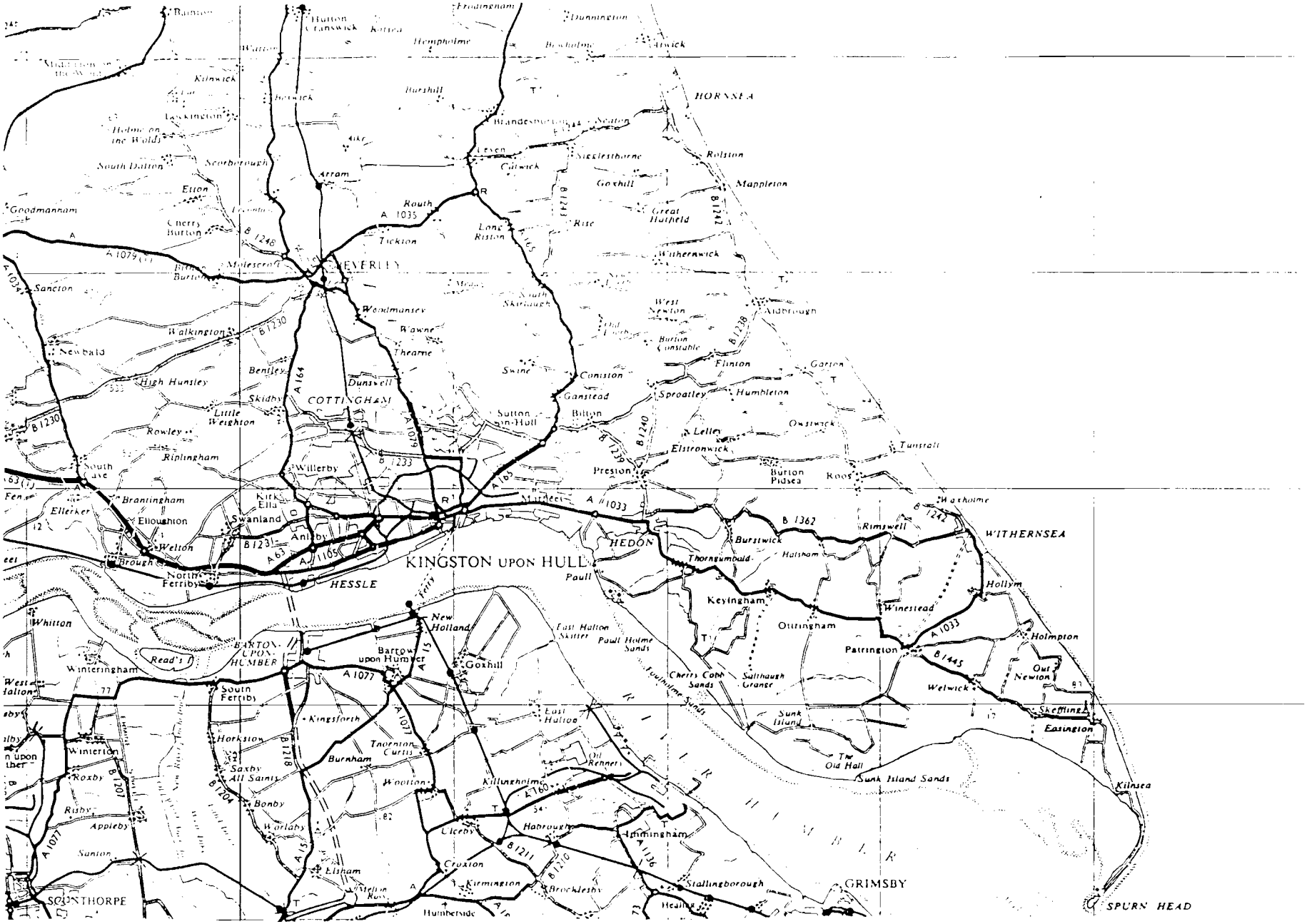
This can be a particularly difficult coastal environment as storms generated in the north sweep down the North Sea, generating a surge at high tide in the bottleneck between East Anglia and the Netherlands. This can cause abnormally high tides along the low-lying south-east coastline with occasionally disastrous consequences.

4.1.1 Lindisfarne

In the Lindisfarne - Holy Island area there are extensive saltings in a large cove sheltered largely by the Island itself. There are no significant problems and although conditions fluctuate, over the last five years there has been more accretion than erosion. Spartina, first planted in 1929, protects the more vulnerable areas to the south and west and its seaward edge is controlled using herbicides to allow wading birds to feed on the fronting mudflats. The whole area is classified as a reserve under the auspices of the Lindisfarne National Nature Reserve. It is sheltered, apart from Holy Island itself, by expanses of sand to the north and in the south. There are few man-made defences, and low lying land near Fenham is thought to be eroding some two metres per year.



BERWICK-UPON-TWEED
Spittal
Cheswick
Cheswick Black Rocks
Haggerston Castle
Beal
Keel Head
HOLY ISLAND
Holy Island
Holy Island Sands
Castle
Castle Point
Buckton
Elwick
Ross
Fenwick
Lowick
Holburn
Detchant
Middleton
Belford
Budle Bay
Waren Mill
Budle
Bamburgh
FARNE ISLANDS
Monks House Rocks
Spindlestone
Burton
Bradford
Seahouses
Carr End
North Sunderland
Elford
Lucker
Warenton
Horton
Newham Hall
Newham
Beadnell
Warenford
Swinhoe
Benthall
Fleetham
Chathill
Newstead
Rosebrough
Ellingham
Preston
Snook Point
Brunton
Brockdam
Middle Moor
Doxford
Christon Bank
Embleton
North Charlton
Cateran Hill
West Ditchburn
Dunstan
Craster
South Charlton
Rock
Harehope
Eglingham
New Bewick
Rennington
Howick
Hulne Priory
Hulne Park
Longhoughton
Denwick
ALNWICK
Hawkhill
Lesbury
Alnmouth
Bilton
Shilbottle
High Buston
Birling
Warkworth
Eastfield Hall
Newton-on-the-Moor
Coquet Island
Swarland Estate
Morwick Hall
Guyzance
Amble
Hauxley
Radcliffe
Broomhill
Hadston Carrs
Felton
A1
B1342
B1340
B6346
B6341
B6348
B6349
B6353


KINGSTON UPON HULL
BEVERLEY
COTTINGHAM
HESSLE
BARTON-UPON-HUMBER
HEDON
WITHERNSEA
HORNSEA
GRIMSBY
SCUNTHORPE
SPURN HEAD
HUMBER

4.1.2 Lincolnshire

There are two main areas of saltings here, one in the south stretching from Gibraltar Point round the Wash Estuary. The other is on the north and east coastline from Whitton on the southern bank of the Humber Estuary south to Theddlethorpe on the coast. There are several gaps in this stretch where the land is protected by hard defences as at Grimsby and Cleethorpes.

The saltings on the southern shore of the Humber Estuary are, in the main, the responsibility of Anglian Water and are in a general state of erosion. Several different methods are being employed to halt this process including the use of kidding (eg brushwood fencing) to hold up the river sediment. When this has been done, marram grass is planted to further stabilise the fluid mud. The planting of Spartina has, over the last couple of years, been discouraged as its prolific growth and ground cover makes it difficult for wading birds to feed in the mud. In other places rock is being dumped close inshore to protect the earth embankments from becoming undermined. This is expensive as there is now no slag coming from the steel mills, and the Lincolnshire quarries are mostly of limestone which is too soft and easily eroded. The rock has to come from quarries in Derbyshire. There seems to be a lot of silt in suspension and any obstruction quickly builds up sediment around it. Kidding, buckthorn and chestnut paling seems to work well in this situation. From observation it would seem likely that the low water channel on this side of the Estuary is meandering toward the south bank, pushing the fast flowing river across and this might well be playing a major role in causing the problems here.

North of the Estuary, on the Holderness Bank, saltings are evident from a point just east of Hull to Spurn Point. At Sunk Island, twelve square miles of land has been reclaimed by dykes and banks. A stone wall protects the low lying farmland from flooding. Currently, a survey of the Humber Estuary is being carried out by The Institute of Estuarial and Coastal Studies of Hull University. The study, entitled, "Spartina in the Humber Estuary, Present and Recent", is being carried out at the request of the Nature Conservancy Council.

The coastline south-east of Cleethorpes around to Theddlethorpe, where the saltings effectively finish, is also the responsibility of Anglian Water. Much of this coastline is designated as a nature reserve and Anglian Water's local engineer said they have no problems and the trend is accretion. This is not altogether surprising as the sediment, flowing seaward down the River Humber, drifts into this area. Although nature reserve wardens are responsible for the saltings generally (as in most other areas), they would obviously inform Anglian Water of any problems as they have responsibility for the sea defences. These consist in the main of well vegetated earth embankments and sand dunes. Any local erosion noticed is curtailed with the use of kidding. As the coastline here is not in private hands, there is little or no reclamation work. The local engineer could remember only one piece of land reclaimed and that was years ago at Tetney, south of the Haven.

Just south of Cleethorpes, stabilised sand dunes play their part as sea defence. As the drift is generally southward down the Lincolnshire coast it seems likely that the sediment, flowing seaward down the Humber contributes in no small measure to the accreting flats south of Cleethorpes. In fact the coast south-east of

CLEETHORPES
Great Coates
Aylesby
Riby
Laceby
Bradley
Scartho
Humberston
Irby upon Humber
Barnoldby le Beck
New Waltham
Holton le Clay
Waltham
Brigsley
Ashby cum Fenby
Beelsby
Cuxwold
Hatcliffe
Tetney Lock
Tetney
North Cotes
Marshchapel
Donna Nook
Grainsby
East Ravendale
North Thoresby
Fulstow
Grainthorpe
North Somercotes
Thorganby
Swinhope
Wold Newton
Ludborough
Covenham St Bartholomew
Covenham St Mary
Conisholme
South Somercotes
Saltfleet
Binbrook
Utterby
North Ormsby
Yarburgh
Skidbrooke
Saltfleetby St Clements
Fotherby
Alvingham
North Elkington
Kelstern
Cockerington
Saltfleetby All Saints
Ludford
South Elkington
Keddington
Saltfleetby St Peter
Theddlethorpe St Helen
North Willingham
Welton le Wold
LOUTH
Stewton
Grimoldby
Theddlethorpe All Saints
Gas Terminal
Burgh on Bain
Manby
Little Carlton
Great Carlton
MABLETHORPE
Hainton
South Willingham
Donington on Bain
Raithby
Lesbourne
Little Cawthorpe
Gayton le Marsh
Trusthorpe
Tathwell
Haugham
South Reston
Withern
Strubby
Thorpe
Sutton on Sea
Benniworth
Muckton
Authorpe
Maltby le Marsh
Sandilands
Market Stainton
Beesby
Ponton
Sotby
Goulceby
Scamblesby
Burwell
Belleau
Markby
Great Sturton
Ruckland
Aby
Saleby
Huttoft
South Thoresby
Bilsby
Belchford
Tetford
South Ormsby
ALFORD
Farlesthorpe
Anderby
Mumby
Baumber
Hemingby
Salmonby
Brinkhill
Driby
Well
Authorpe Row
Cumberworth
Somersby
Ulceby
Wispington
Fulletby
West Ashby
Harrington
Hogsthorpe
Chapel St Leonards
Willoughby
Claxby
Edlington
High Toynton
Greetham
Aswardby
Langton
Hagworthingham
Sloothby
Skendleby
Ingoldmells
Thimbleby
HORNCASTLE
Sausthorpe
Partney
Scremby
Welton le Marsh
Addlethorpe
Horsington
Langton
Thornton
Lusby
Raithby
Candlesby
Orby
Orby Marsh
Burgh le Marsh
Mareham on the Hill
Hameringham
Asgarby
Spilsby
Ashby by Partney
Hundleby
Halton Holegate
Winthorpe
Stixwould
Dalderby
Hareby
Mavis Enderby
Old Bolingbroke
Great Steeping
Bratoft
Irby in the Marsh
Wood Enderby
Moorby
Roughton
Miningsby
Keal
Toynton All Saints
Haltham
Toynton St Peter
Firsby
SKEG.
WOODHALL SPA
Kirkby on Bain
East Kirkby
Toynton Fen Side
Little Steeping
Croft
Mareham le Fen
Revesby
Keal Cotes
Thorpe St Peter
Seacroft
Croft Marsh
Fendike Corner
Tattershall Thorpe
Tumby
Stickford
Wainfleet All Saints
Tattershall
Coningsby
Wainfleet Bank
Gibraltar
New Bolingbroke
New Leake
Tattershall Bridge
Tumby Woodside
Stickney
Midville
Eastville
Wainfleet Sand
Carrington
Dogdyke
Scrub Hill
New York
Friskney
Chapel Hill
Lade Bank
West Fen
East Fen
Northlands
Leake Common Side
Wildmore Fen
Friskney Flats
Frithville
Sibsey
Old Leake
Wrangle
Gipsey Bridge
A 16
A 18 (T)
A 1098
A 1031
B 1201
B 1203
B 1431
B 1200
A 631
A 157
A 153
A 1104
A 1031
B 1373
A 111
A 52
A 158
A 158 (T)
A 1028
B 1196
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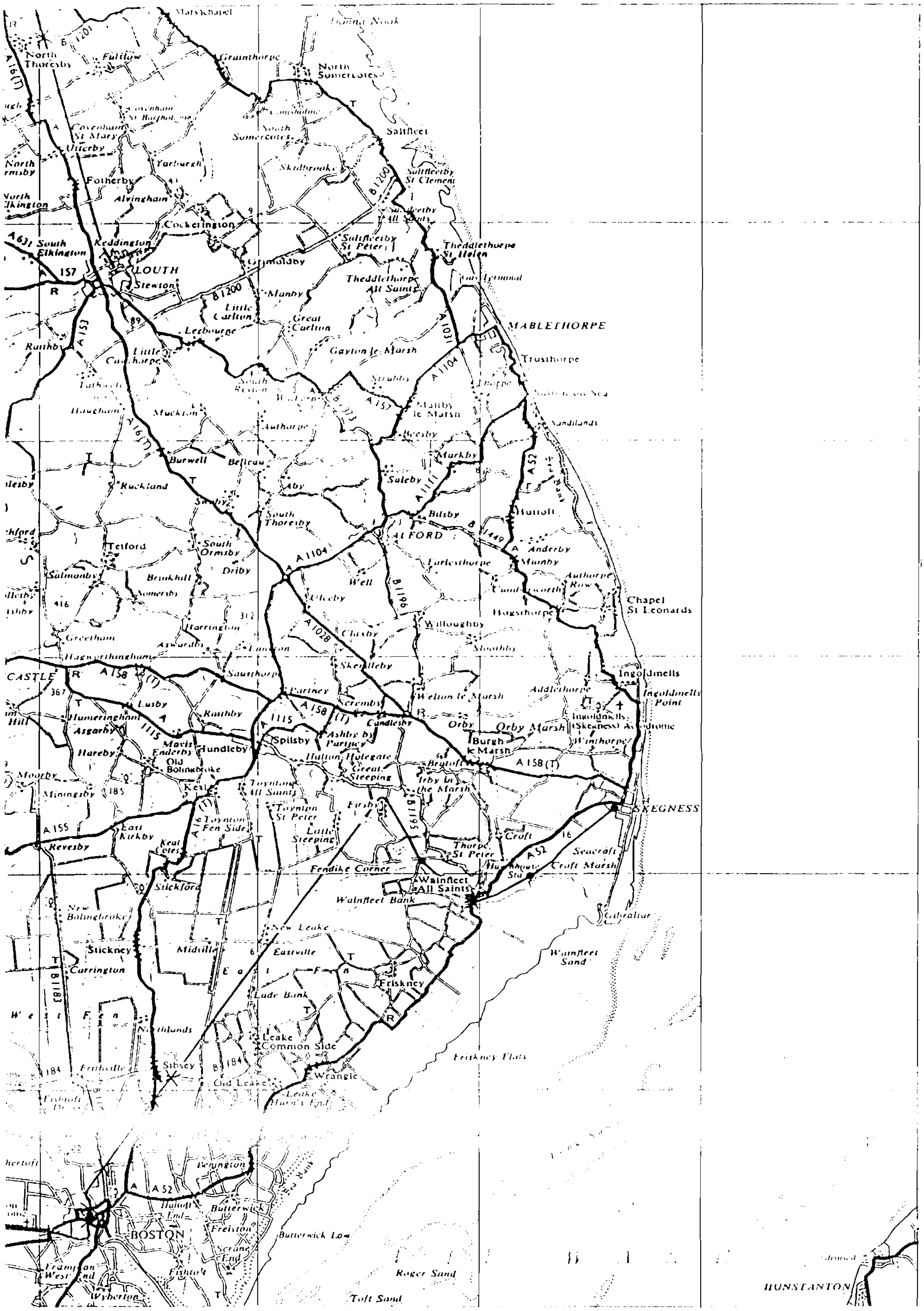
A 155
B 1192
A 1115
A 16 (T)
B 1449



North Thoresby
Fulstow
Grainthorpe
North Somercotes
Saltfleet
South Somercotes
Skidbrooke
Saltfleetby St Clement
Covenham St Mary
Utterby
North Ormsby
Yarburgh
Fotherby
Alvingham
North Elkington
Cockerington
Saltfleetby All Saints
Saltfleetby St Peter
South Elkington
Keddington
LOUTH
Stewton
Grimoldby
Theddlethorpe St Helen
Theddlethorpe All Saints
Manby
Little Carlton
Great Carlton
MABLETHORPE
Legbourne
Little Cawthorpe
Gayton le Marsh
Trusthorpe
Raithby
Sandilands
Maltby le Marsh
Authorpe
Beesby
Burwell
Belleau
Markby
Aby
Saleby
Ruckland
South Thoresby
Hannah
Huttoft
Bilsby
ALFORD
Tetford
South Ormsby
Driby
Anderby
Mumby
Salmonby
Well
Authorpe Row
Chapel St Leonards
Hogsthorpe
Harrington
Willoughby
Greetham
Claxby
Aswardby
Skendleby
Ingoldmells
Ingoldmells Point
Partney
Lusby
Raithby
Scremby
Welton le Marsh
Addlethorpe
Candlesby
Orby
Orby Marsh
Ingoldmells (Skegness) Aerodrome
Hameringham
Asgarby
Hareby
Mavis Enderby
Old Bolingbroke
Hundleby
Spilsby
Ashby by Partney
Halton Holegate
Great Steeping
Bratoft
Burgh le Marsh
Irby in the Marsh
Winthorpe
Moorby
Miningsby
Keal
Toynton All Saints
Toynton St Peter
Firsby
SKEGNESS
Revesby
East Kirkby
Keal Cotes
Toynton Fen Side
Little Steeping
Croft
Seacroft
Croft Marsh
Thorpe St Peter
Fendike Corner
Wainfleet All Saints
Wainfleet Bank
Stickford
New Bolingbroke
New Leake
Gibraltar
Stickney
Midville
Eastville
Wainfleet Sand
Carrington
East Fen
Friskney
Lade Bank
West Fen
Northlands
Leake Common Side
Friskney Flats
Sibsey
Old Leake
Wrangle
Leake Hurn's End
Benington
Haltoft End
Butterwick
BOSTON
Freiston
Butterwick Low
Frampton West End
Scrane End
Fishtoft
Wyberton
Roger Sand
Toft Sand
HUNSTANTON
A16(T)
A631
A153
A157
B1200
A1104
A1031
A52
A158
A158(T)
A1028
B1196
B1195
A1111
B1449
A155
B1183
B1184
A16(T)
A1115

Grimsby is flanked by alluvial flats and saltings, protected at the shoreline (except at Cleethorpes where there is a low cliff of boulder clay) by sandy beaches and low dunes.

The area of the Wash Estuary contains Lincolnshire's most well known saltings. Here, strips of land have been reclaimed for centuries, usually by the strip method explained in section 3.1. There are therefore several lines of earth embankments around most of the estuary protecting the land from the sea. The largest area of salting is at Gibraltar Point where the southerly drift down the Lincolnshire coast has caused accretion south of Skegness and created a sand spit at the north eastern corner of the estuary. This in turn provides the shelter for an area of saltings that is the centre of a 1000 acre nature reserve. The saltings seaward of the largely clay embankments here, which were constructed at around the turn of the century, are protected by extensive sand flats which have built out into the estuary in places by up to 1.5km. An N.C.C. publication (Ref 42) on Spartina Anglica in the Wash, suggests that there has been a dramatic reduction in Spartina vegetation since 1958.

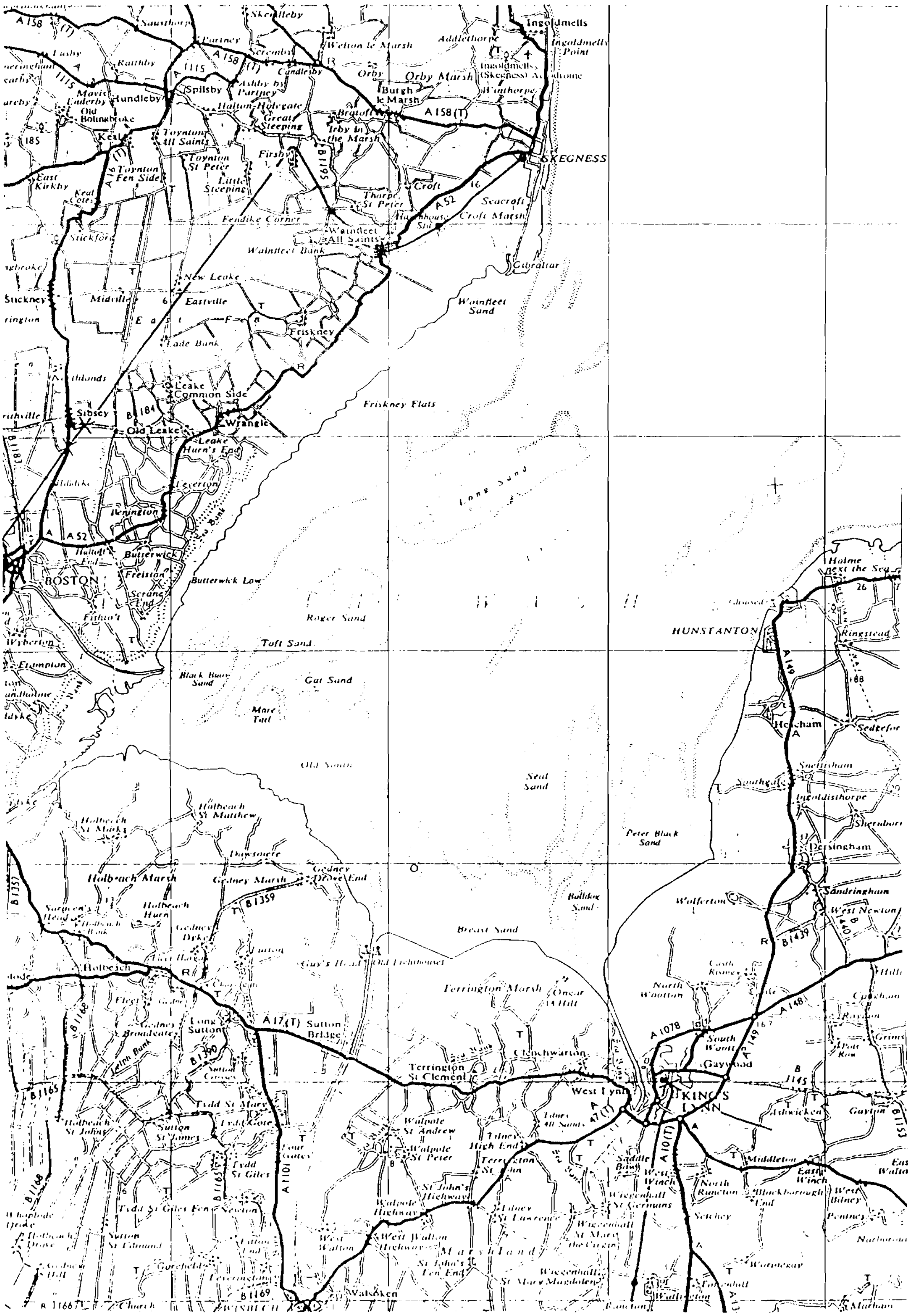
4.1.3 North Norfolk

This area of coastline stretching from Hunstanton in the west to Sheringham in the east, boasts probably the finest development of saltings on the east coast. The front line sea defences here consist of sand or shingle ridges with the saltings, in general, between the ridges and the coast. The coastline consists of long stretches of sand and shingle, low clay cliffs and saltings interspersed with tidal inlets which encourage the growth of further, somewhat more sheltered saltings. Beach levels in 1986, dragged

down by the winter storms, have not recovered and are thought to be at their lowest level in living memory.

This area of North Norfolk stretches some 40km from Sheringham, west to the mouth of the Wash. Starting at Sheringham, the coastline is dominated for some 14.5km by a long shingle ridge with the coastal towns of Salthouse, Cley and Blakeney set back and fronted by saltings and pastures which run seaward out to the shingle ridge. The pastures and hinterland are protected by clay banks. The ridge however is vulnerable to breaching and has done so at intervals in the past. During the last twenty years, the ridge has deteriorated from some 40m wide to a current 3 to 4m in places. Anglian Water have been profiling the ridge annually over the last seven years. West of this ridge, long stretches of sand dunes protect established saltings at Wells next the Sea and the Holkham Marshes. At Wells, silt flowing from the marshes has been causing problems in the main channel. A few years ago on the advice of H.R.L, the Harbour Commissioners started a programme of damming the cross channels in the marsh using people from the Manpower Services Commission. Off Wells, where the dunes are the first line of defence, beach levels are thought to be dropping. Binnie and Partners have been employed as consultants on what is called the "Blakeney Harbour Channel Improvement Scheme".

Scolt Head Island, a nature reserve of dunes and marsh, protects the saltings-fringed coastline to Brancaster. Here the drift is both east and west and the National Trust is concerned that the creek running through the centre of the Head may cut the island in two. It is almost that way now! From Brancaster, where beach levels are very low and the underlying clay's exposed in places, west to Hunstanton the low coastline is protected by sand dunes (stabilised with



Skendleby
Ingoldmells
Ingoldmells Point
Partney
Welton le Marsh
Addlethorpe
Candlesby
Orby
Orby Marsh
Winthorpe
Spilsby
Hundleby
Old Bolingbroke
Halton Holegate
Great Steeping
Burgh le Marsh
Bratoft
Irby in the Marsh
Toynton All Saints
Toynton St Peter
Firsby
Little Steeping
Thorpe St Peter
Croft
SKEGNESS
Seacroft
Croft Marsh
East Kirkby
Keal Cotes
Toynton Fen Side
Fendike Corner
Wainfleet All Saints
Wainfleet Bank
Gibraltar
Stickford
Stickney
New Leake
Eastville
Wainfleet Sand
Friskney
Lade Bank
Leake Common Side
Sibsey
Old Leake
Wrangle
Friskney Flats
Leake Hurn's End
Leverton
Long Sand
Benington
Butterwick
BOSTON
Freiston
Butterwick Low
Roger Sand
Toft Sand
Wyberton
Black Buoy Sand
Gat Sand
Mare Tail
Old South
Seal Sand
Peter Black Sand
Holme next the Sea
HUNSTANTON
Ringstead
Heacham
Sedgeford
Snettisham
Ingoldisthorpe
Dersingham
Sandringham
West Newton
Wolferton
Bulldog Sand
Holbeach St Matthew
Holbeach St Marks
Dawsmere
Holbeach Marsh
Gedney Marsh
Gedney Drove End
Holbeach Hurn
Gedney Dyke
Breast Sand
Guy's Head
Old Lighthouse
Holbeach
Terrington Marsh
Fleet
Long Sutton
Sutton Bridge
North Wootton
South Wootton
Gaywood
Clenchwarton
Terrington St Clement
West Lynn
KING'S LYNN
Tydd St Mary
Sutton St James
Walpole St Andrew
Walpole St Peter
Tilney High End
Tilney All Saints
Ashwicken
Gayton
Holbeach St Johns
Tydd St Giles
Terrington St John
Saddle Bow
Middleton
East Winch
West Winch
North Runcton
Blackborough End
West Bilney
Pentney
St John's Highway
Walpole Highway
Tilney St Lawrence
Wiggenhall St Germans
Sutton St Edmund
West Walton
Marshland
Wiggenhall St Mary the Virgin
Wiggenhall St Mary Magdalen
Setchey
Wormegay
Walsoken
WISBECH
A 158
A 158(T)
A 1115
A 16(T)
A 52
B 1195
B 1184
B 1183
A 149
A 148
B 1439
B 1440
A 1078
A 17(T)
A 47(T)
A 10(T)
A 1101
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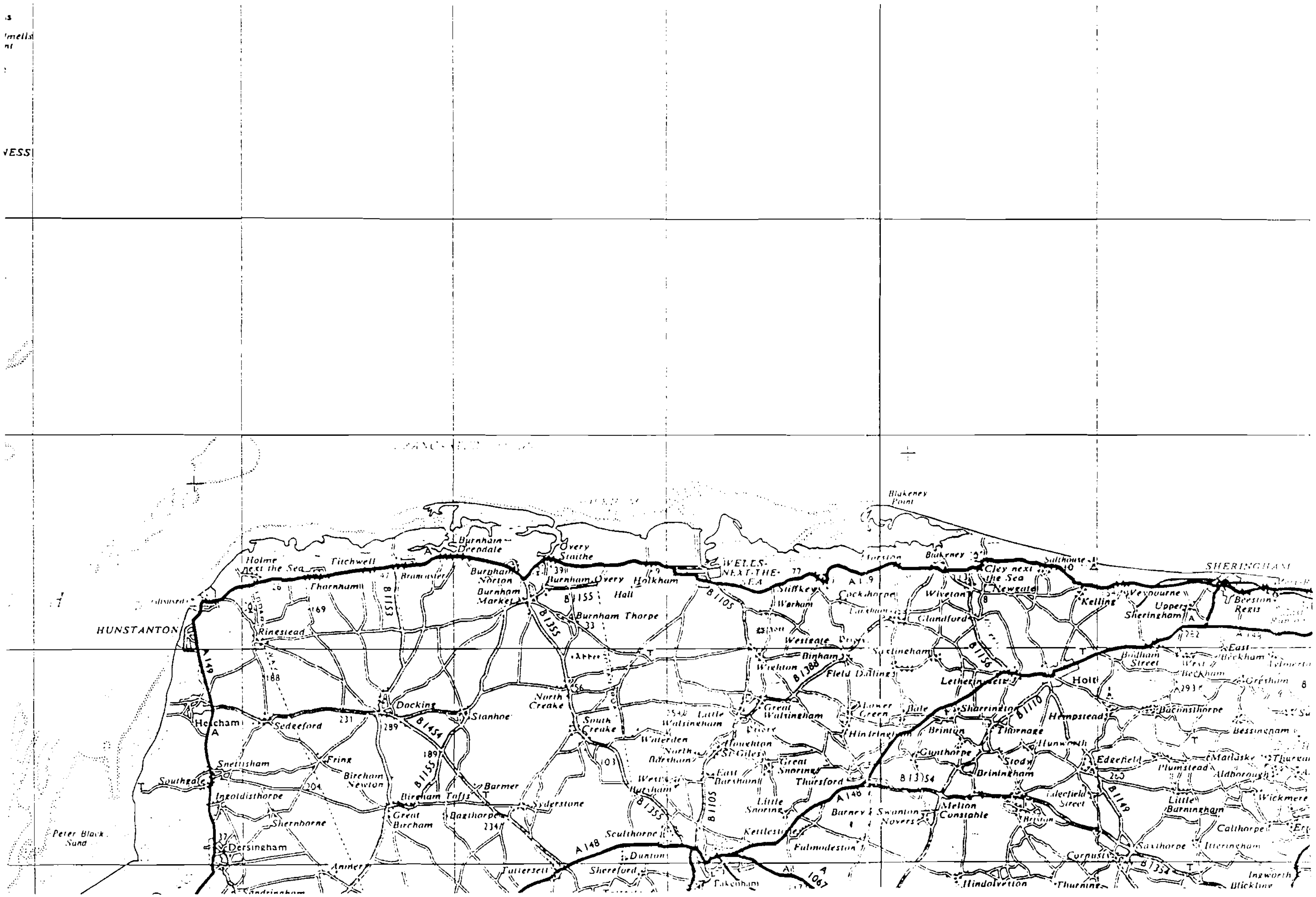
B 1169
B 1357
B 1145
B 1153



HUNSTANTON
Holme next the Sea
Titchwell
Thornham
Brancaster
Burnham Deepdale
Burnham Norton
Burnham Market
Overy Staithe
Burnham Overy
Holkham
Hall
Burnham Thorpe
WELLS-NEXT-THE-SEA
Stiffkey
Warham
Cockthorpe
Morston
Blakeney
Blakeney Point
Cley next the Sea
Newgate
Wiveton
Glandford
Salthouse
Kelling
Weybourne
Upper Sheringham
SHERINGHAM
Beeston Regis
Ringstead
Docking
Stanhoe
North Creake
South Creake
Sedgeford
Heacham
Snettisham
Southgate
Ingoldisthorpe
Shernborne
Dersingham
Fring
Bircham Newton
Bircham Tofts
Great Bircham
Bagthorpe
Barmer
Syderstone
Sculthorpe
Dunton
Shereford
Tattersett
Fakenham
Anmer
Peter Black Sand
Binham
Wighton
Field Dalling
Great Walsingham
Little Walsingham
Waterden
Houghton St Giles
North Barsham
East Barsham
West Barsham
Great Snoring
Little Snoring
Thursford
Hindringham
Lower Green
Kettlestone
Fulmodeston
Barney
Swanton Novers
Melton Constable
Briston
Brinton
Gunthorpe
Sharrington
Letheringsett
Holt
Hempstead
Thornage
Stody
Brinningham
Hunworth
Edgefield
Edgefield Street
Bodham Street
Baconsthorpe
Bessingham
Plumstead
Matlaske
Aldborough
Little Barningham
Wickmere
Calthorpe
Itteringham
Saxthorpe
Corpusty
Hindolveston
Thurning
Ingworth
Blickling
East Beckham
West Beckham
Gresham
Saxlingham
Westgate
A 149
A 148
A 1067
B 1153
B 1155
B 1355
B 1454
B 1105
B 1388
B 1156
B 1110
B 1354
B 1149

kidding and netlon gabions in places), and intermittent clay banks. Erosion of the dunes is causing some concern here and at Titchwell, the sand dunes and saltings are the only protection apart from the rising ground level. The saltings are themselves protected, to a large extent, by the long shingle ridges and the main concern here is the movement of the sand dunes.

On the Norfolk side of the Wash the saltings are mainly spread either side of the River Great Ouse. This again is a landscape of reclamation behind embanked enclosures, especially on the south bank. Saltings, sheltered by flat expanses of sand, front these earth and clay embankments.

4.1.4 Essex

There are probably more coastal saltings on this coast, coupled to sea defence, than anywhere else in the country. This is especially so in the low lying coastal zone between the River Blackwater and the River Crouch. This area is known as the Dengie Flats, although in fact it has a very shallow slope where the tide can retreat up to three kilometres from the seawall.

Nearly all this coastline is flat, low and protected by seawalls or embankments, while saltings fringe the coast from Bradwell to the River Crouch. Peculiar also to this part of England is the coastal belt of reclaimed marshland stretching from the River Colne to Shoeburyness. Won back from the sea by Dutch Engineers during the seventeenth century, there are still large expanses of mudflats and saltings seaward of the largely clay bank sea defences. They usually show two distinct levels. At the top of the beach the saltings, which spread outwards from the seawalls

extend from near the high water mark to about one metre below that level. Seaward of this lie the mudflats. Flooding occurred fairly extensively during storms in 1932 and 1933, inundating several areas of marshland previously reclaimed from the sea.

The general trend here is one of erosion or die back with no discernible cyclic reversal. The Crouch and Blackwater Estuaries are also troubled by erosion which seems a gradual occurrence over the last decade or so. There is thus obvious cause for concern, and foreshore levels are at the lower limit for regeneration. Several schemes are under way to attempt to reverse this trend and these are described a little later.

Exceptions to this climate of erosion seem to be in the Hamford Water, (south of Harwich), and the Stour Estuary. The mud flats in Hamford Water could benefit from sediment from the river or dredging operations at Harwich and Felixstowe. Two-Trees Island on the Thames Estuary is really the only other area, we are told, in which there is healthy growth.

Anglian Water, who are responsible for some 250km of saltings on this coast, are rightly concerned with their continuing foreshore erosion and have sought advice from various institutions and individuals. They have also established measuring stations along the coast and tried various methods of protection.

Different forms of regeneration have been experimented with on the Dengie Flats and three of these are detailed below.

(b) Marsh House, Dengie Flats

Another attempt to reverse this erosional trend on a short stretch was tried on the saltings seaward of Marsh House Farm (see figure 4). Here the low-lying largely agricultural land of the Dengie Peninsula is protected, apart from the saltings, only by an earth embankment at the coastline. As a development of the Schleswig-Holstein method tried at Deal Hall (see below), it was thought that a regenerative scheme with the seaward side one metre higher than at Deal Hall might be beneficial at this site. Thus the 'low cost' solution opted for was to buy up sixteen old lighters (barges), fill them with silt and tow them out and sink them in a position seaward of the eroding saltings. This was done and the barges, each 19.2m long, 4.6m wide and 2.4m high, were positioned some 600m offshore and sunk parallel to the shoreline leaving a 10m gap between each barge. The silt in each barge was covered with gravel (which has since washed off) to stop it from being washed out and to allow an area for migrating terns to nest.

The initial purpose of the lighters was as part of a regeneration programme, the intention being to install flanking brushwood groynes. These were not constructed at the time but a similar system (described below) has since been constructed.

The barges have thus been in place since 1983 as offshore breakwaters and, at a cost of £48000, the results have been encouraging and a recent survey shows accretion has taken place over the full length of the lighters. Of late however, there are reports of scour on their seaward side. This is thought to be the result of wave disturbance causing a shallow trench to form. This in turn was exacerbated by a

nearby cut draining the mudflats, which moved to run into this shallow trench.

To enclose the area landward of the lighters, two rows of stakes have been driven in (some 0.9m high) at right angles to the coast to meet the lighters at either side. The gaps between the stakes were then covered with a fine plastic mesh. This was extended beyond the lighters on the downdrift side to try and retrain the cut seaward away from the seaward edge of the lighters.

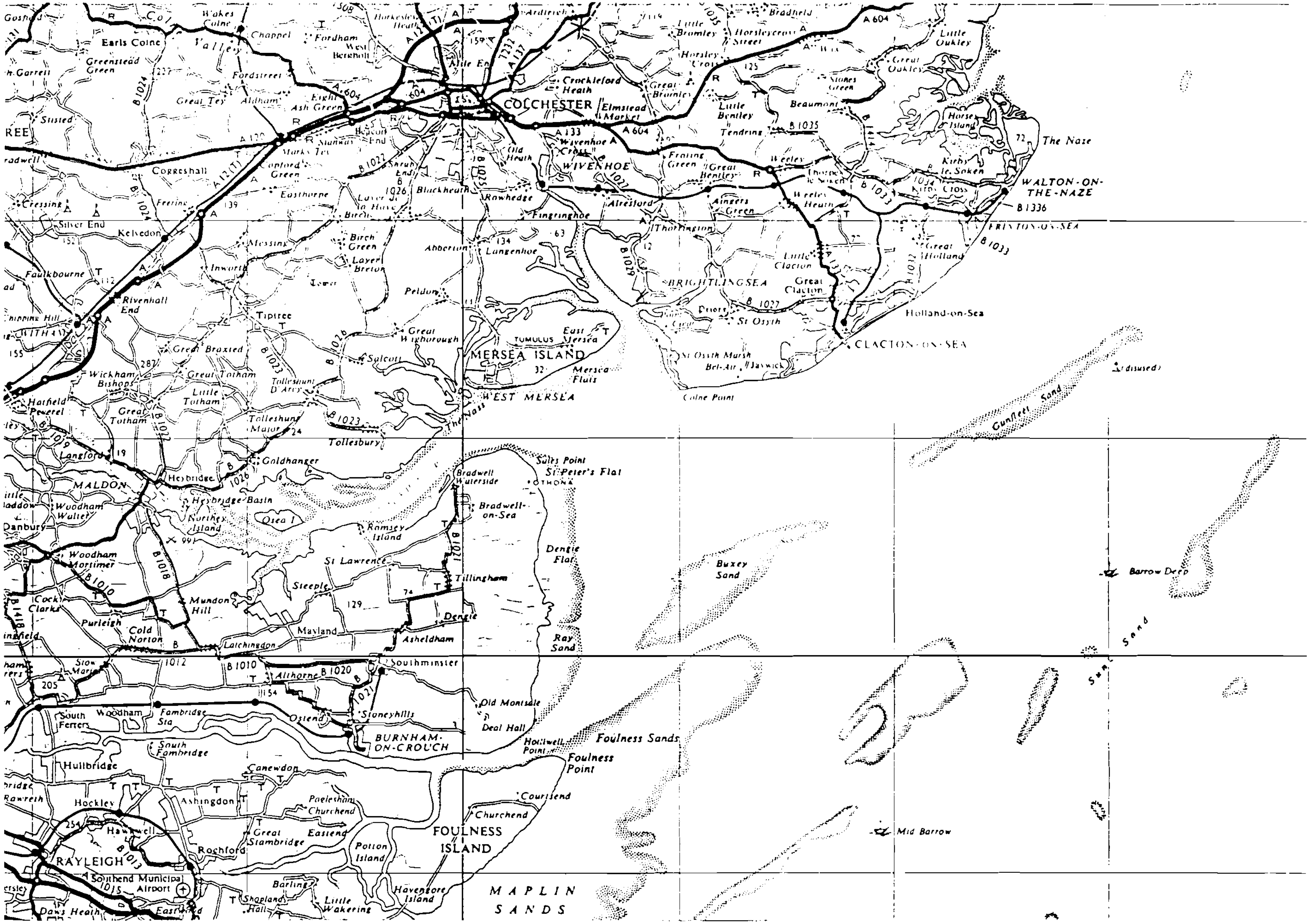
As of mid March, the buildup of the mudflats to landward of the lighters is better than was originally hoped for, and the sheltered saltings to landward seem in a better state than those in the unprotected areas on either side, which are still eroding back.

It is thought there might be a lack of cohesive clay on the foreshore and the build up to the landward of the lighters seems to be mostly silt. This was for some time a glutinous mud but much of it has now consolidated to give a firm footing.

The gravel which initially topped the silt fill in the lighters has now mostly disappeared and the silt now has a cover of sea water. This seems to keep the silt fill fairly stable.

(c) Sales Point, Dengie Flats

Further north, again on the Dengie Peninsula, plans are going ahead to install more offshore breakwaters again using lighters spaced, on the advice of HRL, twenty metres apart. This is to protect an eroding area at the northern edge of the saltings along this part of the coast. The breakwaters will be placed in position, and filled with silt.



COLCHESTER
Earls Colne
Wakes Colne
Chappel
Fordham
West Bergholt
Great Tey
Aldham
Fordstreet
Coggeshall
Kelvedon
Silver End
Cressing
Stisted
Faulkbourne
Rivenhall End
WITHAM
Wickham Bishops
Great Totham
Little Totham
Tiptree
Great Braxted
Inworth
Messing
Feering
Marks Tey
Copford Green
Easthorpe
Birch Green
Layer Breton
Peldon
Abberton
Langenhoe
Fingringhoe
Rowhedge
Blackheath
Old Heath
WIVENHOE
Wivenhoe Cross
Alresford
Thorrington
Elmstead Market
Crockleford Heath
Great Bromley
Little Bromley
Horsley Cross
Horsleycross Street
Bradfield
Little Bentley
Great Bentley
Frating Green
Aingers Green
Tendring
Beaumont
Weeley
Weeley Heath
Thorpe le Soken
Kirby le Soken
Kirby Cross
Great Oakley
Little Oakley
Stones Green
Horsey Island
The Naze
WALTON-ON-THE-NAZE
FRINTON-ON-SEA
Great Holland
Little Clacton
Great Clacton
Holland-on-Sea
CLACTON-ON-SEA
BRIGHTLINGSEA
St Osyth
Priory
St Osyth Marsh
Bel-Air
Jaywick
Colne Point
MERSEA ISLAND
East Mersea
WEST MERSEA
Mersea Flats
The Nass
Great Wigborough
Salcott
Tolleshunt D'Arcy
Tolleshunt Major
Tollesbury
Goldhanger
Heybridge
Heybridge Basin
Northey Island
Osea I.
MALDON
Langford
Hatfield Peverel
Woodham Walter
Woodham Mortimer
Danbury
Cock Clarks
Purleigh
Cold Norton
Mundon Hill
Latchingdon
Mayland
Steeple
St Lawrence
Ramsey Island
Bradwell Waterside
Bradwell-on-Sea
Sales Point
St Peter's Flat
OTHONA
Dengie Flat
Dengie
Tillingham
Asheldham
Ray Sand
Southminster
Althorne
Stow Maries
South Fambridge
South Woodham Ferrers
Fambridge Sta
Ostend
Stoneyhills
BURNHAM-ON-CROUCH
Old Montsale
Deal Hall
Holliwell Point
Foulness Point
Foulness Sands
Courtsend
Churchend
FOULNESS ISLAND
Potton Island
Havengore Island
MAPLIN SANDS
Hullbridge
Rawreth
Hockley
Hawkwell
Ashingdon
Canewdon
Paglesham Churchend
Paglesham Eastend
Great Stambridge
Rochford
RAYLEIGH
Southend Municipal Airport
Barling
Little Wakering
Shopland Hall
Daws Heath
Eastwood
Buxey Sand
Gunfleet Sand
Sunk Sand
Barrow Deep
Mid Barrow
(disused)
A 12(T)
A 120
A 604
A 133
A 137
A 1232
B 1022
B 1023
B 1024
B 1025
B 1026
B 1027
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B 1018
B 1020
B 1021
B 1418

The lighters, similar to those used offshore at Marsh House, are to be placed some 300m offshore with their crests at about mean high water springs. As saltings are not considered amenity areas, this could be a viable solution. The lighters will probably sink to an extent under their own weight but could well be cost-effective and preferable to refurbishing, armouring or renewing miles of embankments.

Elsewhere along the low lying stretches of the Essex frontage, polders, some 50m long and 100m wide, are being placed along the more vulnerable spots. Materials being used include brushwoods, timber offcuts and plastic mesh. Straw bundles were also tried but were not a success.

Lighters, as offshore breakwaters, are also planned for use in Hamford Water at the north-eastern edge of Horsey Island and at Foulton Hall to the north.

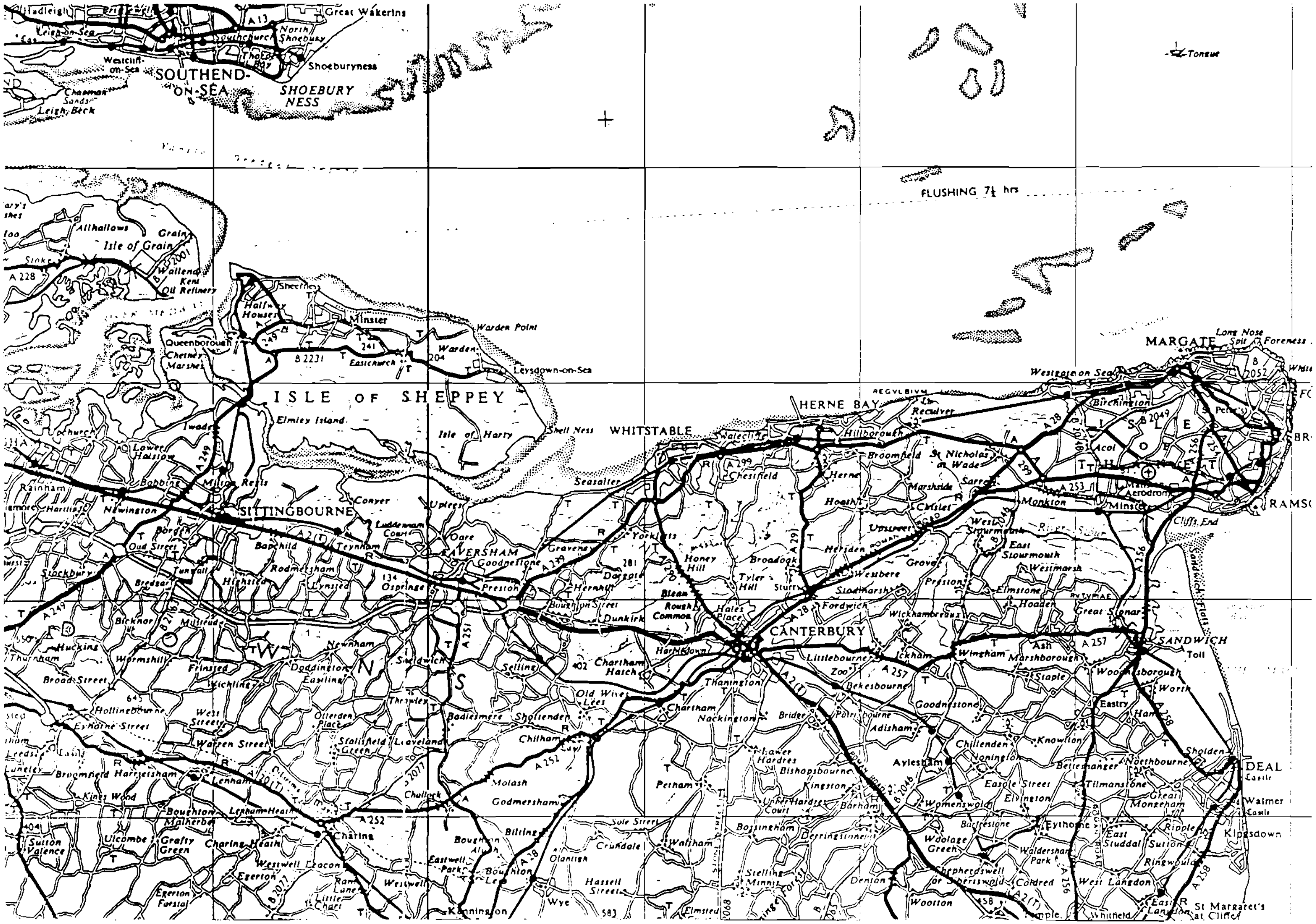
4.1.5 Kent

Coastal saltings here are, in general, confined to the southern bank of the Thames Estuary and the reaches of the estuaries of the Medway, Swale and Stour.

They are thought in general to be on the decline although the reason is not fully understood. The seaward edges of the flats have sharp, clifflike edges as have been observed in other parts of the country. Some benefit may have been gained with the partial closure of the refineries on the Isle of Grain. A plan to reclaim the saltings at Stoke on the Medway with rubbish was abandoned with the demise of the Greater London Council.

A report by Kirby (Ref 42) suggests that wave attack, mud digging and sea level rise are all contributary

factors to the general erosional regime in the Medway Estuary today.



Great Wakering
Leigh-on-Sea
Westcliff-on-Sea
SOUTHEND-ON-SEA
Southchurch
North Shoebury
Shoeburyness
SHOEBURY NESS
Leigh Beck
FLUSHING 7½ hrs
Allhallows
Isle of Grain
Grain
Kent Oil Refinery
Sheerness
Minster
Queenborough
Warden Point
Warden
Eastchurch
Leysdown-on-Sea
ISLE OF SHEPPEY
Elmley Island
Isle of Harty
Shell Ness
WHITSTABLE
HERNE BAY
Reculver
MARGATE
Long Nose Spit
Foreness
Westgate on Sea
Birchington
Acol
St Nicholas at Wade
Sarre
Monkton
Minster
Cliffs End
RAMSGATE
Seasalter
Chestfield
Herne
Broomfield
Hillborough
Hoath
Chislet
Marshside
SITTINGBOURNE
Conyer
Teynham
Bapchild
Rodmersham
Newington
Rainham
Bobbing
Milton Regis
Iwade
Lower Halstow
Tunstall
Borden
Bredgar
Stockbury
Bicknor
Milstead
Hucking
Wormshill
Frinsted
Hollingbourne
Broad Street
Eyhorne Street
Harrietsham
Lenham
Broomfield
Kings Wood
Boughton Malherbe
Sutton Valence
Ulcombe
Grafty Green
Charing Heath
Charing
Egerton
Egerton Forstal
Westwell Leacon
Westwell
Warren Street
Wichling
Doddington
Eastling
Newnham
Otterden Place
Stalisfield Green
Leaveland
Throwley
Sheldwich
Badlesmere
Sheldwich
Ospringe
Lynsted
Hiehsted
FAVERSHAM
Oare
Goodnestone
Graveney
Preston
Hernhill
Dargate
Yorkletts
Boughton Street
Dunkirk
Selling
Chilham
Old Wives Lees
Chartham Hatch
Molash
Godmersham
Challock
Boughton Aluph
Boughton Lees
Eastwell Park
Kennington
Wye
Olantigh
Crundale
Hassell Street
Waltham
Petham
Bossingham
Stelling Minnis
Elmsted
Honey Hill
Broadoak
Tyler Hill
Sturry
Blean
Rough Common
Harbledown
Hales Place
CANTERBURY
Fordwich
Westbere
Stodmarsh
Upstreet
Hersden
Grove
Preston
Elmstone
Hoaden
West Stourmouth
East Stourmouth
Westmarsh
Great Stonar
SANDWICH
Toll
Sandwich Flats
Wickhambreaux
Littlebourne
Ickham
Wingham
Ash
Marshborough
Staple
Woodnesborough
Worth
Eastry
Ham
Bekesbourne
Thanington
Chartham
Nackington
Bridge
Patrixbourne
Adisham
Goodnestone
Lower Hardres
Bishopsbourne
Kingston
Upper Hardres Court
Barham
Aylesham
Nonington
Chillenden
Knowlton
Betteshanger
Northbourne
Sholden
DEAL
Walmer
Kingsdown
Tilmanstone
Great Mongeham
Easole Street
Elvington
Womenswold
Barfrestone
Eythorne
East Studdal
Sutton
Ripple
Ringwould
Woolage Green
Shepherdswell or Sibertswold
Waldershare Park
Coldred
West Langdon
East Langdon
St Margaret's at Cliffe
Whitfield
Temple
Wootton
Denton
Derringstone
Tonsue
REGVLBIVM
A 13
A 228
A 249
A 2(T)
A 251
A 252
A 20(T)
A 28
A 299
A 290
A 253
A 256
A 257
A 258
B 2231
B 2049
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B 2046
B 2077

4.2 The South coast

Due to the exposure to the dominant south-westerlies there are very few coastal saltings in evidence. The saltings fringing the English Channel are found mostly in the area of the Solent or in the various harbours or river mouths along the coast. Probably the most extensive are those between Hurst Castle to the west and Southampton Water, in the shelter of Hurst Castle Spit and the Isle of Wight.

Southern saltings are in general of mud and silt, with tall grasses of which Spartina is one of the more important species.

The N.C.C. (Ref 42) suggests that the chronology of marsh degeneration varies from place to place but it has been generally rapid and extensive since about 1960.

4.2.1 Hampshire

The majority of the saltings on this coast are confined to the area between Hurst Castle and Southampton Water and in Portsmouth, Langstone and Chichester Harbours. The open coast salting between Keyhaven and Calshot is sheltered to the south by the Isle of Wight and, more importantly by Hurst Castle Spit. This shingle spit (which is currently being reinforced) provides shelter from the prevailing south-westerlies and without its protection the saltings to the east would soon be washed away. An oily scum, presumably from the refineries at Fawley, covers a lot of the saltings which are generally giving cause for concern.

Hurst Castle Spit is really an extension of the shingle beach of Milford on Sea. Built up on a clay bench from shingle derived from both offshore and the

retreating cliffs of Christchurch Bay, the spit is some 2km long. It has lengthened little over the last 400 years as evidenced by the castle, built near the end of the ridge in 1541. It has however had to withstand the impact of south-westerly storms over the years and concern is growing because of possible breaching at its neck.

Coastal protection behind these saltings is largely of earth and clay embankments, a large proportion of which have fairly recently been reinforced on their seaward side by concrete grouted rock or stone block. The toe of the wall has also in some places been refurbished. The spit directly protects the tidal inlet at Keyhaven which is mostly saltings and mudflats at low tide and which are reducing in area.

Further east at Lymington, saltings and mudflats fringe the estuary and coastline. In the nineteenth century one of the chief occupations here was the collection of brine in the shallow pools of the marsh and then boiling off the water to obtain salt. These old saltings are now inside the sea wall. The saltings just within the River Lymington itself help protect two large yacht marinas plus the river moorings. Both the New Forest District Council and the Lymington Harbour Commissioners are directly concerned with problems of erosion. Mr Arthur Mascall, who has recently retired from the post of technical manager for the Colchester Division of Anglian Water, was consulted by the Lymington Harbour Commissioners. His opinion was that the rate of loss of vegetation in Lymington Harbour is probably greater than that on the Essex coast and merits immediate investigation. On a visit to the Harbour Commissioner by H.R.L. in March the problem was discussed. It was suggested to the Harbour Commissioner that, initially, a project to determine the hydraulic climate within the Estuary should be started.

Continuing eastward, the saltings fringe the coastline which although groyned in places, is only occasionally artificially embanked, as far as the Beaulieu River. Within the mouth of the river there is a large expanse of saltings protected by the eastward growing shingle spit of Needs Ore Point. Here the river mouth was partially protected by the shingle spit of Needs Ore Point and the muddy Gull Island. It was thought that the eastward drift of the shingle was being interrupted by the river flowing out between the Point and the Island and in 1986 the gap between the two was closed to facilitate shingle migration eastward to protect the eroding Gull Island. In the river itself, saltings flank both banks up as far as Beaulieu. Spartina die back with the familiar cliff like edges is taking place. The Spartina in some cases is being replaced naturally with mainly Sea Purslane.

In Southampton Water the most extensive saltings extend along its west bank south from Hythe. A project undertaken by Portsmouth Polytechnic apparently showed major advances of saltings during the period 1870 - 1950, along the Solent near Fawley where healthy saltings still persist. In the River Hamble on the east side of Southampton Water the saltings are thought to be fairly stable with some growth upstream at Bursledon Point. There is thought to be some die back from the Marine Terminal opposite, south-west to Calshot Spit.

In the east of the county, saltings are to be found within the Portsmouth, Langstone and Chichester harbours.

Portsmouth Harbour

Within the harbour there has been much reclamation over the years and the saltings lie mainly on the western shore between Gosport and Fareham.

Langstone Harbour

Although the harbour mouth here is narrower than Chichester Harbour and therefore more sheltered, the picture is again of general erosion. The islands in the middle of the harbour, based on London Clay, are eroding especially on their south and west facing edges.

The Spartina marshes which peaked some thirty years ago, have over the last twenty years been on the decline. Coastal protection on the Farlington marshes is provided by a chalk/rubble embankment some 4km long. Faced with concrete and reno mattresses, it was built in stages and finally completed in 1981.

Standing on Langstone Hard within the harbour it is possible to see slumping of the flats where the saltings are dying back.

Chichester Harbour

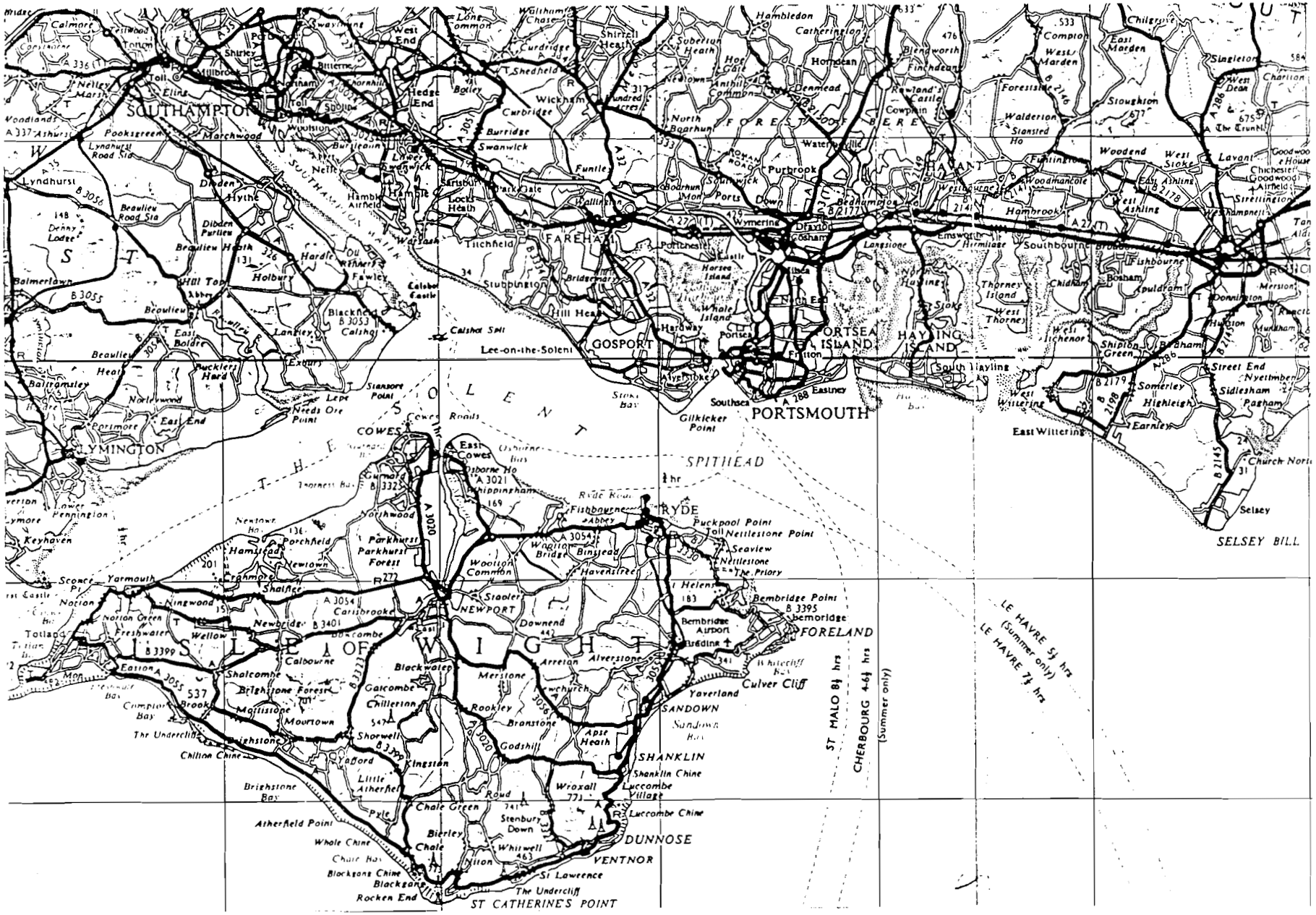
The saltings within the harbour are said to be fairly stable, more so on the western, Hayling Island, side. Spartina die-back is taking place mostly on the eastern, lee shore, in the more exposed areas especially between Itchenor and Rockwood. Coastal protection is mostly clay embankments and in some places there is natural progression (ie mudflats - saltings - agricultural land). A conservation warden is about to be employed by the Harbour Commissioners. Part of his job will be to monitor the saltings.

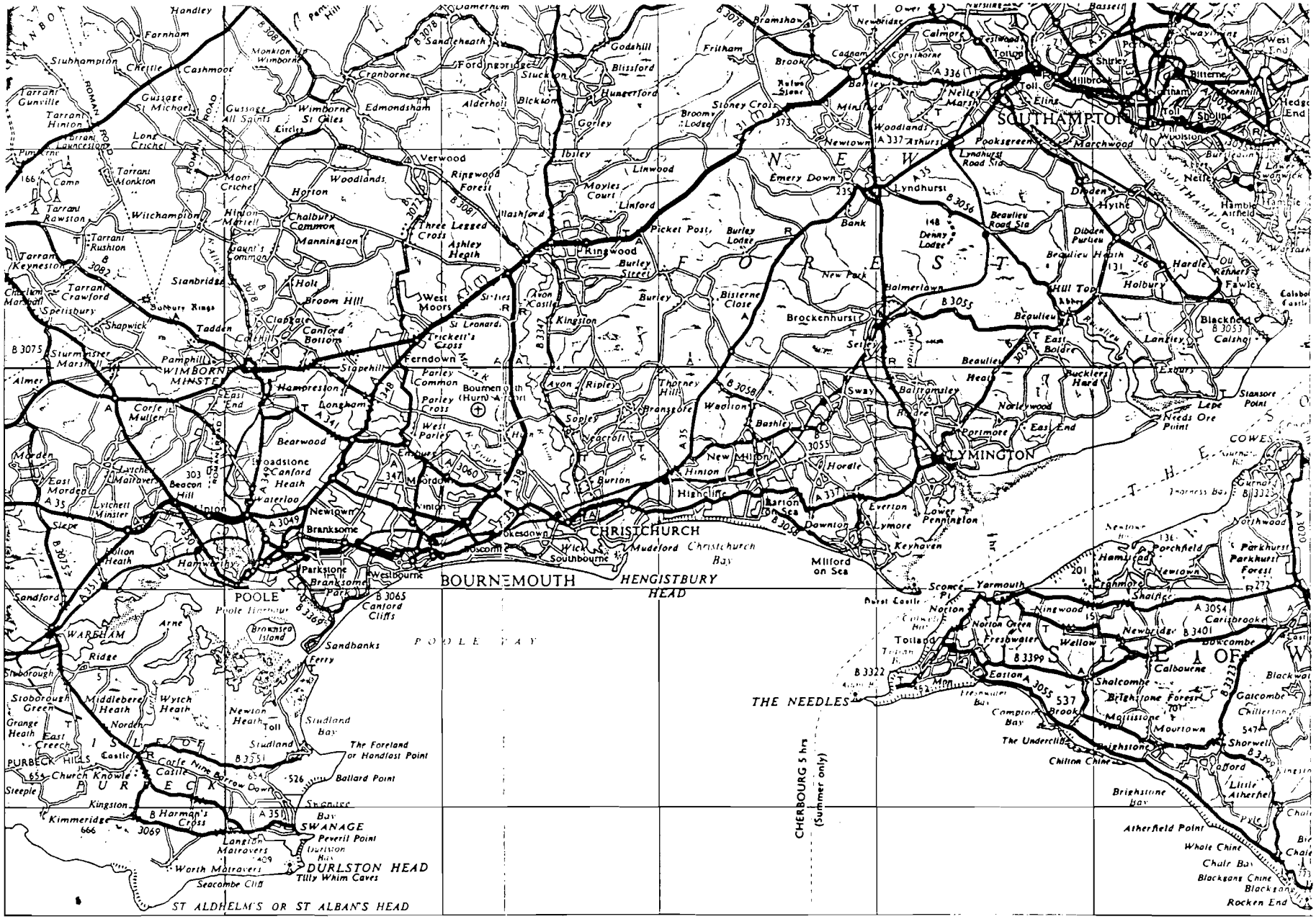
Hydraulics Research are currently taking part in a review of the Hampshire coastline on behalf of the Hampshire County Council. This report, due out in July 1987, will no doubt reveal the state of saltings on this coast in greater detail.

Further east, on the Sussex coast in Pagham Harbour, the saltings appear healthy although it is very sheltered.

4.2.2 Dorset

The saltings here are concentrated mainly within Poole Harbour. The Spartina grass saltings, within and to the south of the harbour entrance, are disappearing. This is especially so in Brand's Bay and around Furzey Island. The saltings in Holes Bay to the north of the harbour are also in a state of erosion. Further inside the harbour, in the Wareham area where there is more fresh water flow, the saltings are stable. There are several reports on the saltings within Poole Harbour and the story seems similar to those in other areas; Spartina die back seems to have been happening since the 1930's and noticed in the 1950's. Die back, which appears to be a natural phenomenon, has continued since then with the decline in area and the break up of the saltings in the seaward part of the harbour.


SOUTHAMPTON
PORTSMOUTH
GOSPORT
FAREHAM
NEWPORT
RYDE
COWES
YARMOUTH
SANDOWN
SHANKLIN
VENTNOR
DUNNOSE
FORELAND
SELSEY BILL
ST CATHERINE'S POINT
SPITHEAD
SOLENT
THE SOLENT
ISLE OF WIGHT
PORTSEA ISLAND
HAYLING ISLAND
LYMINGTON
ST MALO 8½ hrs
CHERBOURG 4-6½ hrs (Summer only)
LE HAVRE 5½ hrs (Summer only)
LE HAVRE 7½ hrs


SOUTHAMPTON
NEW FOREST
BOURNEMOUTH
CHRISTCHURCH
POOLE
WIMBORNE MINSTER
RINGWOOD
LYMINGTON
ISLE OF WIGHT
POOLE BAY
HENGISTBURY HEAD
Christchurch Bay
THE NEEDLES
DURLSTON HEAD
ST ALDHELM'S OR ST ALBAN'S HEAD
PURBECK HILLS
CHERBOURG 5 hrs (Summer only)

few problems downstream of Lavernock Point. In the Estuary itself, there are areas of accretion and also erosion. These are summed up in the following.

The Bristol Channel - South Bank

Moving upstream, the first large area of saltings lies to the west of the entrance to the River Parrett on the Somerset coast. This expanse, bounded to the east by the river and to the west by a shingle spit, is vegetated largely by Spartina, introduced in 1930 and supplemented since. Up to 400m wide in places, the area seaward of Steart Point and up to the schedule 4 boundary, is backed by clay embankments. Although in retreat since about 1975, the salting is still very wide and effective in reducing wave attack at the coast. The shingle ridge coastal defences to the west, however, are shortly due for refurbishment and this could affect the saltings.

North of the River Parrett as far as Sand Point, the foreshore is generally of sand interspersed by saltings at Huntspill, either bank of the River Axe (no Spartina) and in the north-east corner of Sand Bay. They are all thought to be in a state of slow erosion except at Sand Bay where the Spartina growth has had to be cut back.

The Bristol Channel - North Bank

No real problems downstream of Lavernock Point.

Severn Estuary - South Bank

The seaward end of the estuary begins at Woodspring Bay. At its southern end, the saltings are thought to be stable. Further north-east however, beyond Kingston Seymour, they are eroding. This is due in

part it is thought to the construction of a new seawall. This erosional trend continues to Clevedon. An area of saltings fronting the earth embankment at Portbury is thought to be stable.

Severn-Trent Water are responsible for most of the coastline north-east from Avonmouth. The saltings here really start at Redwick, and from there to Aust Cliff, they are accreting steadily. North of Aust Cliff the saltings are eroding and stone reinforcing has been placed at their seaward edge. From Avonmouth north-east to the Severn Bridge, the coastal defence is largely clay embankment, concrete faced in places. Upstream of the bridge at Oldbury, most of the salting is enclosed by clay banks. At Shepperdine too, some are enclosed and the saltings seaward of the embankments, 50m wide in places, are accreting. Further upstream at Frampton and Slimbridge there are problems due to erosion.

Severn Estuary - North Bank

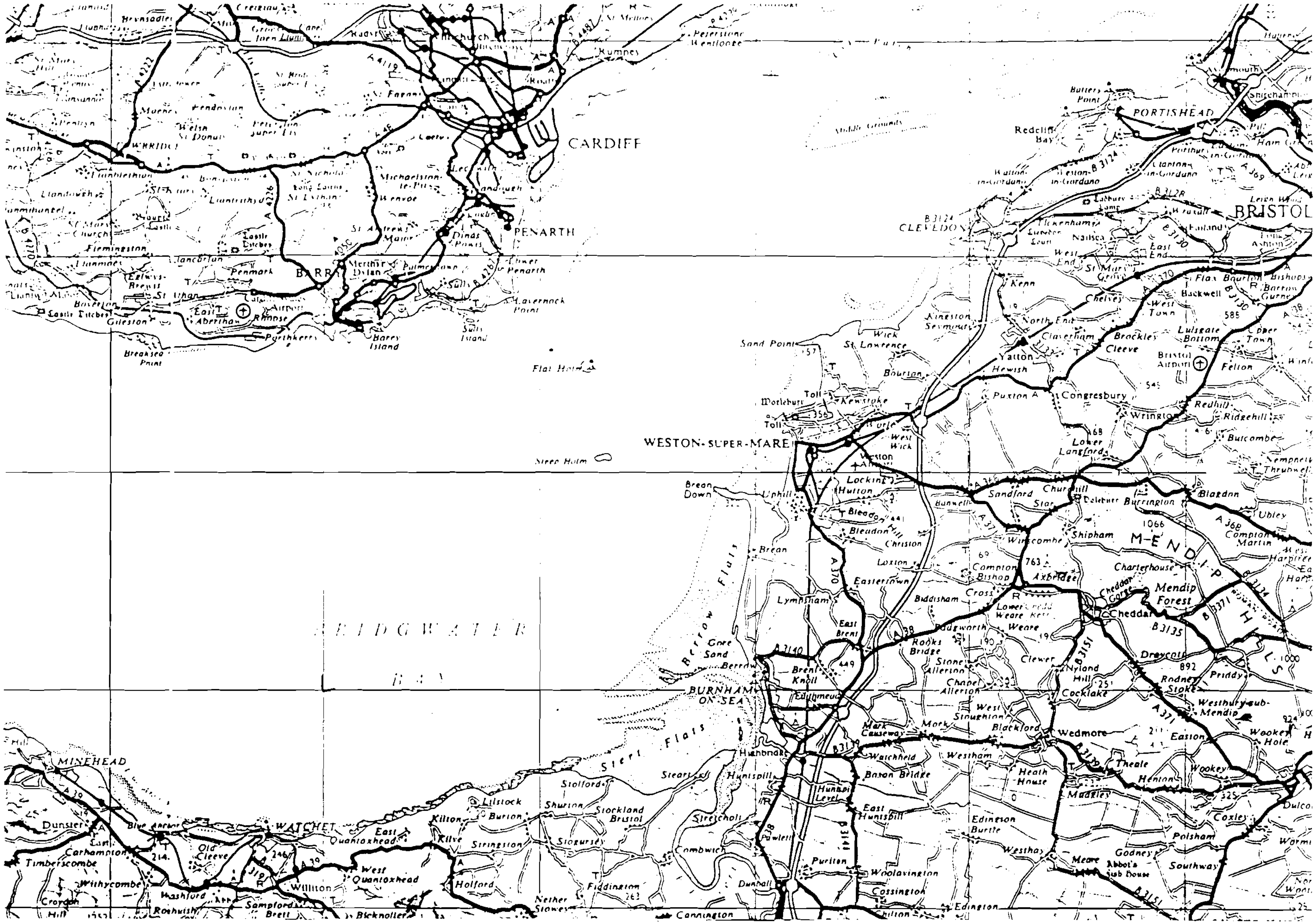
On the Welsh side of the estuary, the largest area of saltings lie between Cardiff and Chepstow, and this is the main problem area as far as Wales is concerned. Apart from two small areas of natural high ground, the coastline is low-lying, protected by either earth embankments or concrete walls. The responsibility of Welsh Water, this area which has a tidal range of up to 12m, has a history of flooding. The defences here depend on local conditions but in general the earth embankments were built to a level of between 8.8m and 9.5m A.O.D. The saltings fronting these defences are, in places, on two levels and range generally between 6.0m and 7.5m A.O.D. According to a paper by Green (Ref 23) they are in a state of general erosion (although in some parts the saltings are accreting)

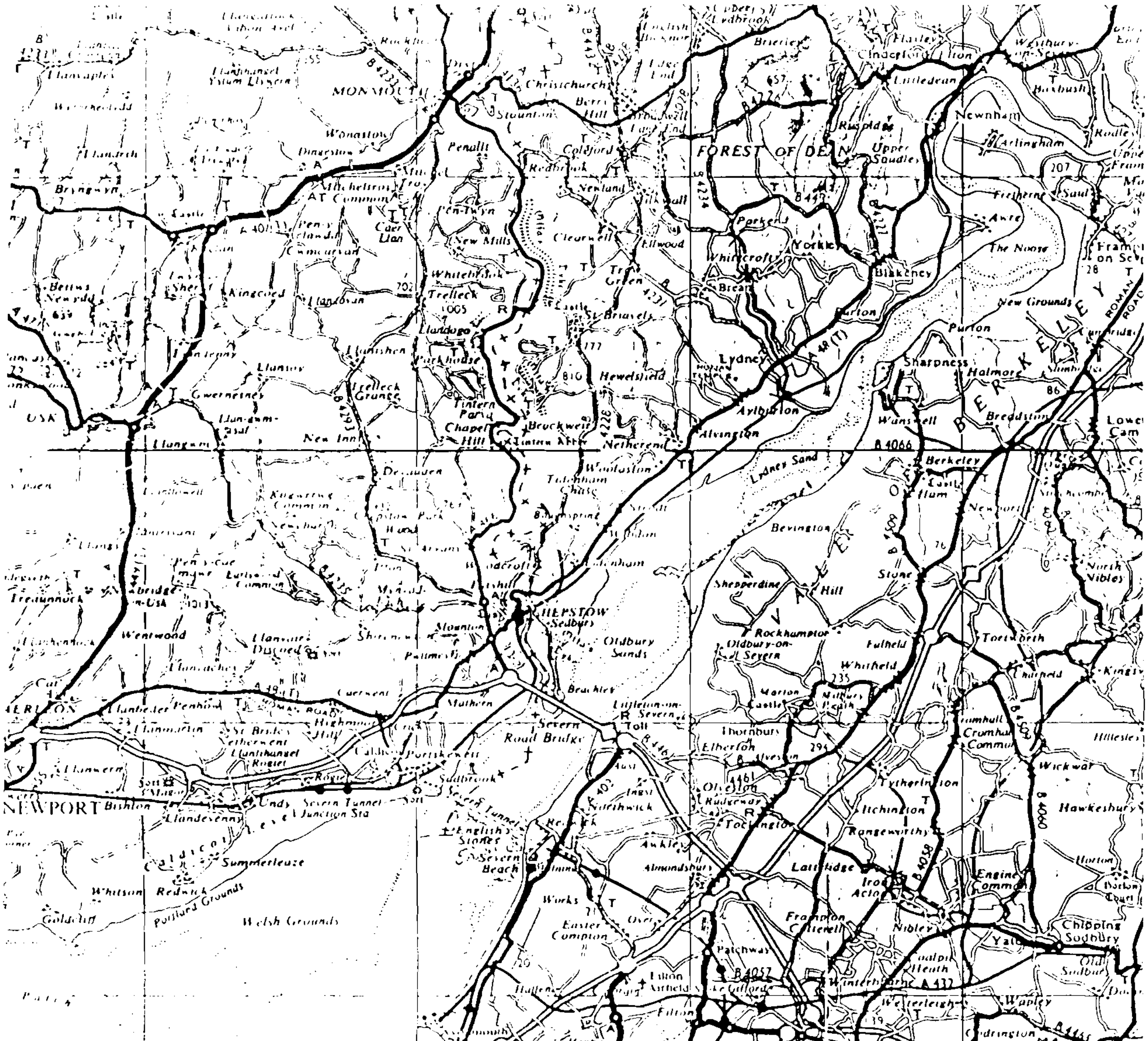
and measures to halt this trend are being carried out on a regular basis.

The optimal saltings width seem to be 30 to 40m and in areas where it is less than this, extra protective measures have to be taken. Preservation of the saltings is by placing stone rubble at their seaward edge to deter erosion, while in some cases the bottom 1 to 2m of the earth embankment is pitched. Where the saltings no longer exist, vertically faced masonry walls, topped by a concrete wave return coping are in place, fronted by rockfill and built with a crest level of about 10m A.O.D. Extensive reconstruction was undertaken between 1953 and 1974 and included a groyne system when 1.5m high, widely spaced, permeable barriers were placed. Expected to work in isolation, their success varied widely.

Further protective measures including articulated concrete units, silt traps and groyne systems are under consideration and there is a plan to regenerate an area of Rumney Great Wharf east of Cardiff (which it is hoped will start this year), where the lower level salting has disappeared leaving the high level seaward edge up to 2.5m deep. This will be a polder scheme using posts and fagotting, and the enclosed section of salting will comprise an area some 240m long, 100m wide with a gap of 10m in the centre of the fagotting to allow the tide to flow in. Welsh Water are hoping to start the project this year.

The River Wye is the boundary between Wales and England. Upstream from there, the shoreline to the west of Lydney Harbour is faced with clay embankments, protected with rock along a stretch west of the Harbour. This area, the responsibility of Severn Trent Water, is under attack.


CARDIFF
PENARTH
BARRY
Barry Island
Flat Holm
Steep Holm
WESTON-SUPER-MARE
CLEVEDON
PORTISHEAD
BRISTOL
BRIDGWATER
BAY
BURNHAM-ON-SEA
MENDIP HILLS
Mendip Forest
Cheddar
Axbridge
Wedmore
Congresbury
Yatton
Bristol Airport
WATCHET
MINEHEAD
Dunster
Williton
Stert Flats
Berrow Flats
Brean Down
Sand Point
Kewstoke
Worle
Nailsea
Backwell
Blagdon
Shipham
Winscombe
Wookey Hole
Rhoose Airport
Breaksea Point
Lavernock Point
Rumney
Highbridge
Puriton
Stogursey
Holford
West Quantoxhead



MONMOUTH
FOREST OF DEAN
Newnham
Littledean
Cinderford
Coleford
Trelleck
Whitecroft
Blakeney
Lydney
Sharpness
Berkeley
Alvington
Aylburton
Woolaston
Tidenham
CHEPSTOW
Sedbury
Oldbury Sands
Oldbury-on-Severn
Rockhampton
Thornbury
Falfield
Tortworth
Charfield
Wickwar
Hawkesbury
Severn Road Bridge
Severn Tunnel
Severn Tunnel Junction Sta
NEWPORT
Bishton
Caldicot Level
Summerleaze
Magor
Undy
Redwick
Welsh Grounds
Portskewett
Sudbrook
Caldicot
Penhow
Wentwood
Usk
Severn Beach
Pilning
Almondsbury
Tockington
Olveston
Aust
Patchway
Frampton Cotterell
Iron Acton
Yate
Chipping Sodbury
Winterbourne
MANGOTSFIELD
Pucklechurch
Siston
PORTISHEAD
Portbury
Redcliff Bay
Walton-in-Gordano
Weston-in-Gordano
Clapton-in-Gordano
CLEVEDON
Tickenham
Nailsea
Pill
Ham Green
Shirehampton
Avonmouth
Henbury
Filton
Westerleigh
Redland
Clifton
Abbots Leigh
Leigh Woods
BRISTOL
Long Ashton
Wraxall
Flax Bourton
Backwell
Barrow Gurney
Bishopsworth
Dundry
Dundry Hill
Winford
Felton
Bristol Airport
Chew Magna
Chew Stoke
Stanton Drew
Pensford
Hunstrete
Compton Dando
Kingswood
Hanham
Brislington
KEYNSHAM
Saltford
Queen Charlton
Whitchurch
Oldland
Wick
Doynton
Cold Ashton
Upton Cheyney
North Stoke
Kelston
Langridge
Charlcombe
BATH
Twerton
Newton St Loe
Englishcombe
Marksbury
Priston
Farmborough
Timsbury
Clutton
Temple Cloud
Hinton Blewett
Bishop Sutton
Compton Martin
West Harptree
Ubley
Blagdon
Nempnett Thrubwell
Butcombe
Redhill
Wrington
Congresbury
Yatton
Claverham
Cleeve
Brockley
Kenn
Kingston Seymour
Wick St Lawrence
Churchill
Sandford
Shipham
Winscombe
Paulton
Camerton
Peasedown St John
Hallatrow
High Littleton
M·END

4.3.2 Cardigan Bay

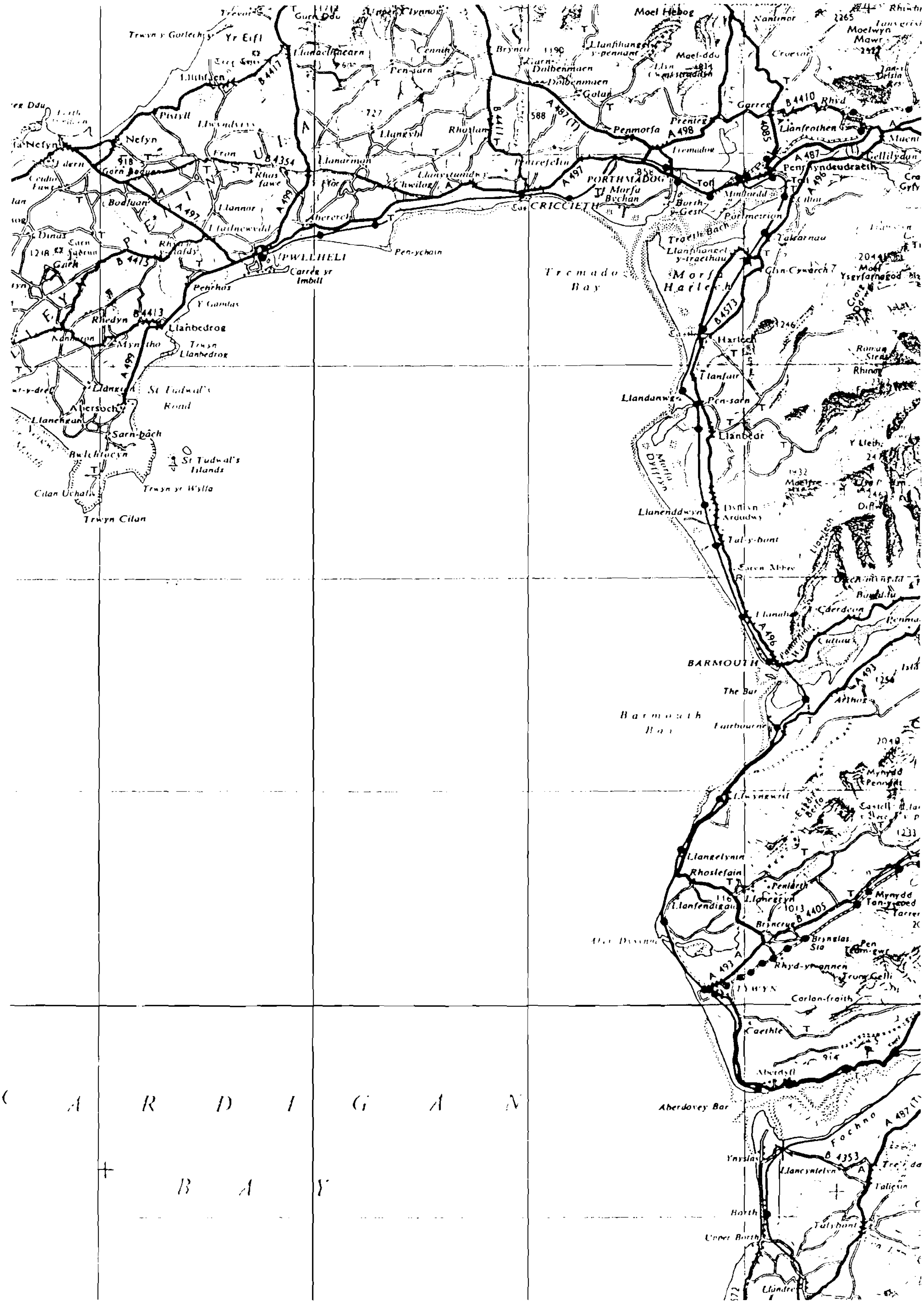
Cardigan Bay, which covers the major part of the west coast of Wales, has within it, the largest area of salt marsh to be found on its west facing shores. These marshes, situated between the Dyfi Estuary in the south and the Glaslyn Estuary in the north, are all sheltered from the sea, mostly by sand dunes but also in places by sand and shingle ridges.

The composition of the Welsh marshes, thought to have formed from sand and silt brought down from the rivers, are generally more sandier than those on the east coast where there is a greater concentration of mud. As for the vegetation, Glyceria Maritima is probably the most predominant. Salt tolerant plants such as Obione and Sea Lavender which grow well on the east coast are rarely found here.

The Dyfi Estuary

In contrast to the open sand flats with sand and shingle ridges which form to the seaward of the Norfolk marshes, the Dyfi Estuary is surrounded by mountains and is sheltered by a coarse shingle and sand spit running north from Borth.

Where the River Dovey flows west to meet the sea, the spit mentioned above, intrudes from the south providing the necessary shelter for a salt marsh some 8km long and up to 2km wide. The low-tide channel flows along its northern bank with the main salt marsh to the south. There are no saltings other than in the estuary and these are well sheltered with little other protection required. Spartina, introduced some 60 years ago, has almost taken over this area which is a nature reserve. South of these marshlands, still


Moel Hebog
Yr Eifl
Trwyn y Gorlech
Llithfaen
Pistyll
Nefyn
Garn Boduan
Bodfuan
Llannor
Rhydyclafdy
Garn
Rhedyn
Llanbedrog
Penrhos
Y Gamlas
PWLLHELI
Carreg yr Imbill
St Tudwal's Road
Abersoch
Llanengan
Sarn-bach
Bwlchtocyn
St Tudwal's Islands
Trwyn yr Wylfa
Cilan Uchaf
Trwyn Cilan
Llanaelhaearn
Pen-sarn
Llangybi
Llanarmon
Chwilog
Abererch
Pen-ychain
Llanystumdwy
Pentrefelin
CRICCIETH
Rhoslan
Bryncir
Dolbenmaen
Golan
Penmorfa
Prenteg
Tremadog
PORTHMADOG
Morfa Bychan
Borth-y-Gest
Tremadoc Bay
Portmeirion
Minffordd
Penrhyndeudraeth
Llanfrothen
Garreg
Nantmor
Moel-ddu
Llanfihangel-y-pennant
Talsarnau
Glyn-Cywarch
Morfa Harlech
Harlech
Llanfair
Llandanwg
Pen-sarn
Llanbedr
Morfa Dyffryn
Llanenddwyn
Dyffryn Ardudwy
Tal-y-bont
Sarn Badrig
BARMOUTH
The Bar
Barmouth Bay
Fairbourne
Arthog
Llwyngwril
Llangelynin
Rhoslefain
Llanfendigaid
Llangynfelyn
Bryncrug
Bryn-glas Sta
Rhyd-yr-onnen
TYWYN
Caethle
Carlon-fraith
Aberdyfi
Aberdovey Bar
Ynyslas
Llancynfelyn
Tre'r ddol
Taliesin
Borth
Upper Borth
Talybont
Llandre
A 497
A 499
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A 487 (T)
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B 4417
B 4354
B 4413
B 4415
B 4411
B 4410
B 4085
B 4573
B 4405
B 4353
C A R D I G A N
B A Y

4.3.3 Dee Estuary

The Dee Estuary is fringed by saltings, the main areas are concentrated on the eastern side of the estuary, south of Heswall where they are covered once or twice a year, with the hinterland further protected by earth embankments. Minor rubble defences exist at Parkgate where there are no flood protection problems. The old harbour wall at Parkgate, which was open to shipping until the early nineteenth century, now overlooks a wide expanse of saltings.

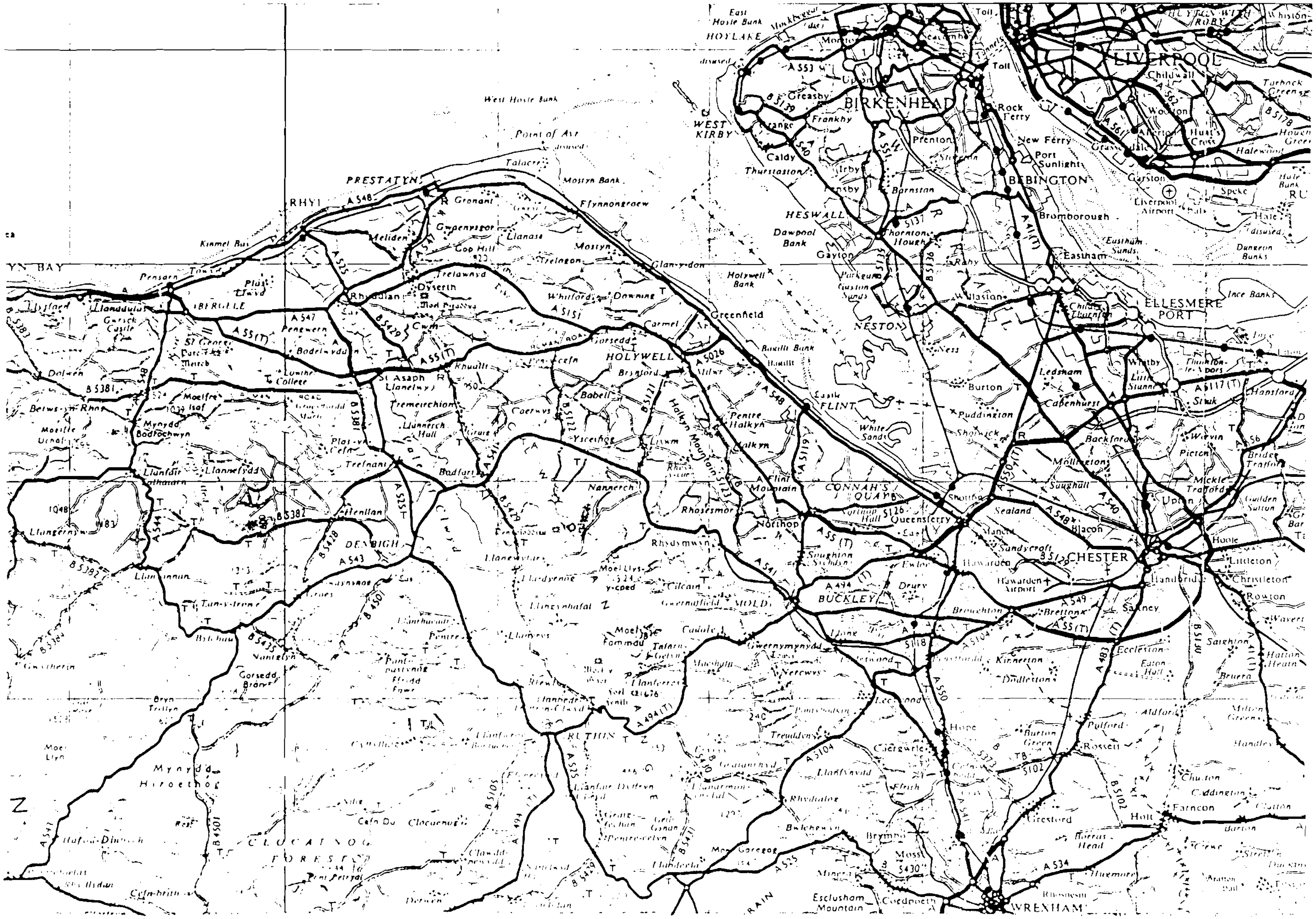
4.3.4 Ribble Estuary

The bed of the estuary is composed of fine sand overlying clay and peat. The formation of saltings in this estuary really began with the canalisation of the low tide channel some 200 years ago. This stopped channel meander and the saltings, which can vary in width on the southern bank from 300 to 750m (Ref 42), spread.

A large proportion of the original saltings have been reclaimed over the years, especially on the southern shore at North Meols and Hesketh. It is thought that a layer of clay and silt from the construction in the 1970's of the coast road, had found its way onto the foreshore at Marshside and encouraged the establishment of vegetation there.

A new tidal embankment has been constructed fairly recently on Hesketh Marsh to reclaim an area of saltings. This comes almost to the river in places but it is not known how the saltings to seaward are faring.

It is thought that the marshes are generally expanding and the N.C.C. are monitoring the situation.



LIVERPOOL
BIRKENHEAD
BEBINGTON
ELLESMERE PORT
CHESTER
WREXHAM
HOLYWELL
FLINT
BUCKLEY
MOLD
CONNAH'S QUAY
PRESTATYN
RHYL
DENBIGH
RUTHIN
HESWALL
NESTON
WEST KIRBY
HOYLAKE
Greenfield
Halkyn Mountain
Queensferry
Shotton
Saltney
Rock Ferry
New Ferry
Port Sunlight
Bromborough
Eastham
Prenton
Upton
Greasby
Frankby
Caldy
Thurstaston
Gayton
Burton
Mostyn
Point of Ayr
Gronant
Dyserth
Rhuddlan
Trelawnyd
Caerwys
Northop
Rhosesmor
Nannerch
Bodfari
Trefnant
Tremeirchion
St Asaph
Kinmel Bay
Pensarn
Llanddulas
Clwyd
Mynydd Hiraethog
Esclusham Mountain
Gresford
Rossett
Pulford
Hawarden
Broughton
Kinnerton
Sealand
Mollington
Backford
Hoole
Christleton
Littleton
A41 (T)
A55 (T)
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A550
A5117 (T)
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A541
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A5151
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B5130
B4501

4.3.5 Morecambe Bay

Saltings cover a large part of the Bay's periphery. On the east side between Park Point and Bolton le Sands, there was a scheme during the last century to reclaim large tracts of the marsh. After spending some £84 000, the scheme was abandoned, the only remaining evidence being an old wall out on the mud flats. The other main area is to the north where saltings cling to the sides of the Rivers Kent and Leven where they enter the Bay. There are some problems near the viaduct in the River Kent but this is thought to be sand movement.

Although the saltings in the Bay are thought to be generally healthy, there is an area north of Arnside in the River Kent where it is thought that the meandering low water channel is cutting into the salting.

On the south side of the bay, the saltings extend from the River Wyre at Fleetwood, north and east to the River Lune. Pilling Marsh, the biggest area here, is generally accreting. The turf embankment here was renovated in 1981 and the slope changed from 3:1 to 6:1. West from here to the River Wyre at Knott End on Sea, work is being carried out to raise the embankments, returf them, and protect them in exposed places with large boulders. This should be completed by the end of the year.

4.3.6 Solway Firth

A wide tract of saltings covers an area on the south side of the estuary from Silloth around the coast to the Scottish border.

They have instances of both accretion and erosion and some areas of salting are termed unstable. However this is generally in a low priority area or less and does not give rise to immediate concern. The majority of protection at the coast is earth embankments.

Running eastward from Silloth Bay, the first area of saltings is in Morecambe Bay. This is a fairly well sheltered area and the saltings of the Grune and Newton marshes are stable with earth bank protection in places. The area to the south of Skinburness Marsh is designated for urban development and North West Water are to take over responsibility for the earth banks at Seadyke and update them. The saltings here are stable.

The coastline south-west of Bowness on Solway to Morecambe Bay is accreting slowly in places while other parts are said to be stable. North-east of the old railway crossing however, the area is slowly eroding and it would appear that the tidal channels are moving inshore at this point.

The responsibility for Burgh Marsh was taken over by North West Water in 1982 from a private company. Coastal protection is provided by the old railway embankment which is also the high water line. Two small dykes were dredged for land drainage and as a consequence, the western side of the salting has built up, up to 0.75m in places, over the last seven years. The salting is also accreting generally, possibly due to the tidal channel in the estuary moving north. The salting area from here to the Scottish border is thought to be generally unstable and Rockcliffe Marsh is tending to change shape, again possibly because of channel meander. There is a scheme of reclamation put forward by the Nature Conservancy Council for this area. Generally earth bank protection exists in this

area up to the border, which runs along the River Sark.

5 OBSERVATIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Observations

1. This report is an initial project definition review for the Ministry of Agriculture, Fisheries and Food and concentrates on the coastlines of England and Wales. On the mainly rocky coasts of north and west Scotland saltings are not widespread and are mainly isolated and not connected with sea defence. Further south, towards the border they are more extensive but mainly in estuaries.

2. Almost ten per cent of the coastline of England and Wales is fringed by saltings. Most of these areas are designated nature reserves and are managed by specialist bodies such as the National Trust, the Nature Conservancy Council, the Royal Society for the Protection of Birds etc., The sea defences, however, are the responsibility usually of the local water authority. In Scotland such areas come under the Countryside Commission for Scotland who appoint a Beaches Project Officer to initiate management of the beaches, dunes and machairs.

3. The condition of the saltings around our coasts and indeed in Europe, vary widely. So too do the theories as to why problems exist. In the U.K. the east coast has its share of problems, especially so in the south-east where the land crust is low lying and gradually sinking. With the added knowledge that the sea levels are said to be rising, the anxieties felt in that part of the country can well be understood.

4. On parts of the east coast such as North Lincolnshire, the saltings are said to be healthy and little needs to be done to retain their effectiveness as the first line of defence. Just north of here however, in the Humber Estuary, it is a different story. Due probably to the meander of the low water channels, the southern shoreline is being cut back in a number of places. Embankments are being reinforced and kidding placed to build up the foreshore. Planting of Spartina however has been discouraged.

   South of the Wash, the saltings of North Norfolk are, in general, sheltered by offshore ridges. These are either in the form of an offshore bar or an extension by littoral drift of a beach. Although behind a seaward ridge, these saltings do play their part in absorbing the tidal flows and as such form an integral part of the sea defence system.

   Coastal protection landward of the saltings west of Brancaster is mainly sand dunes with intermittent clay banks. Sand movement is causing some concern here.

5. On the low lying coasts of Essex and Southern Suffolk, saltings play a major role in the sea defence system and there is probably more reclamation, regeneration and offshore protection here than elsewhere in the U.K. The areas that appear most troubled by erosion are the Dengie Flats and the Estuaries of the Crouch and Blackwater.

   Purely from visual observation, a member of the Anglian Water team monitoring the schemes being put in on the Essex coast, thought that the

cohesive clay content of the saltings at Dengie seems to be less than it was a few years ago. This could, if it were so, affect stabilisation.

6. Strengthening of the man-made sea defences has been quite extensive on the south coast since about 1969, especially in the Solent area. The authorities are engaged in a programme of strengthening the clay embankments with concrete grouted rock or stone blocks. In places also the toe of the embankments are being refurbished and strengthened. Recession is on the increase too east of Hurst Spit on the Hampshire coast while the saltings within Southampton Water are also generally on the decline.

7. On the west coast, apart from stretches in the Severn Estuary, the saltings are not generally giving cause for concern. Few if any are actually on the coast and are mostly found in the estuaries of the Dee, the Mersey and the Ribble as well as in the Solway Firth and Morecambe Bay. On the Welsh coast too, the saltings are to be found mostly within estuaries sheltered by sand or shingle spits.

8. To summarise the foregoing, although erosion or 'die back' of coastal saltings is taking place in several areas around the coast, the areas which are causing major concern are the low lying Essex saltings and possibly the approaches to the Lymington River on the Hampshire coast.

5.2 Conclusions

1. In the course of this review it has become clear that the salt-marshes and coastal saltings of the U.K. have been and are being studied by a wide range of research bodies. This research is mainly

in the Ecological and Geomorphological fields with little being done on the engineering side.

2. The spread of Spartina since its introduction in this country over a century ago has changed the face and character of much of our saltings and has led inevitably to cross breeding. Where it is healthy it tends, because of its prolific growth, to colonise the lower mudflats. There is conjecture as to whether it should be allowed to spread in this way, curtailed because of its consequent threat to wildlife feeding or completely eradicated in certain areas.

3. The pattern of erosion and accretion on mud flats and saltings is complex. There are many theories put forward as to the cause of die back ranging through seasonal changes, cyclical changes, degeneration of species of vegetation, and pollution in various guises. On the hydraulic front, the theories include changes in sea level, changes in the regime of the littoral drift, sinking of the land crust, alteration in the wave climate and temperature variation.

4. Several people have described the seaward edge of eroding saltings as having sharp, cliff like faces. This could indicate a change in the wave climate and the possibility of plant decay.

5. Available evidence (Ref 9) suggests that the magnitude of the problem, which appears to affect the lower parts of the vegetation zone, will increase in the coming years.

6. The die-back of Spartina grass which is thought to have started in the 1930's, was first noticed in the 1950's, and is still continuing in some areas.

This seems to be more pronounced on the south and southeast coasts. In areas of the west coast; in Morecambe Bay and the estuaries of the Ribble and Conway, Spartina seems to be thriving.

7. The re-structuring of part of any coastline may seriously affect other coastal areas through the re-distribution of littoral sediment. In the estuary of the River Dee for example, the re-training of a low water channel caused the silting up of what was a relatively deep channel at Parkgate, and the consequent quiescent conditions allowed a salting and mudflats to form in front of the town quay.

8. On the Essex coast it is thought that although silt is still carried in suspension, there seems to be a dearth of clay which could be important in holding the coarser uncohesive silt particles together. This could be because of cliff protection or dredging works updrift depriving the area of this important medium and halting erosion of the updrift cliffs.

   It could also be a lack of dredging as for instance in the Thames where dredging has virtually stopped. This spoil which was normally dumped in Black Deep off the Essex coast could have found its way back inshore.

9. Saltings regeneration using man-made structures has been achieved in North Friesland, West Germany, in about seven years. This however does depend on the hydraulic and ecological circumstances and will not necessarily be the same for other areas.

10. It would appear that one of the more popular means of regeneration is the Schleswig-Holstein method, originated on the North Sea coast of West Germany. This is a fairly well established method of regeneration. It has been tried in the U.K. by Anglian Water, on the Dengie Flats in Essex, and is shortly to be tried by Welsh Water on the Severn Estuary. It would be beneficial to determine whether German engineers they have come up with any other ideas that may be useful in the U.K.

11. There is a form of artificial seaweed now on the market that can be attached to an open grid type mat. These in turn can be clipped together, rolled up, transported to site and laid. This as far as we know has never been tried on saltings, and it might be of benefit to try it on the seaward edge of an eroding salting to both stabilise and attract sediment. If successful the mats can be lifted and tried elsewhere. It is understood that this is to be tried on the Essex coast in April or May 1987. Some 60 square metres will be placed in up to 10 small trial fields around the coast.

12. Aerial photography with photographs taken periodically give a good indication of the state of saltings which might otherwise be difficult to estimate. Satellite imagery techniques could also help determine the distribution of salting deterioration.

13. This review, for obvious reasons, has concentrated in the main on saltings recession. There are however, areas of saltings mostly in the estuaries on the west coast, where the vegetation is being sprayed with herbicide to curtail their spread.

5.3 Recommendations

It has become clear while carrying out this review that several related research contracts are currently being carried out. Due to the obvious interest of the Nature Conservancy Council and the research being carried out by other research bodies, it is suggested that a working group of interested parties should be set up to co-ordinate a multi-disciplinary research programme.

This could include a representative from some or all of the following authorities;

Ministry of Agriculture, Fisheries and Food
Crown Estate Commissioners
Department of the Environment
The Welsh Office
Nature Conservancy Council
Science and Engineering Research Council
Institute of Terrestrial Ecology
Institute of Oceanographical Sciences (Tidal branch)
Anglian Water
Southern Water
North West Water
Hydraulics Research Ltd

Two other specialists in this field are Mr A Mascall formerly Technical Manager with Anglian Water and Dr D Ranwell now with the University of East Anglia both of whom could be relied on to make a significant contribution.

This working party would need to be set up quite quickly as erosion in some parts of the UK is quite serious, as mentioned below.

The impact of the degeneration of saltings is obviously of prime concern where saltings form part of

the sea defences. This is especially so on the south and south-east coasts where it is particularly severe in places. The Nature Conservancy Council have a major interest in this natural habitat and should be consulted in any proposed research.

From the engineering point of view the immediate problem is not why is erosion taking place, but how to stop it. In this respect the need is to determine the best form of regeneration and the most effective means of construction. Other priorities must include how to improve sediment supply and vegetation growth.

Saltings will not thrive without adequate sediment supply. It is suggested that thought should be given to recover the silts and clays that are dredged regularly from nearby rivers, estuaries and harbours and dumped at sea. This residue could for instance be placed to supplement supply to a particular area naturally, or held in an offshore pound for use when required. This would presumably require an amendment to the Dumping at Sea Act.

Recommendations for further research include the following:

An in-depth assessment of the overall pattern of accretion or erosion in the UK.

Investigation of man-made impacts that could affect saltings stability. This would include coastal construction and pollution.

Exploration of the relationship between saltings status (accreting or eroding) and sea level rise.

An investigation of the sediment content of both eroding and accreting saltings to determine whether

there is a lack of certain ingredients in the eroding saltings that could be added artificially.

An investigation of plant virility and condition at several locations on different coastlines.

A review of other countries, especially those on the North Sea Coasts. Are they also having problems and if so, how they are being tackled.

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Capt Nichol	Harbour Master, River Hamble

Sites where, according to the 1980 Coastal Suvey, saltings are in evidence together with the relevant coastal survey map number and the type of coastal defence.

Map No.	Site	Type of defence
East Coast		
12	Spurn Head to Hawkins Point	Clay banks
13	Cleethorpes to Saltfleet Haven	Clay banks
14	Skegness to Gibraltar Point	Seawall, sand dunes
15/16	Holme to Weybourne	Fronted by shingle ridge
19/20	Southwold to Sizewell	Fronted by shingle ridge
21	Aldeburgh to Shingle Street	Fronted by shingle ridge
22	Harwich (south) to Walton on the Naze	Various embankments
22	Jaywick to Brightlingsea	Various embankments
23	R Blackwater to R Crouch	Clay embankments
24	Foulness Point to Southend	Clay embankments
25	Southend (west) to Canvey Island	Flood banks-Seawall
39	Queensborough (R Medway)	Seawalls
40	R Swale (entrance)	Clay embankments
40	R Stour (entrance)	Sand dunes
South Coast		
47	Pagham Harbour	Intermittent banks
47	Chichester Harbour	Clay banks-natural progression
48	Langstone Harbour	Chalk/rubble banks - seawalls
49	Southampton Water to Hurst Beach	Intermittent banks
52/53	Poole Harbour	Seawalls, gabions, rock, dunes and heathland
57	R Otter (entrance)	Gabions
58	R Teign (entrance)	Seawalls, rock
77	West of R Parrett	Clay banks
77	R Axe (entrance)	Clay banks
78	South of Clevedon	Clay banks

78	West of R Avon	Clay banks
79/80	Upstream Severn Bridge (south side)	Clay banks

West Coast

36	Ellesmere Port	Seawalls, earth banks, rock
35/36	R Douglas to Southport	Earth banks, concrete faced walls
35	Lytham to Freckleton Pool	Seawalls, intermittent Earth banks
34	Pilling Marsh (M.Bay)	Earth banks
33	Middleton (M.Bay)	Intermittent earth banks
33	Arnside to Morecambe	Intermittent earth banks
32	Flookburgh (M.Bay)	Earth banks
32	R Kent (entrance)	Earth railway embankment
31	R Leven (entrance)	Earth railway embankment
31	Angerton (east of Duddon Channel)	Earth railway embankment
30	Walney Island (north east side)	Intermittent earth banks, rock, concrete or stone revetments
29	Millom (west of Duddon Sands)	Earth banks
26	Skinburness to Carlisle	Intermittent earth banks

FIGURES.

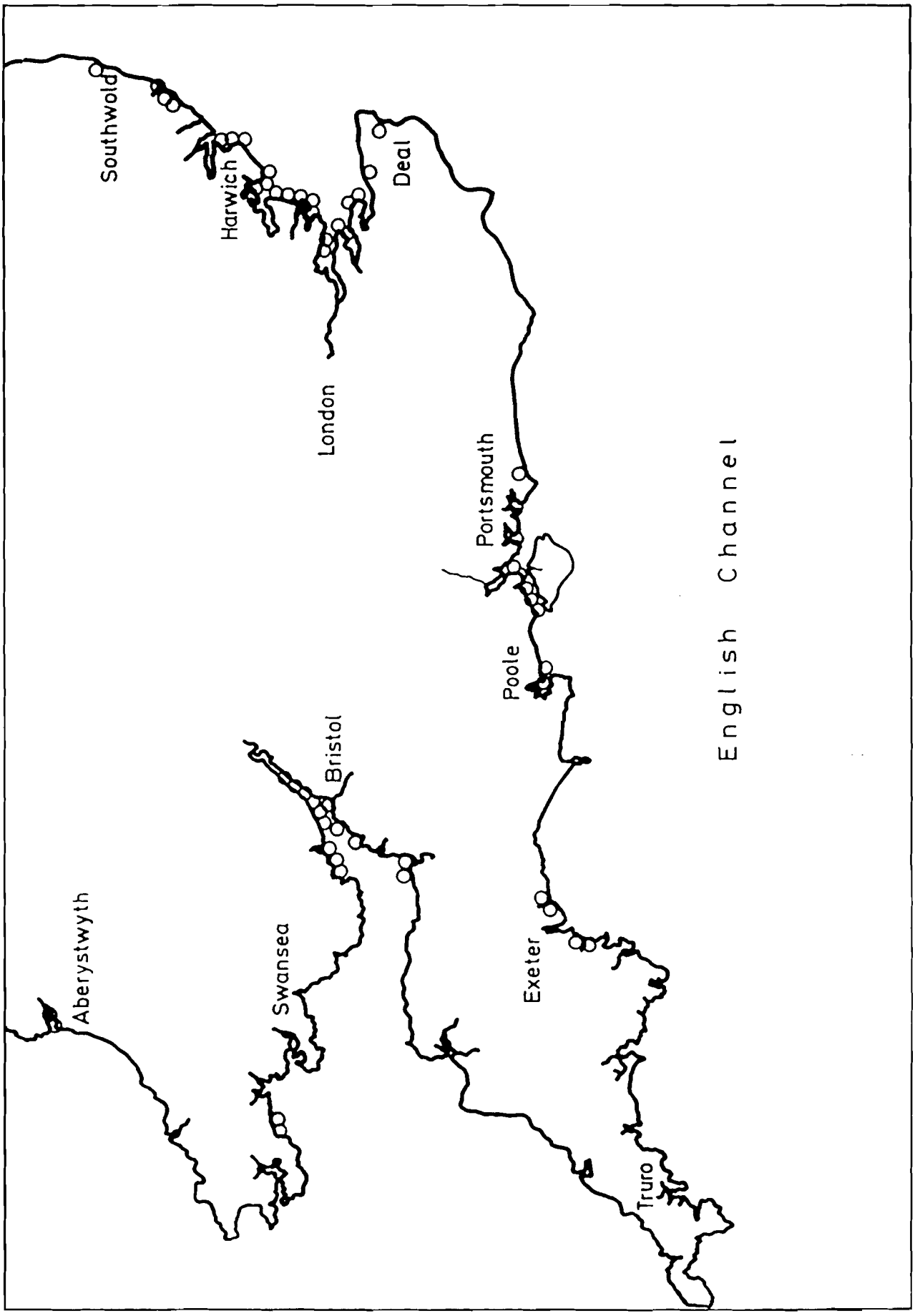


Fig 1 Location of main coastal saltings in England and Wales - south

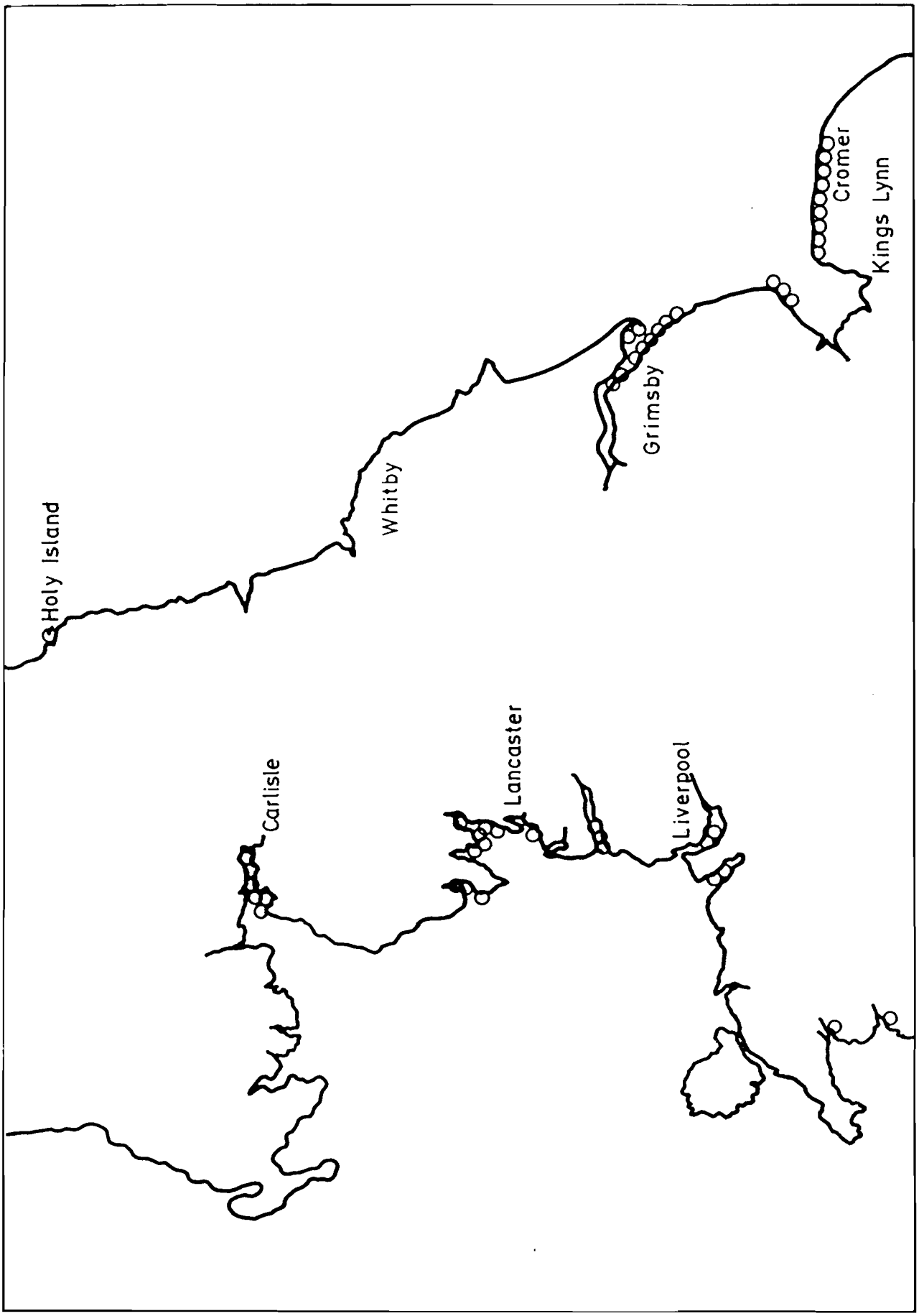


Fig 2 Location of main coastal saltings in England and Wales - north

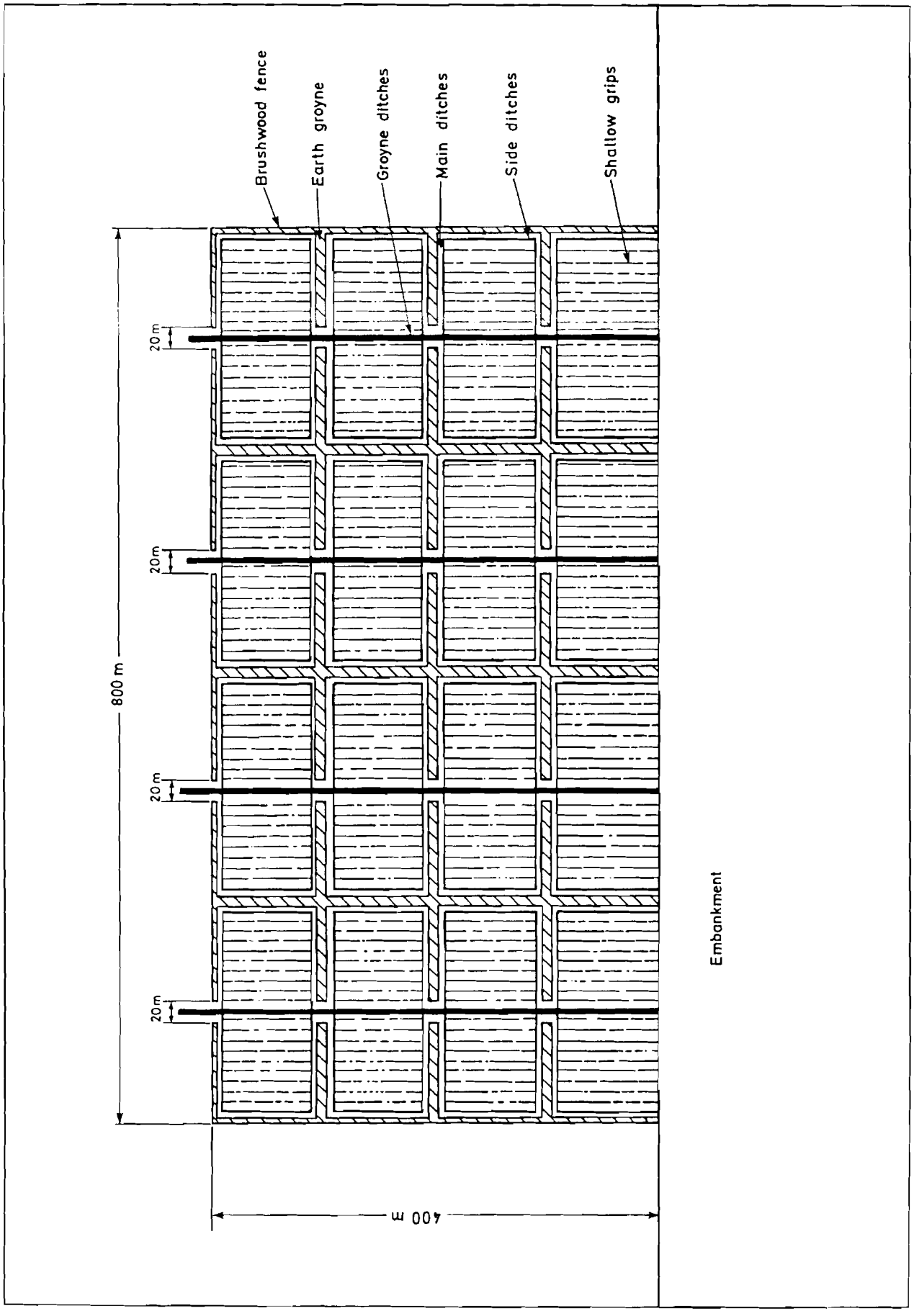


Fig 3 Schematic sketch of the Schleswig-Holstein method of regeneration

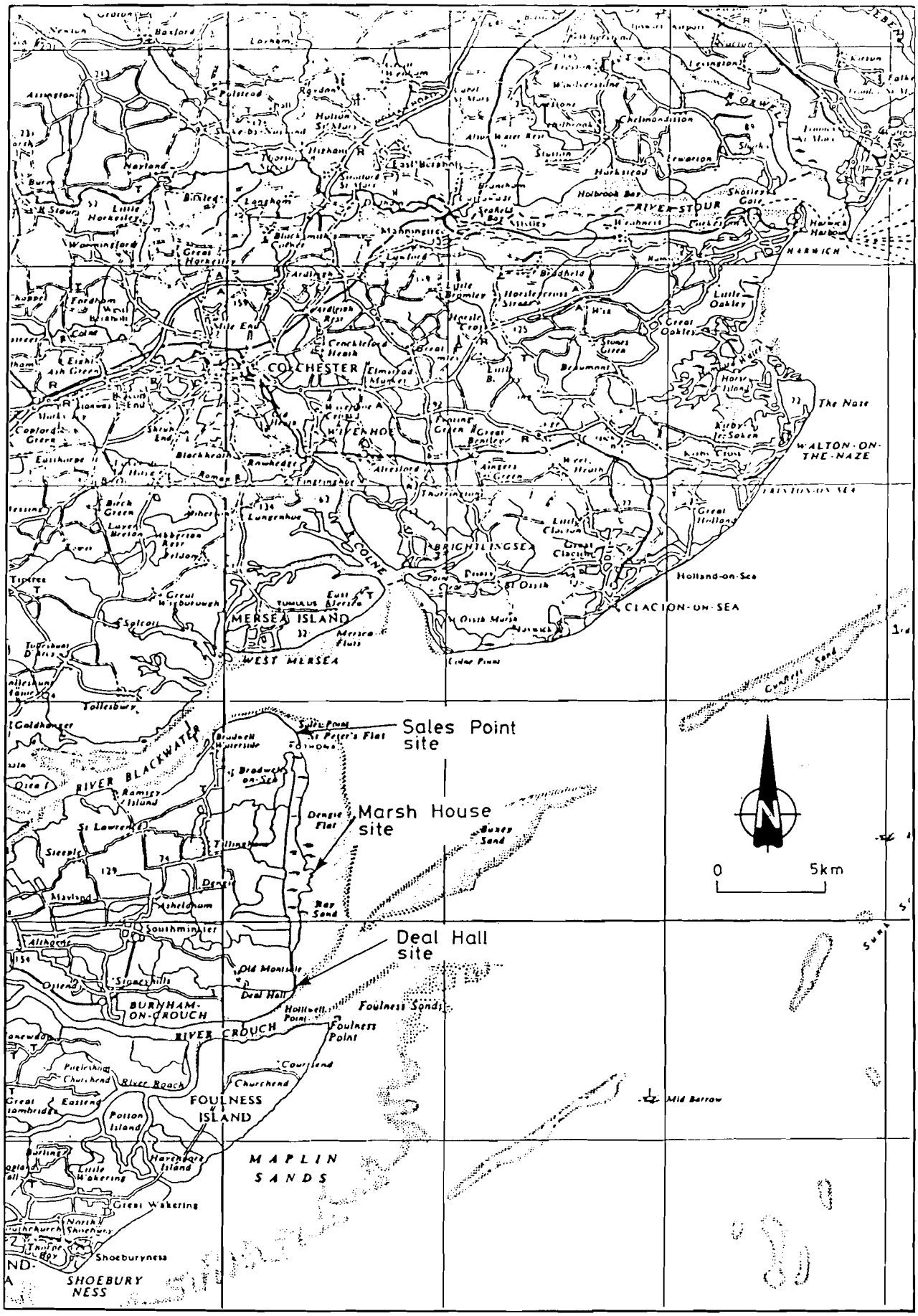
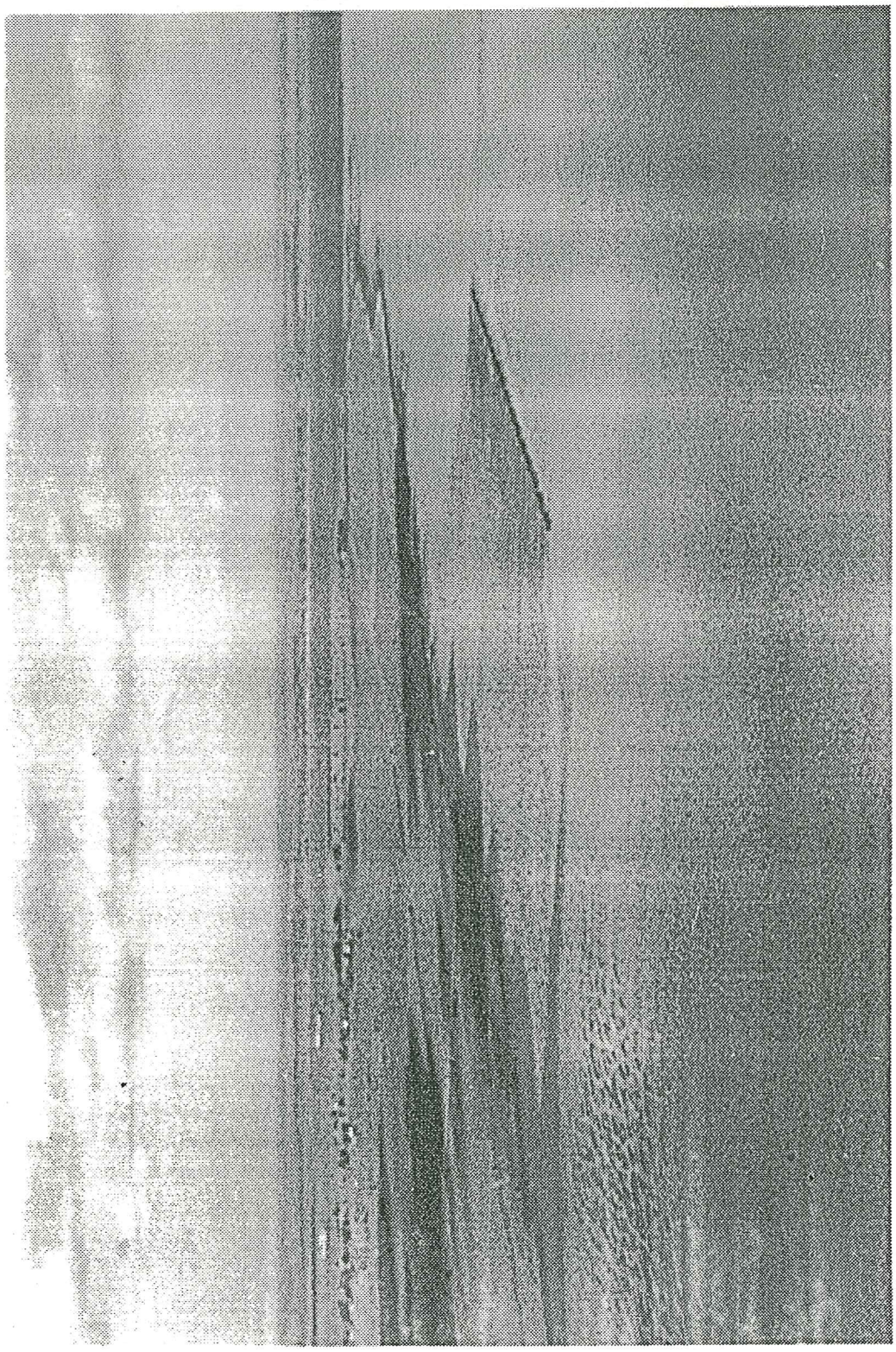


Fig 4 Essex coastline

PLATE.



1. Offshore lighters, Dengie, Essex