

LCA/143/95

LANDS TRIBUNAL ACT 1949

COMPENSATION - coast protection works -groynes - whether the cause of increased erosion at farm to the south - whether a beach breakwater scheme should have been used - whether nuisance or negligence - independent consultants - validity of claims - claims for partnership business losses - whether compensation limited to loss or damage by the carrying out of the works - Coast Protection Act 1949, s. 19

IN THE MATTER of a NOTICE OF REFERENCE

BETWEEN

JOHN DAVID FOSTER EARLE

Claimant

SUSAN ANNE FLETCHER EARLE

Claimant

and

EAST RIDING OF YORKSHIRE COUNCIL

Compensating Authority

Re: Grange Farm, Great Cowden, Yorkshire

Tribunal Members: A DINKIN Esq QC and P H CLARKE Esq FRICS

Assessor: G F HAWKER Esq FICE

Sitting in public at 48/49 Chancery Lane, London WC2 on 5, 7-9, 19-23, 26, 29 and 30 October 1998

The following cases are referred to in this decision:

R v Commissioners for Pagham (1828) 8 B&C 355

Gerrard v Crowe [1921] 1 AC 395

Bradford v Pickles [1895] AC 587

Home Brewery Co Ltd v William Davis & Co (Leicester) Ltd [1987] 2 WLR 6

	Stephens v Anglian Water Authority [1987] 1 WLR 1381 Cambridge Water Co v Eastern Counties Leather plc [1994] 2 AC 264 Rylands v Fletcher (1866) LR 1 Ex 265; (1868) LR 3 HL 330 Bamford v Turnley (1862) 3 B&S 62
5	Robinson v Beaconsfield RDC [1911] 2 Ch 188 Liesbosch v Edison [1933] AC 449 Harrison-Broadley v Smith [1964] 1 WLR 456 Lakeman v Bournemouth Corporation (1956) 8 P&CR 265
10	Argyle Motors (Birkenhead) Ltd v Birkenhead Corporation (1973) 27 P&CR 122 Hammersmith and City Ry Co v Brand (1869) LR 4 HL 171 Biard v Deal Corporation (1961) 12 P&CR 398
15	John Hand QC and Michael Johnson instructed by Wood Sherwood & Co, solicitors of Pocklington, York, for the claimants Stephen Furst QC and Nicholas Huskinson instructed by Hammond Suddards, solicitors of Leeds for the compensating authority
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DECISION OF THE LANDS TRIBUNAL

This is a reference to determine the compensation payable (if any) under section 19(1) of the Coast Protection Act 1949 for alleged loss or damage in consequence of the carrying out of coast protection works at the village of Mappleton on the Holderness coast of East Yorkshire. The claimants are the owners and occupiers of Grange Farm, which is situated on the cliffs approximately one kilometre south-east of Mappleton, on a coast which has suffered erosion for centuries. The claimants contend that, in consequence of the works at Mappleton, the rate of erosion at Grange Farm has increased; the coast protection authority (now the East Riding of Yorkshire Council) would have been liable to them in negligence and/or nuisance in respect of the works in the absence of statutory powers; and that therefore compensation under section 19(1) of the Coast Protection Act 1949 is payable for the loss or damage suffered in consequence of the increased rate of erosion.

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John Hand QC and Michael Johnson appeared for the claimants and called:-

- (i) Professor Hans Falk Burcharth Dr Techn Dr Hc, Professor of Marine Civil Engineering and Head of Department of Civil Engineering at the University of Aalborg, Denmark.
- (ii) Graham Bate BSc CEng MICE MIStructE FICD FRAS, Principal of A&F Consulting Engineers of Brough, East Yorkshire.
- 25 (iii) Dr Alan Roy Clark PhD BSc CEng CGeol FIMM FGS, a Director of Rendel Palmer & Tritton Ltd, consulting engineers, and Managing Director of Rendel Geotechnics, a specialist division within this company.

Written statements were put in evidence for:-

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- (i) Susan Anne Fletcher Earle of Grange Farm, Cowden (claimant).
- John David Foster Earle of Grange Farm, Cowden (claimant).
- (iii) Raymond Brunning of Bridlington, retired professional news photographer.
- (iv) Walter Gray of Poplar Grange Farm, Wyton, cattle broker.

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Stephen Furst QC and Nicholas Huskinson appeared for the compensating authority and called:-

- (i) Robin Taylor DipTP FRTPI, formerly Chief Planning Officer and later Director of Development at Holderness Borough Council (now retired).
 - (ii) Allan Chilton CEng, formerly Assistant Director of Development (Technical) at Holderness Borough Council (now retired).
- 45 (iii) Edward Knapp, formerly an Engineer with Holderness Borough Council (now retired).

- (iv) Michael George Barrett MBE BSc FICE MConsE, formerly a partner in Lewis & Duvivier and later partner and director of Posford Duvivier, consulting engineers of Haywards Heath, Sussex (now retired).
- 5 (v) John Llewellyn Andrews DLC MICE MIWEM, a divisional director of Posford Duvivier, previously an associate of Lewis & Duvivier.
 - (vi) Dr Roger James Maddrell PhD BSc CEng FICE FGS FAE Dip Port, Coastal & Hydraulic Engineering, Delft, a chief engineer in the Maritime Department of Sir William Halcrow & Partners of Swindon, Wiltshire.

We heard this reference with an assessor, Geoffrey F Hawker TD BSc FEng FICE CEng FIEI MCons E MSocIS (France) FCIArb, Barrister-at-law. Mr Hawker accompanied us on our inspection and sat during the hearing. He has prepared a written report which we have considered. We reproduce the material parts (paragraphs 11-18 and 30) of this report in an Appendix to this decision. His report also contains an introductory factual description and narrative and the remainder deals with issues of fact on which it has not been necessary for us to make a decision. We have not reproduced these parts of the report in our decision. We have been assisted in reaching our decision by a daily transcript of the hearing.

COASTAL EROSION

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Before proceeding further with this decision we think it will be helpful if we explain briefly the nature of coastal erosion and the use of groynes and other coast protection works.

Erosion is the wearing away and removal of soil and rock fragments by wind, water or ice. Shoreline cliff erosion is due mainly to wave action which attacks the toe of the cliff. Storm waves occurring at low water have little immediate effect but storm waves at high tide or surges produce significant erosion due to increased wave energy. Erosion at the toe steepens the face of the cliff beyond its natural angle of repose and causes it to fail along a slip plane usually roughly semicircular in section and plan. Failures can also be wedge-shaped and form fissures along the top of the cliff. Erosion takes the form of "bites" out of the cliff face. Although this can take place in a series of sharp changes over short time scales there is usually a broadly similar long-term rate of erosion. Other natural factors affecting coastal erosion include an increase in the number and severity of storms, rainfall, changes in sea level, increases in water depths (which allow more wave energy to reach the shore), soil strengths of the cliffs, and low beach areas, called "ords" on the Holderness coast, where sand is absent and the underlying clay till is exposed. As explained below, in additional to natural erosion, erosion may be caused by the building of coast protection works to form "hard points" along the coast.

Along the east coast of Yorkshire (the Holderness coast) there is a prevailing alongshore current which runs parallel to the shoreline in a broadly north to south direction. This carries in suspension sand and shingle (sediments), known as alongshore or littoral drift, within the littoral zone, that is to say the inter-tidal zone where periodic exposure and submersion by tides is normal. There is also movement of sediment onshore and offshore by wave and current action.

The Holderness coast has been eroding naturally for many thousands of years due mainly to sea level rise and wave action. The coastline has eroded 3 kilometres since Roman times. Waves

from the north-east arrive at an angle to the coast and have the capacity to erode the cliffs and move the eroded and beach material in a north to south direction from the "hard point" of Flamborough Head, virtually non-erodable chalk cliffs, to Spurn Head, a semi-hard deposition point at the mouth of the River Humber in the south. The coast between these two points is overall a naturally formed crenulate bay.

When sea defences are built (in the form of groynes or breakwaters protruding into the sea) they capture the alongshore drift and, at least initially, deprive the beaches downdrift (to the south on the Holderness coast) of sediment. They are intended to lead to the accretion of material between the groynes and on the beach updrift, or to the north, and this can lead to increased erosion downdrift of the defences. It is an issue in this reference as to whether and where and to what extent this downdrift erosion occurs. The effect of the sea defences which have been built at Bridlington, Hornsea and Withernsea has been to create a series of crenulate bays to the south of each hard point within the overall bay formation between Flamborough Head and Spurn Head.

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The most common form of coastal protection structure in Britain is the groyne, a long, thin or parallel-sided structure built at 90° to the shoreline, extending from above the high water line usually to a point on the beach above low water mark. Their purpose is to restrict the movement of sand and shingle in the littoral drift in order to protect the local coast from erosion. This may be supplemented by the artificial addition of beach material (beach nourishment). Where several groynes are placed at intervals to protect a section of coast this is a groyne field and the areas between them are groyne bays. Littoral drift is trapped in each bay to form a crescent shaped beach. Groynes may be used with a sea wall or revetment, parallel to the shore connecting the heads of the groynes, with terminal structures at each end in the form of extensions to the sea wall or revetment to prevent erosion by scour immediately downdrift of the end groyne and to assist accretion of the beach updrift. This is the form of the Mappleton sea defence works.

Groynes are constructed of rock, concrete, wood or metal and are either permeable, with openings sufficiently large to permit the passage of longshore drift, or impermeable, where beach material cannot pass. Groynes may vary in length within a groyne field. A terminal groyne may be longer in order to trap more of the longshore drift. This is the position at Mappleton. Alternatively, in order to reduce the immediate impact of downdrift erosion, groynes may be made progressively smaller in a downdrift direction.

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The shape and composition of a coastline are the result of a complex geomorphological system which in the long-term adjusts towards equilibrium in response to natural physical changes. For the Holderness coast this has taken the form of a large crenulate bay between Flamborough Head and Spurn Head. The placing of obstructions on the coast line interferes with the natural regime and causes short-term changes in erosion and accretion, as at Bridlington, Hornsea and Withernsea and now at Mappleton. Groynes affect beach shape within groyne bays and along the adjacent coast line.

Groynes directly affect local wave-induced and tidal currents. In addition to the trapping of sediment in the alongshore drift, material will be diverted away from the shore. At the updrift groyne of a system the alongshore current is diverted offshore at an angle to the shoreline. This diverted flow then combines with any tidal and wave-induced current flow at the groynes to create a current which runs along the groyne heads. After passing the last (downdrift) groyne this flow returns landward and the open-beach current distribution is restored downdrift of the groyne field.

The direction of sediment offshore is particularly seen where rip currents occur. These are jet-like seaward-going currents normal to the shoreline and associated with wave-induced currents. Rip currents occur naturally along the coastline and can be formed along the sides of groynes. This can result in the transport of sediment off-shore where it may be deposited and lost from the beach system.

In addition to groynes other methods of providing beach control to prevent erosion are available, including offshore beach breakwaters placed close to and parallel with the shoreline. These provide partial sheltering and encourage formation of salients or tombolos to build up the beach between the coast and the breakwater. Such schemes may also include sea walls and reverments.

FACTS AND AGREEMENTS

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It is unfortunate that, in this case of some complexity, the parties were unable to prepare a statement of agreed facts. They produced a Joint Memorandum of Agreed Issues which includes some facts, agreements on technical matters and the contentions of the experts on other issues. From this document and the evidence, we find the following facts and record the following agreements.

We find the following facts:-

- (1) The Holderness coast of the East Riding of Yorkshire, from Flamborough Head and Bridlington in the north to Spurn Head at the mouth of the River Humber in the south-east, has suffered from coastal erosion for many centuries. It is now in the form of a crenulate bay betweer Flamborough Head (chalk cliffs) and Spurn Head (deposited material from coastal longshore drift). Coast protection works have been carried out at Bridlington, Hornsea, Mappleton Withernsea and Kilnsea (now abandoned). Bridlington is approximately 20 kilometres to the north of Hornsea. Hornsea is approximately 4.5 kilometres to the north-west of Mappleton and Withernsea is about 19 kilometres to the south-east of Mappleton.
- The Holderness coast comprises cliffs of glacial till deposited during the last advance of the Pleistocene ice sheet (the Devensian) between 10,000 and 70,000 years ago. Two tills are exposed in the cliffs: the upper Withernsea and the lower Skipsea. These comprise mainly silts and clays with some large water-borne and ice-borne blocks or boulders transported by glacial or floating ice (erratics), and horizons of sands, silts and gravels. Soil strengths are generally weak. The beach between Mappleton and Grange Farm is mainly sand on the lower beach with sand, shingle and some eroded glacial till and boulders on the upper beach.
- (3) The coast protection works carried at Mappleton ("the Mappleton works") comprise: two rock groynes and a rock revetment linking the heads of the groynes at the base of the cliff extended by terminal structures of rock to the north and south of the groynes and revetment. The parties have been unable to agree the dimensions of the works and we record their figures as follows:-

	Claimants	Council
North groyne, crest length to seaward toe	63 metres	64 metres
South groyne, crest length to seaward toe	112 metres	103 metres
Distance between groynes	268 metres	265 metres
Total crest length of protected frontage	447 metres	452 metres
South terminal structure	104 metres	95 metres
North terminal structure	75 metres	97 metres

However, resolution of the issues between the parties does not require us to choose between these figures.

- The Mappleton works were carried out by Holderness Borough Council ("HBC"), the coast protection authority, under the Coast Protection Act 1949 ("the 1949 Act"). HBC were predecessors of the East Riding of Yorkshire Council ("the Council"), now the coast protection authority and compensating authority in this reference. HBC instructed consulting engineers, Lewis & Duvivier (now Posford Duvivier), to advise them and design and supervise the construction of the works. The claimants do not allege that the works were constructed negligently or defectively by the contractors. The works substantially commenced in February 1991 and the certificate of completion was dated 9 September 1991 and issued on 30 September 1991.
- 15 (5) Professor Burcharth's alternative scheme for coast protection works at Mappleton ("the Burcharth alternative scheme") comprises a revetment along the toe of the cliff without terminal structures with five beach breakwaters offshore. These are located close to the shoreline. The dimensions of the scheme are:-

Length of breakwaters crest to crest	30 metres
Gap between breakwater crests	52 metres
Length of revetment (crest)	395 metres
Distance between revetment and breakwater crest	
centre lines	22-45 metres

A detailed design might result in adjusted dimensions and positions.

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(6) Grange Farm is at Great Cowden and is situated on the edge of the cliffs between approximately 700 and 1200 metres to the south-east of Mappleton. The parties have been unable to agree exact distances and we record their figures as follows:-

	Claimants	Council
Mappleton south groyne to Grange Farm:		
north boundary	744 metres	750 metres
farm buildings		1,150 metres
south boundary	-	1,240 metres
Mappleton south terminal structure to		
Grange Farm:		
north boundary	640 metres	

farm buildings 1,000 metres south boundary 1,125 metres Frontage of farm buildings 125 metres -

However, resolution of the issues between the parties does not require us to choose between these figures.

- 5 (7) The extent of Grange Farm is in dispute. We record the position as follows. It is common ground that the major part of Grange Farm lies to the north of Eelmere Lane, which is now the only access road and runs west to east from the B2142 (Withernsea to Hornsea road) to the cliff edge at the Farm. To the north of this lane is a rectangular plot of land, which the claimants contend was about 25 acres in 1991 and is now approximately 20 acres. This 10 land is bounded on the north by agricultural land and a drain which terminates at the cliff edge, on the east by the edge of the cliffs, on the south by Eelmere Lane and on the west by a caravan park. Excluded from the land in the south-western corner are two houses. The remaining farm buildings are all in the south-eastern corner of the land, close to the cliff edge with access from Eelmere Lane. The freehold interest in this land and a smaller plot 15 to the east (now lost by erosion) with a total area of 25.356 acres was purchased by Mr Earle in April 1958. A short distance to the south of Eelmere Lane, with a frontage to the cliffs, is a now land-locked parcel of land of about 8 acres which it was contended during the hearing is owned by Ms Earle.
- 20 (8) On 6 October 1990 Mr Earle and Ms Earle (then using the name Susan Anne Fletcher) entered into an agreement ("the partnership agreement"):-

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"that the parties are partners in the business of poultry farmers under the name of Grange Farm at Cowden Hull or such premises or in such trade as the partners agree and that the capital and surplus assets and all profits and losses shall be divided or borne as to capital and surplus assets entirely by John David Foster Earle and as to profits equally".

The claimants and the Council agree that at all material times Grange Farm has been farmed by the claimants as partners.

- (9) The coast protection works at Homsea now comprise 16 groynes with a concrete and rock revetment at the beach head protecting approximately 1.8 kilometres of coastline. In 1869 two groynes were constructed and further works were carried out between 1876 and 1891. Following storm damage in 1906 a sea wall and groynes were built between 1906 and 1910. Similar works were carried out in the 1920s. Following storm damage in 1953 further works, particularly to the south of the town, were carried out between 1953 and 1975, in 1979 and the 1980s.
- 40 (10) The coast protection works at Withernsea now comprise 19 groynes with a sea wall, revetment and rock armour protection protecting approximately 2.5 kilometres of coastline. In 1871 six groynes and an embankment were built. Further works were carried out in 1909, between 1910 and 1912, in 1914-1915 and between 1921 and 1925. Further works comprising groynes, sea wall and revetment were carried out in 1946, 1947, 1954, 1958.

and 1967. Rock armour protection to the sea wall and revetments was later added and extended to the south in 1998.

- On 10 July 1992 Wood, Sherwood & Co, solicitors, wrote to HBC giving formal notice that a claim pursuant to the 1949 Act is being pursued in respect of accelerated coastal erosion at "our client's property" following the Mappleton works. This letter was headed "Mr J D F Earle of Grange Farm, Cowden, Hull". This claim was confirmed by a letter from Wood Sherwood to HBC dated 7 August 1992. The parties agree that the former letter constituted a valid notice of claim by Mr Earle under section 19(2) of the 1949 Act.

 An itemised claim for compensation dated November 1995 has been prepared by Shilcocks Construction Consultants of Hull in the total sum of £374,504 (as at August 1995 and subject to review).
- On 8 September 1995 Wood Sherwood & Co, on behalf of Mr Earle, referred the above claim for compensation to this Tribunal for determination. On 9 April 1996 the Registrar gave leave for Ms Susan Earle to be joined as a claimant. On 24 November 1997 the President directed that the reference be set down for hearing of all questions arising "save only for the quantification of such compensation (if any) as the claimants or either of them may be entitled..." under section 19(1) of the 1949 Act.

We record the following agreements on technical matters:-

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- (i) The following data sets of coastal erosion are acceptable, subject to the qualifications noted:-
 - (a) HBC erosion post measurements since 1951, subject to the disturbance of measurements by lost posts and some errors.
- Mr Bate's cliff erosion measurements and beach surveys from April 1992, subject to the recognition that the origin of the beach sections from April 1992-97 is the toe of the eroding cliffs, not a fixed point (fixed beach markers were used after this period).
- Geographical Information System (GIS) measurements at 50 and 100 metre intervals using Ordnance Survey maps and aerial surveys for the period 1852 to 1998 and the comparisons using bathymetric charts, subject to recognition of differences in accuracy stemming from the different sources of information.
- 40 (d) Data provided by the RAF for Cowden in a letter dated 24 November 1997.
 - (e) Data from 1852 to 1952 contained in Valentin, "Land Loss at Holderness" Applied Coastal Geomorphology (1971) pages 116-37.
- 45 (ii) Statistical comparisons should ideally have the same natural conditions. Where they differ the interpretation of the results must consider the differences.

(iii) The evaluation of the effect of the Mappleton works on coastal erosion can be based on a comparison of data before and after the construction of the works. Dr Madrell (Council) believes that the evaluation of any short-term erosion caused by the Mappleton works can be made by a comparison of erosion during the longest post-construction period (1991-98) with the erosion during any pre-construction period of the same length. Professor Burcharth (claimants) believes that this is the best possible way.

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- (iv) When coastal structures interrupt the movement of granular sediment in the littoral zone this can lead to downdrift erosion. The greater the interruption of the drift by the structure the greater will be the impact downdrift and the greater the erosion. The shape of the eroding coast or beach line should be broadly similar to that described by Hsu & Sylvester ("Growth of crenulate shaped bays to equilibrium" ASCE Journal of Waterways & Harbours Division, WW2 1970 and "Use of crenulate shaped bays to stabilise coasts" ASCE coastal engineering, conference proceedings 1972). For Holderness the net drift of sediment is southerly and thus the Hsu & Sylvester bay shape can be expected to develop south of any fixed point. This bay shape can vary according to whether or not there is sediment transport past the fixed points.
- (v) Rock costs for the construction of coast protection works at Mappleton at the relevant time were £30 per cubic metre with an allowance of 26% for mobilisation and demobilisation, overheads, etc. This cost includes purchase, transport and placing. The Van de Meer approach for deriving rock sizes is agreed (see Delft Hydraulics Report NO483 (1993) and CIRIA/CUR Report 154 (1992)).
- On the Holderness coast the net alongshore movement of beach sands and gravels is from north to south. Coastal structures have the potential to impact on adjacent coastal areas by trapping the sediment at the structures and updrift (to the north) of them and by directing material away from the shore. Updrift accretion can reduce erosion to the north. To the south the beaches can be starved of sediment, beach levels lowered and the amount of wave energy reaching the cliffs increased. This can lead to an increase in cliff erosion rates. The situation only stabilises once and if the natural rate southerly drift is re-established on the downdrift beaches.
- (vii) The groyne bay at Mappleton reached its stable degree of filling or equilibrium state within one year after the start of construction.
 - (viii) No models can accurately predict the rates of erosion of clay till cliffs. In 1990, other than the Halcrow Beach Plan Shape Model ("the Halcrow BPSM"), there were no appropriate commercially available models in existence which would have given more precise answers.
- (ix) Water can be trapped within the breaking wave zone during storms or periods of swell waves and can escape seawards in the form of rip currents which can transport sediment offshore. When a structure is built in the coastal zone it becomes a barrier along which a current forms and thus rip currents can be found along the sides of such structures. Even a weak current can transport fine material because of the high level of turbulence during storms. When tide levels fall and more of the groyne is exposed they become less efficient in forming rip currents. The groynes at Mappleton are completely exposed near low water. At low water there are no erosion problems. Groynes cause concentration of the longshore

tidal and wave generated currents and create seagoing components of the currents compared to situations without groynes or breakwaters.

(x) Wave conditions at Hornsea, Mappleton and Withernsea are similar. The potential for longshore drift is greater than the actual amount of sediment available to be moved. Because cliff erosion is providing the sediment, more sediment should be available for transport to Withernsea than to Hornsea.

ISSUES

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Section 19(1) of the 1949 Act is as follows:-

"Where on a claim being made under this section it is shown -

(a) that the value of an interest of any person in land has been depreciated, or that any person has suffered damage by being disturbed in his enjoyment of land, in consequence of the carrying out of coast protection work by a coast protection authority in the exercise of the powers conferred by this Part of this Act,

(b)

the coast protection authority shall pay to that person compensation equal to the amount of the depreciation or damage:

Provided that a person shall not be entitled to compensation under paragraph (a) of this subsection unless the act or omission causing the depreciation or disturbance would have been actionable at his suit if it had been done or omitted otherwise than in the exercise of statutory powers."

Subsection (2) provides that a claim for compensation under this section shall be made within 12 months of the completion of the coast protection work. It is agreed that Mr Earle has made a valid claim. Subsection (5) provides that "interest" in section 19 "includes any estate in or right over land".

In order to recover compensation under section 19 of the 1949 Act the claimants, or either of them, must show that:-

- (i) They have suffered depreciation in value of an interest in land or damage by disturbance in respect of Grange Farm in consequence of the carrying out of the Mappleton works (loss or damage).
- (ii) The act or omission by the Council causing the depreciation or damage would have been actionable by the claimants, or either of them, if done or omitted otherwise than in the exercise of statutory powers (liability).
- (iii) A valid claim for compensation has been made under the section (compensation).

It is the claimants' case that the rate of coastal erosion at Grange Farm has increased in consequence of the carrying out of the Mappleton works causing loss and damage; that the Council would have been liable to them in negligence and/or nuisance in respect of the works in the absence of statutory powers; that a valid claim has been made covering both claimants and the whole of Grange Farm; and that compensation is payable for the loss or damage suffered (the amount to be quantified and agreed or determined following this decision).

The parties have agreed a list of issues for our determination which we have rearranged under the general headings of loss or damage, liability and compensation.

Loss or damage

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- (i) Has there been any increase in the rate of erosion at Grange Farm since the commencement/completion of the Mappleton works (issue 5)?
- (ii) If so, have the Mappleton works caused the whole or part of this increase (issue 6)?
- (iii) If so, as to the increased rate of erosion, by how many metres per year has the erosion. increased and over what length of the sea frontage of Grange Farm has the increase taken effect (issue 7), and for how long will the increased rate of erosion continue (issue 8) and at what rate and over what length of the sea frontage of Grange Farm (issue 9)?
- (iv) If the Burcharth alternative scheme had been constructed in place of the Mappleton works, then how would issues 5-9 respectively have been answered, mutatis mutandis, as to the Burcharth alternative scheme (issue 13)?

Liability

- (v) Did Lewis & Duvivier and the Council consider constructing a beach breakwater scheme of the sort proposed by Professor Burcharth as an alternative to the Mappleton works (issue 10)?
 - (vi) Would the Burchart alternative scheme have been an effective scheme to provide the desired protection at Mappleton (issue 11)?
 - (vii) What would have been the cost of the Burcharth alternative scheme and how would this compare on a like for like basis with the cost of the Mappleton works (issue 12)?
- (viii) For the purposes of the proviso to section 19(1) of the 1949 Act, would the Council's implementation of the Mappleton works and not the Burcharth alternative scheme have rendered the Council liable to the claimants in nuisance or negligence by reason of some negligence or fault on the part of the Council as particularised in the Particulars of negligence and of fault or negligence relied upon by the claimants dated 2 May 1997 (issue 14)?
 - (ix) Can a person who carries out works to protect land from the common enemy, the sea, be liable in nuisance to a person who establishes that such works adversely affect his land (issue 15)?

- (x) For the purpose of the tort of negligence, did the Council owe to the claimants, or either of them, a duty of care, and, if so, what was the nature of that duty (issue 16)?
- 5 (xi) Would the Council have been afforded a defence to any claim in negligence and nuisance by having acted on the advice of independent consultants (issue 17)?

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Compensation

- (xii) If the Council are liable to the claimants, or to either of them, what is (a) the quantum of the increase in the rate of erosion, (b) the period of time, and (c) the length of the claimants' sea frontage in relation to which the compensation payable is to be assessed (issue 18)?
- (xiii) Can the claimants claim for compensation in respect of alleged losses to their partnership business as well as the depreciation in the value of Mr Earle's interest in Grange Farm (issue 19)?
 - (xiv) If so, in respect of what period (issue 20)?
- (xv) If the claimants can claim for alleged partnership losses, did the notice of claim constitute a valid claim in respect of partnership business losses (if any), either on the footing that the claim was made by both claimants, or on the basis that the claim was made by Mr Earle alone but on behalf of himself and his partner (issue 21)?
- (xvi) During the hearing a further issue arose, namely whether the notice of claim included the parcel of land with an area of about 8 acres to the south of Eelmere Lane, which it is alleged is owned by Ms Earle and forms part of Grange Farm?

INSPECTION

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We carried out an inspection on 8 September 1998 accompanied by representatives of both parties. We viewed Grange Farm and the Mappleton works; we walked along the beach from Mappleton to Grange Farm; we visited the coast protection works at Withernsea and Hornsea; and we saw coastal erosion at Aldbrough and Cliffe Farm to the south of Grange Farm and at Atwick to the north of Hornsea.

LOSS OR DAMAGE

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Claimants' case

Evidence

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Professor Burcharth gave evidence on the causes of erosion at Grange Farm and the construction and effect of beach breakwaters (the Burcharth alternative scheme) in place of the Mappleton works.

The Mappleton works have obstructed the littoral drift and produced rip currents causing sediment to be jetted away from the coast and lost to the beaches to the south. The longer south groyne has caught the sediment moving north to south. The south groyne should have been shorter than the north groyne. Surveys undertaken by Mr Bate between 1992 and 1996 show that the maximum retreat of the coastline south of Mappleton at the beginning of this period took place at about 500 to 1,000 metres from the works. Over the whole of this period, however, the coast from Mappleton to about two kilometres to the south suffered an increased rate of erosion. In the absence of significantly stronger storm winds in the period after the works it is likely that the Mappleton works were the cause of the increased erosion. This conclusion is supported by technical literature on the influence of groynes and also by cliff top measurements. Professor Burcharth did not support this conclusion by mathematical or physical modelling. He referred to the effect of the construction and disrepair of the Hornsea groynes on rates of erosion.

He had considered alternative methods of coast protection: sea walls, groynes, beach breakwaters, beach nourishment and combined solutions. He said that detached beach breakwaters situated very close to or on the beach would protect the cliff toe, maintain beach levels and avoid severe downdrift erosion. The area behind the breakwaters would be less eroded than the adjoining areas and would act as a "strong point". Some downdrift erosion would occur but would not be as drastic as in the case of longer groynes.

A coast protection scheme for the coast between Hornsea and Mappleton comprising a few strong points, between which stable bays would develop, is a solution if the erosion related to such bays can be accepted. However, erosion will be significant if the distances between the strong points are large. There is more sediment coming to Hornsea from the north than is passing Hornsea because of the effect of the Hornsea groynes. At Mappleton there will be a similar obstruction but downdrift erosion will be more pronounced there due to less supply from the shorter updrift coastline (4.5 kilometres to Hornsea compared to 20 kilometres from Bridlington to Hornsea). At a protected point on the coast, although the number and length of groynes are important influences on downdrift erosion, the most important factor is the supply of sediment moving downdrift. It is difficult to estimate the extent of the erosion because no existing mathematical models can handle the complicated morphological conditions which exist. However, from a case of downdrift erosion on the west coast of Denmark it is known that the depth of erosion behind a strong point can be considerable. This example showed that the development of stable bays between widely spread strong points most probably involves the unacceptable loss of land by erosion.

A preferred solution for the protection of Mappleton would have been the Burcharth alternative scheme. This would build up or retain the beach level at Mappleton and cause significantly less downdrift erosion, both in terms of retreat and distance affected from the works. The cost would be no more than the Mappleton works. The downdrift erosion associated with groynes is well-documented in technical literature and Lewis & Duvivier were aware of this

problem when they designed the Mappleton works. There was no reason why the Council chose a solution involving groynes.

Natural forces may have led to the acceleration in erosion. Erosion is caused by waves and currents. Tidal currents are unchanged; wave energy is generated by winds, particularly, on the Holderness coast, from the north to north-east. Wind statistics, however, do not show that winds from these directions have been stronger or more frequent after the construction of the Mappleton works than before. Another natural reason for accelerated erosion could be that the exposed cliffs became less resistant to wave action after 1991. There is, however, no sign that the cliffs within the 1-kilometre stretch south of Mappleton are inhomogeneous.

Professor Burcharth made the following criticisms of Dr Maddrell's evidence. The filling of the groyne bay at Mappleton will not cause a slowing down of erosion at Grange Farm. The Mappleton groynes will continue to deflect sediment offshore and, as the distance from the tip of the south groyne to the eroded beach increases, it will be more difficult for some of the material to reach the beach. The rate of erosion just downdrift of the groynes will not therefore decrease within a foreseeable time. Furthermore, the by-passing of the groynes by alongshore transported material is to a large extent prevented by the rip currents produced by the groynes. The erosion data produced by Mr Bate does not show a reduction in the rate of erosion.

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Rainfall and a high ground water table are unlikely to be contributory causes of erosion after 1991 because 1991 to 1995 was one of the driest five year periods. Drains discharging over the cliff edge might cause increased erosion but the drain at the northern end of Grange Farm is unlikely to be the cause of increased erosion. No increase at this particular point has been identified by Mr Bate. Sea level changes are unlikely to be the cause of increased erosion at Grange Farm because these changes affect the whole of the Holdemess coast. They do not produce different erosion rates along the coast. Winter storms between 1991 and 1995 have not been severe and wave action was well below average. These factors could not have been the cause of increased erosion at Grange Farm.

Dr Maddrell's conclusion that there has been no increase in erosion due to the Mappleton works is likely to be due to lack of data (only HBC data has been used) and its inaccuracy. Furthermore, his opinion that the Hornsea coast protection works are still causing erosion well to the south is inconsistent with his opinion that there has been insignificant downdrift influence from the Mappleton works.

Professor Burcharth referred to the Lewis & Duvivier report to Holdemess Borough Council dated 21 January 1987, which tentatively indicated that a stable bay between Hornsea and Mappleton would take 250 years to develop and would have a maximum depth of 650 metres at a point 2,000 metres south of the Hornsea works. He said that there is uncertainty regarding the time needed to produce crenula bays between hard points. Data points to a ratio of bay depth of 1/15 to 1/5 of bay width. South of Mappleton the bay width is about 19 kilometres (the distance between the sea defences at Mappleton and Withernsea). The long term bay depth would then be at least 1.25 kilometres. The average annual erosion at Grange Farm following the Mappleton works is about 6.5 metres (subsequently reduced). This corresponds to a minimum of 192 years of erosion before a stable bay is formed. It is unlikely therefore that the present rate of erosion of 6.5 metres will decrease significantly within the next 50 years even when a decrease in the erosion rate over the years is considered. It will reduce after this 50 year period. In cross-examination, Professor

Burcharth accepted that one of the best ways to test the long-term rate of erosion caused by the Mappleton works is to look at the performance of the coast where other sea defence works have been built, although he had reservations regarding Withernsea.

He agreed with Dr Maddrell that groynes interrupt the southerly movement of beach deposits but could not agree that the greatest rate of erosion is immediately downdrift of the groynes, reducing southwards. Maximum erosion occurs at some distance from the terminal groyne because the coast between two hard points develops in the shape of a bay. The point of maximum erosion tends to move downdrift with time, but not further than that which corresponds to a stable bay situation. This can be seen from Mr Bate's evidence.

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The effects of the Mappleton works were seen soon after construction started when sediments were deposited updrift of the groynes and erosion commenced downdrift. Reliable quantification of downdrift erosion must be based on obstructions over a period of years depending on the size of the structure obstructing the littoral drift. For structures causing a major impact only a few years of obstruction are needed.

Coast protection works will restrict erosion of the cliff they are protecting but they will not stop steepening of the offshore profile to seawards. This profile will, however, stabilise after some years. This has happened at Homsea and Withernsea.

Although the groyne bay at Mappleton filled rapidly, this does not mean that beach sands and gravels are able to bypass the groynes. He drew a distinction between a groyne bay which is "full" and one which is in "equilibrium". A full groyne bay is one which is physically full of beach material. Here, the majority of the littoral drift will by-pass the groynes. A groyne bay is in equilibrium when the material washed into the bay is equal to the material washed out. A groyne bay in equilibrium will still interrupt the littoral drift. At Mappleton the northern groyne is full and the southern groyne is in equilibrium. These positions were established in 1992 or earlier Downdrift erosion rates vary. Increased downdrift erosion does not stop after the filling of groyne bays but continues for years. The main reason for this is storm generated rip currents which jet sediments offshore. During the hearing this became an important part of Professor Burcharth's opinion as to the detrimental effect of the Mappleton works. He said that sediment can be diverted offshore to up to 50 per cent of the length of the diverting groyne when exposed and in storm conditions. Undertow will take it further. The sediment will be deposited at a depth which is too deep for "lazy seas" to bring it back. Tidal current will not stop a rip current: it will only alter its direction.

Professor Burcharth could not agree with Dr Maddrell that erosion pools at the head of the Mappleton groynes indicate that there are strong currents parallel to the shore rather than directed offshore. The pools which sometimes appear at low tide are marginal lowerings and not really erosion holes. They form under normal good weather conditions. However, offshore directed rip currents are formed during storms. After a storm there will be no direct sign of the rip currents. The seabed topography will adjust to normal topography during the decay of the storm, the only sign of which will be loss of material from the coastline.

Rates of erosion are never constant but post-Mappleton works data is available for six years and shows a significant increase in erosion. This is 189% over the previous 36 year average erosion rate or 66% if compared to the previous highest six- year period. No six-year period since

erosion measurement started in 1952 has shown erosion at Grange Farm at nearly the same magnitude as for the period after the Mappleton works.

Professor Burcharth referred to Dr Maddrell's opinion, based on the Halcrow BPSM, that the main area of erosion should be immediately south of the Mappleton works with decreasing downdrift impact. He made numerous criticisms of this model which he said cannot be used to arrive at quantitative results. All that such a model can predict is that there will be downdrift erosion. The BPSM cannot be used for comparative purposes. Actual behaviour of downdrift eroded coastlines shows that the main area of erosion is not immediately downdrift of groynes. At Mappleton Dr Maddrell's own GIS data shows that maximum erosion took place between 1992 and 1995 at a point 1,500 metres to the south of Mappleton. This is confirmed by Mr Bate's evidence, using HBC data.

His alternative scheme would not trap sand and gravel in a similar way to groynes due to the siting of the beach breakwaters close to the shore, minimising obstruction of the littoral drift. Dr Maddrell neglected this important point when applying the Halcrow BPSM to his scheme. The alternative beach breakwater scheme would have caused less downdrift erosion than that caused by the Mappleton works. Professor Burcharth believed that the Mappleton works are responsible for the increased erosion at Grange Farm. The natural rate of erosion has been about 2 metres each year. If the Burcharth alternative scheme had been constructed at Mappleton the increase in erosion at Grange Farm would have been about 20% of that caused by the Mappleton works, i.e. 2.2 metres per annum.

Mr Bate gave evidence of erosion rates on the Holderness coast. His evidence mainly comprised details of his measurements of erosion along the cliff top at Grange Farm and criticisms and re-presentation of Dr Maddrell's data on erosion.

He commenced beach surveys in 1992 at quarterly intervals. Aerial photographs were taken between 1992 and 1996. There has been a serious loss of beach material in the top and middle beach areas downdrift of the Mappleton works, particularly between 500 and 1,000 metres south of Mappleton. Beach movement appears to be cyclical. Severe top beach depletion downdrift of Mappleton has allowed each tide (spring or neap) to reach the toe of the cliff. This has increased erosion. The Mappleton works have increased downdrift erosion by interfering with the flow of beach material. This normally protects the cliff from wave attack. This lack of protection, plus possible wave refraction and tidal current effects, has caused increased scour to the clay floor of the upper beach with consequent accelerated cliff erosion to the south of Mappleton.

He commenced a clifftop survey in April 1992 with quarterly measurements. Owing to the cliff line retreat a number of measuring points were lost and in April 1995 the points were reestablished and re-numbered. The Ordnance Survey were commissioned in 1996 to re-survey the coastline at Grange Farm.

Analysis of the cliff survey data shows:-

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45 (i) The average long-term erosion rate at Grange Farm from 1926 to 1977 was 1.8 metres a year. This is similar to the erosion calculation by HBC for this period of 1.9 metres a year.

- (ii) Following the re-establishment of the cliffline position at Grange Farm on the 1977 Ordnance Survey map and using HBC data it has been found that the erosion rate from 1977 to 1991 was 2.25 metres a year, similar to that in the preceding period 1926 to 1977 of 1.9 metres a year. Owing to the use of only three measuring points in the locality of Grange Farm, however, the figure of 2.25 metres is less reliable than the previous figure of 1.8 metres and this has therefore been used to compare erosion rates before and after the Mappleton works.
- (iii) From April 1992 to October 1996 (when Mr Bate prepared his first report) the average erosion at Grange Farm was 5.59 metres a year, nearly three times the previous long-term rate of 1.8 metres a year. A weighted average to reflect greater winter erosion would be higher. South of Grange Farm the average annual erosion rates reduced to 4.89 metres, 3.09 metres and 1.84 metres (8 kilometres south of the Farm).

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Wind data from the Meteorological Office for 1977-91 and 1992-96 has been analysed. It shows that wind strengths in excess of 28 knots from the north and north-north-east (the directions most likely to result in cliff erosion) have been less than the average after construction of the Mappleton works.

In his second report (April 1997) Mr Bate made numerous detailed criticisms of Dr Maddrell's evidence, particularly with reference to the history of the Hornsea sea defences; the ditch forming the northern boundary of Grange Farm (a dry ditch draining away from the cliff edge); and the inaccuracy of the HBC survey data and the interpretation of the results.

Commenting further on the errors in the HBC survey data Mr Bate said that a probability function graph indicates that erosion at Grange Farm following the Mappleton works equates to 5 to 6 metres a year. This is then supported by the physical evidence.

In his third report (January 1998) Mr Bate said that he has considered the GIS information produced by Dr Maddrell and the HBC data which he corrected for frontage and time weighting (at Grange Farm) and re-presented in a series of graphs and figures. These show variable erosion rates at various HBC erosion points (used to measure clifftop retreat). For example, for posts 16 to 18B (the frontage to Grange Farm and an area to the south now renumbered 54 to 57) erosion rates for six yearly periods from 1955 to 1990 (averaged over the frontage to Grange Farm) varied from 1.25 metres to 3.96 metres a year, with an average of 2.28 metres, compared to 6.58 metres a year from 1991 to 1996.

He accepted that the GIS data along the cliff frontage of Grange Farm is probably the best data, except for his measurements on the ground at the farm buildings, which are more accurate.

Mr Bate referred to Dr Maddrell's erosion averages produced in September 1998. He said that he found inputting and mathematical errors and, at some points, no or incomplete data. He represented this data. Although the revised figures retain a similar profile to that produced by Dr Maddrell, in some instances there is insufficient data to be confident about this profile. His conclusion is that his data from Grange Farm since 1992 is the most accurate. The contrast between this and the long-term average remains.

Surveys at various points along the cliff edge at Grange Farm produced average annual erosion rates varying from 2.32 metres to 9.33 metres a year for varying periods between April 1992 to September 1998. The periods of measurement at each point varied widely from about one year to 4\%4 years.

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The total land lost at Grange Farm between April 1992 and September 1998 (approximately 6½ years) was about 5.51 metres a year. This figure does not take into account the relevant frontage at any particular measuring point. If this simple average figure had been found from weighted average erosion figures (weighted for time and changing cliff frontage) the erosion rate would have been between 5.08 and 5.13 metres a year.

Ms Earle gave evidence in the form of a witness statement. She said that she moved permanently to Grange Farm in May 1989. Before the Mappleton works the farm was a lovely place to live and a great way of life. Cliff erosion was gradual. It was intended to build up the poultry business and build a bungalow. The cliffs sloped gradually to the beach. After the Mappleton works this situation changed. Lumps of up to 30 feet would drop off the cliffs. The beach dropped 10 to 15 feet allowing the tide to hit the cliffs every day. There was an acceleration in the rate of erosion which caused great turmoil in their lives. Many incidents occurred including: the movement of the electricity supply; the loss of the access road causing 20 acres of landlocked land; milk and refuse collections ceased; the rerouting of the water supply; the loss of the central heating boiler shed; and the emergency demolition of their house. Ms Earle put in evidence a plan and photographs of Grange Farm.

Mr Earle did not give oral evidence. In a witness statement he said that he bought

Grange Farm in 1958. It was a derelict dairy farm. He brought the buildings up to a good standard. He had laying hens, pigs, a few beef cattle and some sheep. In 1960 he started rearing broilers and veal calves. He modernised the farmhouse and doubled its size. In 1958 erosion was hardly noticeable and that is the reason he bought the farm. Erosion was reasonable until 1991, apart from an occasional year when it was noticeable. Planning permission was obtained to build a bungalow. When erosion threatened the farmhouse they would be able to build the bungalow further back and either continue in business or sell as a profitable going business.

Mr Gray gave evidence in a witness statement. He is a cattle broker of Poplar Grange Farm, Wyton. Before the Mappleton works erosion was gradual at Grange Farm but the situation changed entirely after 1991. There was rapid erosion with huge amounts of cliff falling into the sea. The claimants were much affected. He often visited them. Erosion particularly affected the cattle side of the claimants' business. The access road was lost quite early and lorry deliveries and collections stopped. In November 1996 the claimants were forced to leave the farmhouse.

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Submissions

Mr Hand QC said that it is common ground that any interruption of the longshore drift will deprive downdrift beaches of materials and cause increased erosion. There has been an increase in the rate of erosion at Grange Farm. The issues are the extent and duration of this increase and whether it was caused by the Mappleton works?

Professor Burcharth's opinion is that these works are the cause of this increased erosion and that this will continue for 50 years. The erosion will be the established short-term rate with a slight decrease during this period. Professor Burcharth originally put this at about 6.5 metres a year, now modified by new figures. The increase will be that figure less the pre-existing natural rate of erosion of 2 metres a year. The new figures are 2.5 metres (Dr Maddrell) and 3 metres (Mr Bate).

Rates of erosion along the Holderness coast have varied in terms of place and time. Mr Hand said that he was doubtful regarding the nineteenth century figures at Mappleton church of 4.6 metres a year over 25 years. This was before the construction of any groynes. When considering rates of erosion at different places it is important to consider the effect of the "hard points". Withernsea and Hornsea must be distinguished from Mappleton because Withernsea is at the southern end of a long coastline whereas Mappleton is only a few kilometres south of Hornsea. On the Valentin data for 1852 to 1952 the erosion peak south of Withernsea was 1 kilometre and at Hornsea it was 3 kilometres. At Withernsea a 45 year annual erosion rate of 2.4 metres is lower than any of the claimants' figures. But this is only significant if natural conditions are similar. The explanation is that there is more material available at Withernsea. At Hornsea the data for 77 years shows the highest rate of erosion to have been 2.5 metres a year, lower than Grange Farm, but, as explained by Professor Burcharth, there were long periods of deterioration of the Hornsea groynes. Erosion downdrift of Hornsea reflects the various works at this location. Thus, longer term rates of erosion can be explained by the historical background, although the pattern is not entirely clear. Manmade works have complicated the pattern of natural erosion.

Mr Hand said that the Council's case is that there will be a temporary interruption of the littoral drift by the Mappleton works but that when the groyne bay is full, then downdrift will resume. Professor Burcharth agrees with that general proposition but only where the groyne bay is truly full. Downdrift erosion does not stop after equilibrium is reached. At Mappleton the northem groyne is full and the southern groyne is in equilibrium. At some tides there will be a "weiring" effect over the groynes and stratification of the water column means that little sediment will be transported over the groynes to the south. The transport of longshore sediment will not be restored simply because equilibrium has been reached in the groyne bay. It is also the Council's case that, although the Mappleton groynes cause sediment to move offshore, it will be deposited on the downdrift beach within 400 to 600 metres of the works. No logic underlies the view that the extent of erosion would be limited to 400 to 600 metres.

Mr Hand referred to rip currents and the divergence of opinion between Professor Burcharth and Dr Maddrell. These currents in storm conditions carry coarse material offshore and deposit it at a level which is too deep for "lazy seas" to bring it back to the beach. Flow patterns, tides and erosion pools were also referred to in evidence. Groynes divert current and therefore sediment offshore, which becomes available downdrift of the works at unspecified points. On the other hand, rip currents cause material to be lost to downdrift beaches by being jetted and deposited well offshore.

Mr Hand referred to Professor Burcharth's disagreement with Dr Maddrell's view that the larger the groyne field the greater the downdrift erosion. Professor Burcharth accepts that the number of groynes is initially significant but, when equilibrium has been reached in the groyne bays, the number of groynes becomes less important. Length of groyne is important. Most important, however, is the amount of sediment transported along the coast at the groynes. A large

groyne field on a coast where there is much sediment will do less damage downdrift than a smaller field which interrupts downdrift with a limited supply of material. Mr Barrett's observation that there was not much sediment being transported downdrift at Mappleton is important. An obstruction has been intruded into a limited supply of sediment causing considerable downdrift erosion.

As to the rate of erosion at Grange Farm between 1991 and 1998, Mr Hand said that there is reliable data showing a range of erosion at Grange Farm of between 4.5 and 4.7 metres a year (Dr Maddrell) and 5.13 or 5.08 metres (Mr Bate). The rate of erosion for this period lies somewhere within this range. The Tribunal should use a (albeit artificial) figure for erosion during this period of 4.75 metres a year. There has been no other period with a similar rate of erosion. There is no obvious explanation for the increase other than the Mappleton works.

Mr Hand urged us to reject the Council's long-term rate of erosion of 2.5 metres a year, based on the highest rate of erosion south of coast protection works. The long-term rate is 4.75 metres a year at Grange Farm; the background rate is 2 metres a year; and therefore the long-term rate of increase due to the Mappleton works is 2.75 metres a year. Professor Burcharth has said that his alternative beach breakwater scheme would increase erosion by 20%, compared to Dr Maddrell's figure of 50%. These figures cannot be compromised and Professor Burcharth's 20% should be preferred. Thus the long-term rate of erosion if the alternative scheme had been built would have been 2.5 metres a year.

Council's case

25 Evidence

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Dr Maddrell gave evidence in his first report of erosion at or near Grange Farm before the construction of the Mappleton works based on measurements and Ordnance Survey maps. Measurements from Mappleton church to the cliffline between 1786 and 1991 show that the natural average rate of erosion was 1.9 metres a year. Just prior to the works it was 2 metres annually. Dr Maddrell accepted an average long-term (or background) rate of erosion on the Holderness coast of 2 metres a year. Data analysed in 1923 and 1971 show variable rates of erosion. Prior to the construction of the main Homsea sea defences in 1923 the average rate between 1852 and 1922 was 1.4 metres a year with up to 2 metres at Great Cowden. A study of data from 1852 to 1952 indicates erosion at 1.45 metres a year with a lower rate at Mappleton and Great Cowden compared to the areas either side. HBC erosion post measurements from 1951 to 1996 show a period of fairly rapid erosion with variable but similar erosion rates north and south of Mappleton of 3.0 metres and 3.07 metres maximum a year. At Grange Farm the rate was 2.2 metres a year with higher rates in the past. Ordnance Survey maps indicate average annual erosion rates varying between 0.64 and 2.95 metres at Mappleton and 1.4 and 1.68 metres at Cowden for various periods between 1852 and 1988. Overall rates, 1852 to 1978, at Mappleton and Cowden were 1.14 and 1.49 metres a year respectively.

Erosion varies along the coast in any one year and year by year. It also varies seasonally due to higher levels of wave energy and rainfall in winter.

He considered whether rates of erosion were influenced by factors other than coast protection works. He said that wave action is the main cause of cliff erosion. There is no evidence

of an overall increase in wave energy in recent years, although between 1977 and 1979 and 1990 and 1995 this appears to have been higher than average. These periods show more rapid erosion. Sea levels have been rising steadily this century and the increase in water depth will allow more wave energy to attack the cliffs. Any increase in erosion will, however, be relatively small and it would not be possible to distinguish any trend due to the variation in erosion rates. Any impact on erosion due to the composition of the glacial till exposed in the cliffs would only be local and should not influence long-term erosion rates.

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Cliff heights along the Holderness coast vary and Valentin's study in 1971 suggests that at Hornsea the overall erosion of high cliffs is slower than that of low cliffs. Between Mappleton and Cowden the cliffs form a low area, with higher promontories further south. Erosion may be less at these promontories but they will gradually become out of phase with the surrounding lower areas and exposed to greater wave energy. This will eventually cut them back. Dr Maddrell said that Cowden may be a case in point and erosion could be rapid in the next five to ten years.

Overall there does not appear to be a direct link between cliff failure rates and rainfall, although the cliffedge may be cut back where a drain discharges at this point (e.g. at the northern boundary of Grange Farm).

20 Dr Maddrell considered the impact of the Hornsea coast protection works on downdrift erosion. These works extend along 1.8 kilometres of coastline and, by trapping sediment in the littoral zone, have caused downdrift erosion. Sea defences at Hornsea were mainly built in the 1920s. Some were present at the beginning of this century. The south promenade wall was built in 1905-6. It was extended and a 1.6 kilometre groyne field built in 1929-30. A southern extension was built in 1959 and the southern rock groyne in 1985. Downdrift erosion reached a maximum 25 between 1950 and 1967 and then generally decreased, indicating that sediments were then bypassing the Hornsea groynes. Initially it was his opinion that these works appear to be the main reason for the increase in erosion at Mappleton and the more recent reduction, although changes in wave energy and offshore bathymetry may also have had an influence. He referred to Valentin's 30 study in 1971, which showed that erosion was almost nil at the Bridlington, Hornsea and Withernsea defences and highest immediately downdrift, tailing off to almost nil at the next southern defences where there is an accretion of beach material and stabilisation of the coast. The rate of erosion between the defences was variable.

35 The impact of other factors can affect cliff erosion, e.g. the presence of "ords", changes in the angle of wave attack, variations in the sand, gravel and boulder content of the till. Some have direct impact, others are indirect, but there is no direct evidence of the influence of these factors on erosion rates, except perhaps drains discharging over the cliff edge.

The following should be the results of the Mappleton works: the stabilisation of the coast at Mappleton; a reduction in the impact of the Hornsea defences by the updrift retention of beach sediments; and an increase in erosion locally downdrift, which should reduce when the groyne bay is full and sediment by-passes the groynes and flows uninterrupted to the south. The beach downdrift of Mappleton is, however, eroding naturally and it is not possible to say whether the Mappleton works have affected the rate of beach loss. The works caused depletion of the beach to the south but this appears to have been for only a short period. He has seen no evidence that this has increased erosion rates. These are similar to the north and to the south of Mappleton. It is his opinion that neither the Mappleton works nor Professor Burcharth's alternative scheme have or

would produce measurable increases in erosion rates at Grange Farm. The impact of coast protection works can only be distinguished if considered in the long-term. If, however, the Mappleton works have been responsible for increased erosion at Grange Farm then the impact of Professor Burcharth's alternative scheme would have been about 50% of that increased erosion.

Dr Maddrell used the Halcrow Coastal Evolution Model to predict future erosion rates to the years 2030 and 2050 for the coastline 1,800 metres to the south of Mappleton, with and without the Mappleton works. This model is calibrated by relating wave energy to known rates of cliff erosion. The calibration achieved by the model over the one kilometre of coastline between HBC exposure posts 13 and 15 (excluding Grange Farm) (where there is complete data) is satisfactory but for the two kilometres to exposure post 18 (south of Grange Farm) (where there is incomplete data) erosion rates are under-predicted. The model predicted that, to 2030 and 2050, the annual erosion rates for the coastline 1,800 metres to the south of Mappleton, with and without the works, will be virtually the same. He was unable to incorporate his GIS data due to the shortness of the time period and the wide variation in natural erosion rates.

Although there is evidence of rates of cliff erosion reducing to the north and to the south of Mappleton, there may be an increase further south due to the influence of the Hornsea defences. Promontories at Grange Farm could be susceptible to rapid rates of recession in the future.

With regard to rip currents at Mappleton, he has seen these currents but they have all been minor features. He believes that the impact of rip currents is limited for three reasons: their measured velocity would be insufficient to move beach sands and gravels on their own; the stronger tidal currents running parallel to the shore will limit their ability to transport material offshore; and, as tide levels fall and the groynes become exposed, they become less efficient in forming rip currents. Strong erosion pools can be seen at the heads and to south of the Mappleton groynes. These are due to a combination of storm waves and tidal currents, which transport the sediment away. An erosion pool which extends to the south has been formed by flood tidal currents. The significance of the erosion pools is that they are evidence of strong tidal currents reacting with rip currents to prevent the off-shore transport of sediments. Sediments which are transported off-shore at Mappleton will return to the beach between 100 and 600 metres downdrift of the groynes.

Long-term measurements of erosion show that the rate of erosion has been increasing. He suggested two main reasons for this increase: net rise in the sea level and the construction of coast protection works at Bridlington, Hornsea and Withernsea. The effect of these works has been to increase downdrift erosion, particularly immediately downdrift of the works then reducing southwards. But once the groyne bays are full the sediment can by-pass these structures and their impact will be negated.

At Grange Farm erosion rates increased rapidly at the northern boundary (EP16) and then reduced. Similar high rates of erosion were seen at this point in the early 1960s. There appeared to be two reasons for the increased erosion at this point: it is adjacent to a drain or ditch and there was an adjacent major cliff fall prior to July 1992. Average erosion at Grange Farm for the period 1992 to 1995 was about 5 metres a year. Rates of erosion, however, are never constant and there was a similar period of rapid erosion between 1960 and 1964. Furthermore, long-term erosion rates have been less and would be expected to catch up in the future.

The Halcrow BPSM analyses indicate that the main area of erosion caused by the Mappleton works is immediately to the south with reducing impact downdrift so that erosion is small at about 600 metres to the south, decreasing thereafter. The area of maximum impact does not reach the northern boundary of Grange Farm and therefore any effect will be small and occur later. The BPSM shows that the impact of an offshore breakwater scheme would be similar.

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In his second report (August 1997) Dr Maddrell stated that he has found that there were potential errors in the HBC erosion post data used in his first report above. He therefore looked at all available maps and aerial photographs and compared them to the HBC measurements to revise his original figures. Many of them are unchanged but he drew attention to the following:-

- (i) For the period 1852 to 1952 Mappleton and Grange Farm were in a trough between two areas of high erosion, 1.7 metres a year compared to 1.4 metres a year at Mappleton and Grange Farm (previously calculated to be 2 metres). Thus, erosion at Grange Farm appears to have reduced from 2 metres to 1.4 metres a year between the building of the Hornsea groynes and 1952. This indicates a variation in the long term rates and that the full impact of the Hornsea defences had yet to be felt in the area.
- 20 (ii) For the period 1951 to 1997 the average rate of erosion north of Mappleton was between 2 and 2.6 metres a year compared to 2.2 metres at Mappleton, 3 metres between Mappleton and Grange Farm and 2.5 metres at Grange Farm. The average annual rate of erosion for the period 1852 to 1952 at Mappleton and Grange Farm was less than the general rate in the area of about 1 metre and 1.2 metres respectively. Thus, while the impact of the Homsea defences is being felt at Mappleton and Grange Farm it has yet to respond fully to the slower rate before 1952.

Although groynes deflect tidal and wave induced currents offshore, there is no evidence that this is a major factor at Mappleton. The only obvious impact is the presence of erosion pools at the head of the groynes. These tend to indicate strong currents parallel to the shore rather than offshore. Such currents would also cause erosion at the seaward toes of offshore breakwaters.

Professor Burcharth's alternative scheme is theoretically a potential solution to the problem of erosion at Mappleton which Posfords examined in their report in 1988. It would trap sediments in the littoral zone in a similar way to the existing Mappleton works. This would depend on the design and spacing of the breakwaters.

Dr Maddrell made a number of criticisms of Mr Bate's evidence. He referred to Mr Bate's erosion figures and said that, while the long-term average rate might be 2.5 metres a year, this comprises periods of no erosion and erosion in excess of 10 metres. The differences in distribution over a short period of time and over a short stretch of coast are not surprising. They do not indicate the impact of the Mappleton works on Grange Farm. Dr Maddrell referred to erosion to the north and south of the Farm and said that the distribution of erosion from 1960 to 1964 and from 1992 to 1996 is similar. Erosion in the 1960s is clearly the result of "natural" conditions and this is probably the case in the 1990s. Both would have been affected by the Hornsea defences. It is likely that erosion in the 1990s is essentially "natural" and not caused by the Mappleton works. It is apparent therefore that the difference in the distribution of erosion compared with the long-term

average for the Holderness coast is a function of the period of measurement, the particular stretch of coast and the frequency of measurements, as well as the distance between the measuring points, especially in the short-term.

He found potential problems with the use of the HBC erosion post data, e.g. the movement of posts and the absence of regular readings. He has therefore carried out more detailed investigation using the Geographical Information System (GIS) with Halcrow's Intergraph equipment. These use Ordnance Survey maps and controlled aerial photographs. To evaluate the relative accuracy of the cliff line digitised from Ordnance Survey maps possible errors of scale and measurement must be considered. This also applies to aerial photographs which must be georectified, i.e. fixed against the base map. Errors will be plus or minus and tend to average out.

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Dr Maddrell used the above data to plot the cliff line north and south of Mappleton between 1952 and April 1995. Overall, Mappleton is the point of least erosion with the highest erosion to the north, i.e. immediately downdrift of Hornsea.

Dr Maddrell produced various comparisons between the HBC erosion post data and the GIS data and said that, although the periods of both sets of data are not the same and therefore direct comparison is not possible, trends appear to be similar. This comparison shows that the GIS data gives an accurate portrait of cliff erosion. A comparison between Mr Bate's measurements at Grange Farm and the GIS data shows that, in terms of trends and annual rates, there can be confidence in the GIS results.

He had plotted annual and total erosion in graph form from north of Hornsea to Aldbrough (south of Grange Farm) for the periods 1852 to 1952 and 1952 to 1994. Although the Hornsea defences stabilise the coast at that point and to the north, downdrift erosion accelerated to a peak immediately downdrift near Rolston Camp, gradually decreasing southwards with local variations. The low general long-term rate of erosion for the Mappleton area is apparent, as is the peak of erosion between Mappleton and Grange Farm. The average annual erosion rates indicate that the general rate for 1852 to 1952 was 1.2 metres a year. The Mappleton and Grange Farm coastline rate was lower at 1 metre a year. The 1952 to 1994 comparison shows the reverse position: the overall average rate was 2.5 to 2.6 metres with a higher local rate of 2.8 to 2.9 metres and a peak rate between Mappleton and Grange Farm of over 3 metres.

Dr Maddrell showed in graph form changes in the cliff line at 50-metre intervals from 1852 to 1997. In the long-term, most erosion occurred south of Hornsea and north of Mappleton. At Mappleton and Grange Farm there were slightly lower long-term rates. Erosion rates are not constant. Since 1952 there has generally been more erosion south of Mappleton than to the north but an increase in the erosion rate is apparent from 1952 to 1972. It is also apparent that the peak erosion area to the south was immediately downdrift of Mappleton. A graph of average annual erosion rates from 1852 to 1997 from Hornsea to south of Grange Farm shows that erosion has been increasing. For longer intervals the erosion lines are relatively smooth with irregular and peaked lines for shorter intervals. It appears that the peaks of erosion seen in 1989 to 1992 to the south and north of Mappleton are moving south along the coast.

He thought that, if the Mappleton works are affecting erosion at Grange Farm, it would be proper to look at the effect of the Hornsea and Withernsea works when the average rate of erosion has been 2.5 metres a year.

He had plotted in graph form average annual erosion north and south of Mappleton for the years 1992 to 1994 and 1994 to 1995. The erosion lines are very irregular, varying from zero to 9 metres a year. Dr Maddrell said that it is apparent that erosion between 1992 and 1994 in the north had moved south in 1994 to 1995, while to the south of Mappleton the rates of erosion are similar.

He compared average annual erosion for the period 1852 to 1995 for 1.8 kilometres north and south of Mappleton. In the middle of each erosion period (e.g. 1852-90, 1890-1908, etc) the position was as follows: the erosion rates were initially between 0.6 and 0.9 metres a year; south of Mappleton the trend rate increased gradually up to 1980 but to the north the rate was more variable, increasing to 1917 and then decreasing to 1960, which may reflect the impact of the Hornsea defences; and the rapid rise and then fall of erosion after 1960 north of Mappleton was reflected by a similar change in the south which started later in 1980. Dr Maddrell said that these figures show the influence of the Hornsea groynes on coastal erosion, which peaked later to the south than to the north. This indicates that erosion generated in the most vulnerable area south of Hornsea moved southwards along the coast. The likely explanation for this is that erosion at one point "exposes" an area immediately to the south which then becomes more susceptible to erosion.

He has also examined rates of beach sediment transport using the Halcrow BPSM. This model is used to examine the impact of various coastal structures. It looks at the movement of sands and gravels in the longshore drift and how they accrete updrift and erode downdrift of coast protection works. The model cannot establish rates of erosion but it can indicate where erosion is likely to increase because of the loss of beach materials. The model requires calibration against actual erosion and the supply of materials provided by that erosion. The model indicated that the impact of the Mappleton works is likely to extend some 1,000 metres downdrift after seven years, tailing off beyond this point, with the maximum impact from the works to a point 400 metres downdrift. For the Burcharth alternative scheme the model predicted that the beachline would connect to the first northerly breakwater about one year after completion. When the shoreline is connected to the breakwaters it acts as a groyne. The model cannot realistically predict beyond two years. After this period the impact of the breakwaters downdrift is similar to the theoretical impact of groynes.

The model also predicts changes in local tidal and wave induced currents due to coast protection works. For the Mappleton works the model indicated that water will be pushed offshore at the groynes in the form of rip currents but come onshore again some 150 to 200 metres downdrift of Mappleton. For the Burcharth alternative scheme the impact could be greater than that of groynes.

Although the BPSM is not capable of accurately modelling rates of cliff erosion, it is capable of predicting the areas where erosion is likely to increase following the construction of coast defences. It supports the experience of the known impact of such works, i.e. that erosion is local to the works. Dr Maddrell said that his examination of actual erosion rates shows that erosion is more local to the works than is predicted by the model.

From his further investigations Dr Maddrell reached the following conclusions:-

- (i) Erosion between Mappleton and Grange Farm was below average between 1852 and 1952. This trend was reversed between 1952 and 1995 and erosion rates are still catching up.
- Erosion north and south of Mappleton increased from 1852 reaching a peak north of Mappleton in 1991 and to the south in 1993. The peak of erosion appears to be moving south, which may reflect the localised changes in cliff erosion downdrift of Hornsea, which in turn influences further downdrift erosion.
- 10 (iii) The main reason for the rapid increase in erosion in recent years appears to be the construction of the Hornsea defences in the late 1920s with later works in 1959, 1978-79, the early 1980s and 1987.
- (iv) Rapid erosion occurred 600 metres south of Mappleton after 1992 (at HBC EP16)

 (12 metres in one year). The reasons for this appear to be the drain at this point and the major cliff failure before 1992.

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- (v) The claimants' calculated a similar erosion rate at Grange Farm between 1992 and 1995, i.e. 5 metres a year, but the rate of 3.9 metres up to 300 metres downdrift of Mappleton is lower. Both rates are higher than the long-term average rate. This rate has increased since 1852, particularly in the 1980s, and this is due to the effect of the Hornsea works.
- (vi) The Halcrow BPSM indicates that the Mappleton works could increase erosion up to one kilometre to the south, some seven years after completion. However, the actual zone of influence is likely to be less and once sediment fully by-passes the Mappleton groynes their impact will be much reduced.
- (vii) Although the construction of the Mappleton works should have resulted in downdrift erosion its impact would be limited due to the relatively small interruption to the littoral drift. The area of impact would be 600 metres downdrift. Grange Farm is 700 metres to the south and the farm buildings 1,100 metres. Erosion in this zone and further south has been higher than average but this is due to the Hornsea defences and the fact that the area is catching up with the overall long-term rate, which mask any impact of the Mappleton works.

Most of the analyses of GIS data referred to above relate to the coastline from Rolston Camp, south of Hornsea, to Cowden. In order to make a more detailed analysis of the effect of the Hornsea defences, Dr Maddrell extended his GIS data northwards to Hornsea. Average annual erosion rates for the coastline from Hornsea to Cowden for various periods between 1852 and 1995 varied between 0.8 and 3.4 metres a year. He said that these figures indicate that the rate of erosion increased threefold between 1952-90 and 1972-89 (later rates have been disregarded due to the short periods). Significant increases are seen between 1908 and 1926, the period during which the Hornsea defences were under construction, and remained relatively high up to 1972. They increased again between 1972 and 1989 when the Hornsea defences were partially rebuilt. There was also a noticeable increase in erosion up to 600 metres immediately downdrift of Hornsea following the construction of the coastal defences. The rate of erosion generally decreased to the south

Dr Maddrell showed as a graph average annual erosion from Hornsea to Cowden for the periods 1852-1908 and 1908-95, i.e. before and after the construction of the Hornsea defences. For the first period the average rate of erosion was 0.9 metres a year; for the second period it was 2.2 metres a year, more than double. For 200 metres south of Hornsea erosion rates were low and the increase was greatest south of Hornsea as far as Rolston Camp (2.5 metres a year) decreasing southwards to 1.8 metres at Mappleton and then rising to 2.0 metres at Grange Farm. For total erosion before and after the Hornsea defences, in the 56 years prior to 1908, erosion was 20 to 70 metres. In the 87 years after 1908 the rate increased significantly but the difference between minimum and maximum overall erosion was much less, 160 metres minimum compared to 225 metres maximum.

He has compared Mr Bate's revised erosion figures with his revised figures referred to above. Average annual erosion rates are generally close, the main differences being in the south. There were some differences which Dr Maddrell could not explain.

Measurements of cliff erosion were carried out by the RAF at Cowden (to the south of Grange Farm) between June 1994 and July 1997. These measurements were approximate. The total erosion for this period was 27.4 metres, an average of 8.8 metres a year. These figures indicate a wide variation over a short period. The average annual rate of erosion was much higher at the northern end of this property (near Grange Farm) than at the Farm or at the southern end of the RAF property.

Dr Maddrell compared HBC erosion data north and south of Withernsea for 1952-1997 with his GIS data. HBC average erosion was 1.5 metres a year compared to 2.0 metres on the GIS data. Dr Maddrell examined the impact of the Withernsea defences on erosion to the south of the town. Between 1852 and 1908 erosion was 0.5 metres a year to the north, between 1.5 and 3 metres at Withernsea and 3.0 metres to the south at Easington. The average rate was 1.6 metres a year. The Withernsea defences were built between 1908 and 1925. During this period average erosion rates were 0.8 metre a year to the north and 1.0 metre to the south. From 1925 to 1952 erosion to the north of the town was 0.3 metre a year and to the south 1.5 metres a year. There was a similar pattern between 1952 and 1978 (0.5 metre to the north and 0.9 metre to the south). Between 1978 and 1989 the rates increased to 0.7 metre a year to the north and 2.2 metres a year to the south. Between 1989 and 1994 erosion decreased to 0.4 metre and 1.1 metres a year respectively north and south. Between 1994 and 1997 erosion was 0.3 metre to the north and 1.1 metres to the south with peaks of 5.0 metres a year immediately south of Withernsea and at Easington.

He showed in graph form average erosion on the coastline between Tunstall and Easington (including Withernsea) for 1852-1908 and 1908-1997, i.e. before and after the construction of the Withernsea sea defences, but excluding the 17-year period when the defences were being built. Dr Maddrell said that, following the construction of the defences, erosion north and south decreased. Downdrift erosion decreased by over 30%. This indicates that these works did not generally increase erosion downdrift. There was a local peak immediately downdrift, however, and a series of peaks to the south. The impact of the Withernsea defences appeared to be confined to a limited area of about 1.5 kilometres immediately downdrift. The reason for this lack of overall downdrift erosion is not obvious. The most likely explanation for the decrease in downdrift erosion rates is that, while there are widespread variations in short-term erosion, these are much

longer term variations with periods of about 60 years or more. This would reflect a period of major reorientation of the coastline.

It might be argued that, following a period of rapid erosion downdrift at Withernsea and the construction of the defences, the lower rate of erosion still represented an increase on the rate excluding the defences. There is, however, no evidence that periods of higher erosion are followed by periods of no erosion, only that the rate is reduced. If the Withernsea defences had not been built then Dr Maddrell would have expected to see an increase in the erosion rate to the north (Tunstall), especially as it had been low there prior to 1908. After this date the rate of erosion remained low and decreased to the south. Dr Maddrell would have expected the background reduced erosion (without defences) south of Withernsea to have been greater than that seen to the north and thus similar to the actual rate, apart from the local increase immediately downdrift of the defences.

The implications of the above for Mappleton are that the increase in erosion over a significant distance downdrift of Homsea, affecting Mappleton and the coastline to the south, would be mainly due to a longer term natural cycle and not to the Homsea defences. As at Withernsea the effect of these defences would be increased erosion immediately downdrift (1.5 kilometres).

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The groyne fields at Hornsea and Withernsea are extensive but their impact appears to be local (1.5 kilometres). Thus, the two groynes at Mappleton would have considerably less downdrift effect, both in terms of erosion rate and downdrift extent. The recent increased rates of erosion at Grange Farm and RAF Cowden are likely to be due to natural changes rather than the impact of the Hornsea groynes as Dr Maddrell originally concluded. There is, however, an element of "catching up" for this area of coast.

Dr Maddrell commented on Mr Bate's revised erosion figures for HBC erosion posts 16 to 18B (54-57), corrected for frontage weighting. He put in evidence bar graphs showing average rates of erosion for the whole of the coast from Bridlington to Kilnsea and for the coastline immediately north and south of Mappleton for six-yearly periods from 1955 to 1996 using data from the HBC table of erosion post measurements. He considered erosion at Cowden in the context of overall erosion along this stretch of coast. Erosion at Cowden in 1991 to 1996 was more here than elsewhere but other areas have had their peak periods, including Cowden in 1961 to 1966. However, erosion 1991 to 1996 was not as large compared with that for 1967 to 1972, which illustrates the sort of normal variation one might expect along the coast.

Dr Maddrell made detailed comments on Mr Bate's figures and reached the following conclusions:-

- Higher rates of erosion in the past have been seen at Grange Farm than during 1991 to 1996.
- (ii) HBC exposure post measurements are useful but not entirely reliable.
- (iii) If downdrift erosion has been caused by the Mappleton works it should be immediately to the south (up to 600 metres) and not over two kilometres away.

- (iv) High erosion rates occurred to the north of the Mappleton works between 1991 and 1996.
- (v) Mr Bate's graph of erosion for the period April 1992 to January 1998 shows erosion increasing in a southerly directly reaching a peak beyond the control tower at RAF Cowden to the south of Grange Farm.

Dr Maddrell produced a graph and table comparing Mr Bate's and the GIS erosion data for Grange Farm for April 1992 to September 1998 and made detailed criticisms of Mr Bate's figures.

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He showed in graph and tabular form average annual erosion rates for the coastline 1.8 kilometres north and south of Mappleton from 1972 to 1998 based on GIS data. He said that it is apparent that the reduced erosion rate north of Mappleton has little to do with the beneficial effects of the Mappleton works because erosion immediately updrift of the works was over twice that seen in the other two zones between 1995 and 1998. He said that, although it can be argued that erosion south of Mappleton is attributable to the works, its distribution suggests otherwise. For example, it is apparent that there are peaks of erosion from earlier periods moving south with some "catching-up", the higher rates of erosion to the north in 1989-92 and 1972-89 moving to the south. This is illustrated by a comparison between the 1989-92 rate north of Mappleton of 3.7 metres a year and the 1972-89 rate to the south of 2.2 metres a year. For the areas north and south the equivalent figures are 2.0 and 4.3 metres respectively.

Or Maddrell's average annual erosion rates for various points along the cliff frontage to Grange Farm, all for the period July 1992 to March 1998 based on GIS erosion data, varied between 3.7 and 5.5 metres a year. He concluded that average erosion at Grange Farm from 1992 to 1998 has been 4.6 to 4.7 metres a year (depending upon whether the measurements are taken at 50 metre intervals or at Mr Bate's positions). These rates are not exceptional on this stretch of coastline. The average rate of erosion at Grange Farm between 1952 and 1989 was 2.5 metres a year. The reasons for this increase (2.5 metres to 4.7 metres) include: the natural variability of erosion on the Holdemess coast; the fact that Grange Farm became a promontory due to surrounding erosion, eroding more slowly and then catching up as it became more exposed and vulnerable; and the greater number of storms and offshore erosion in the 1990s. Local erosion caused by the Mappleton works would not extend more than 500 metres downdrift of the works.

Mr Barrett mainly gave evidence regarding the design and construction of the Mappleton works but he also gave limited evidence on the state of the Hornsea groynes in December 1975 and subsequent works.

Mr Knapp said that he provided calculations following the completion of the Mappleton works demonstrating the effect of these works on beach levels. His figures showed that the groyne bay filled with sand very quickly. There was a significant difference between the first readings on 9 October 1991 and subsequent readings on 21 April 1992.

Mr Knapp attended a meeting with Ms Earle at Grange Farm on 30 January 1992. She claimed that erosion had increased since the completion of the Mappleton works. Mr Knapp subsequently looked at Ordnance Survey maps and aerial photographs which demonstrated that erosion at the Farm had been rapid for at least 65 years.

Submissions

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Mr Furst QC said that the parties' positions regarding erosion at Grange Farm following completion of the Mappleton works are: Mr Bate 5.13 metres a year (weighted average) and Dr Maddrell 4.5 to 4.7 metres a year. He submitted that the average annual rate of erosion was 4.6 metres for the following reasons:-

- (i) the GIS data used by Dr Maddrell is more accurate, it covers the whole period from July 1992 to March 1998;
- (ii) Mr Bate made complex weighting adjustments and had to "mix and match" his readings;
- 15 (iii) some of Mr Bate's readings were ignored and some only cover a short period;
 - (iv) in view of the extreme variability of erosion there is a danger of distortion if readings are only taken over a short period.

An average annual rate of erosion of 4.6 metres can be compared with the agreed long-term rate for the Holderness coast of 2.0 metres a year, indicating that erosion at Grange Farm after the Mappleton works has been 2.6 metres a year higher than the long-term rate.

The more important question, however, is whether the Mappleton works caused this increase in erosion? Mr Furst said that the claimants' case is contained in Professor Burcharth's view that groynes cause downdrift erosion; erosion has increased at Grange Farm; therefore the Mappleton groynes caused this erosion. Mr Furst drew attention to Professor Burcharth's evidence that groynes are not now used in Denmark. This inevitably coloured his view on the cause of erosion at Grange Farm. He did no modelling to support his opinion.

Mr Furst said that it is common ground that groynes interrupt littoral drift and can cause downdrift erosion. At Mappleton, however, the groyne bay rapidly reached equilibrium and the claimants' case is now that it is not the interruption of longshore drift which has caused erosion, but the effect of rip currents produced by the groynes. It is common ground that these only occur in storm conditions or where there are long period waves; that they occupy only a 2 metre band close to the groynes; and that, as groynes are exposed by the falling tide, rip currents are less likely and/or reduced in strength. Rip currents could therefore only have a limited effect. Mr Furst submitted that we should accept Dr Maddrell's opinion that sediments can be carried to the end of the groynes by rip currents and then transported downdrift by the tidal current. The erosion pools observed by Dr Maddrell indicate the dominant effect of the tidal current.

Dr Maddrell's views regarding erosion are to be preferred for the following reasons. He has visited the area every two months since 1996 compared to Professor Burcharth's three visits. Dr Maddrell has observed the operation of a rip current at Homsea and based his views on this matter on measurements. Professor Burcharth has relied solely on his general experience. The Valentin data and a report in January 1994 by the University of Hull show local erosion immediately downdrift of Bridlington, Hornsea and Withernsea. Technical literature indicates that

generally increased erosion occurs locally to the groynes. Dr Maddrell has attempted to model the effect of the Mappleton works. If Professor Burcharth's contentions are correct large amounts of material would be deposited 50 metres offshore by rip currents but Dr Maddrell has not seen such deposits at low tide.

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Rates of erosion along the Holderness coast are highly variable. No clear pattern emerges as to the occurrence and timing of erosion. Short-term erosion (6-7 years) is little indication of long-term erosion (more than 50 years). Mr Bate said that there was statistical significance in the short-term data at Grange Farm. This view is flawed. His comparison is a 45 year period along the whole length of coast with four years at Grange Farm. He has not carried out a probability analysis. He has used HBC erosion post data although the University of Hull report in January 1994 indicated the unreliability of this data. Mr Bate did not discover the standard deviation and the probability of his measurements being outside that deviation. In short, said Mr Furst, he has not carried out the necessary rigorous mathematical analysis to support his contention that the measurements at Grange Farm are exceptional or fall outside the data set of measurements. The converse is likely to be the position, namely that erosion of 4.6 metres a year over 5¼ years is far from exceptional. The detailed evidence on erosion points to this conclusion. There are numerous reasons why short-term erosion at Grange Farm is higher than the long-term rate, including the inherent variability of erosion; lower erosion at Grange Farm in the past; bathymetric changes; and greater storm energy after 1991.

If, contrary to the evidence, the Mappleton works have caused increased erosion at Grange Farm, questions arise as to the amount of the increase and the length of cliff top frontage? Mr Furst said that average erosion at the Farm between 1992 and 1998 has been 4.6 metres a year with long-term erosion at 2 metres. Thus, average erosion since the completion of the Mappleton works has been 2.6 metres a year higher than the long-term average. This is the best comparison that can be made on the evidence. There is no evidence as to the correct comparison for six-yearly periods before and after the works.

The more important question is whether this increased rate of erosion will continue in the long-term, i.e. for 50 years from 1991?

Professor Burcharth initially suggested that this increased rate should be slightly less than 6 metres (his then average over the last seven years) but later accepted that the best way to establish the rate of long-term erosion is to look at the downdrift erosion caused by other groyne fields, with the exception of Withernsea. He conceded that the evidence at Hornsea suggests a much lower rate of erosion. From 1908 to 1995 erosion south of Hornsea was 2.5 metres a year. Professor Burcharth believed that this rate may have been low because some of the Hornsea groynes fell into disrepair. Dr Maddrell also thought that it would be proper to look at the effect of the Hornsea and Withernsea groynes to establish the likely long-term erosion at Grange Farm. At Withernsea he established the long-term rate to be 2.4 metres a year between 1952 and 1997 and at Hornsea 2.5 metres a year between 1908 and 1989.

Professor Burcharth's opinion is not supported by any measurements along the coast. There is no suggestion that, if the groynes do have more than local effect, the rate of erosion decreases significantly before a stable bay is achieved downdrift of the works. He submitted that, if the Mappleton works are affecting the rate of erosion at Grange Farm, the 50-year rate is 2.5 metres a year. Accordingly, the increased erosion attributable to these works is 0.5 metres a

year, i.e. the difference between the very long-term rate of 2 metres a year and the 50-year long-term rate of 2.5 metres a year.

Dr Maddrell's evidence was that Professor Burcharth's alternative scheme for Mappleton would not have produced any measurable increase in erosion at Grange Farm. If, however, the Mappleton works are responsible for any increase, then the impact of Professor Burcharth's alternative scheme would be about 50% of that figure (assuming salients were formed) or 60% (assuming tombolos were formed). Professor Burcharth's figure was 20%. None of these is supported by modelling or measurements. Mr Furst submitted therefore that a mid-point figure of 35% should be adopted for the 50-year long-term period. Thus, if Professor Burcharth's alternative scheme had been built at Mappleton, the long-term increased rate of erosion would be 0.175 metres a year (35% of 0.5 metres) compared to 0.5 metres a year resulting from the groynes.

Decision

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Has there been any increase in the rate of erosion at Grange Farm since the commencement/completion of the Mappleton works (issue 5)?

We heard much evidence on rates of erosion but by the close of the hearing there was little difference between the parties. It is common ground that since 1852 the average long-term (or background) rate of erosion along the Holderness coast has been 2 metres a year. The Mappleton works commenced in February 1991 and were completed in the following September. The claimants contend that erosion at Grange Farm between 1991 and 1998 has been 4.75 metres a year; the Council's figure is 4.6 metres a year. Thus, the claimants maintain that erosion at the Farm during this period has been 2.75 metres a year above the average long-term rate. The Council put this figure at 2.6 metres a year.

Mr Bate based his erosion figures on measurements taken along the cliff frontage at Grange Farm between April 1992 and September 1998. His weighted averages are 5.13 metres a year or 5.08 metres if the two shortest readings are disregarded. Dr Maddrell based his figures on GIS data along the Grange Farm frontage giving 4.5 metres or 4.7 metres a year average erosion, depending upon the intervals of measurement. Mr Hand, for the claimants, submitted that we should take the average of Mr Bate's figure of 5.13 metres and Dr Maddrell's two figures, producing an overall average of 4.75 metres a year. Mr Furst said that we should take the mean of Dr Maddrell's two figures, i.e. 4.6 metres a year.

Our decision on this issue depends upon whether we take Mr Bate's measurements into account or rely solely on Dr Maddrell's figures. Mr Bate has conceded that the GIS data is likely to be more accurate along the Farm frontage, excluding the buildings, where he thought that his measurements were more accurate. We have decided that Dr Maddrell's GIS data is more accurate overall for the following reasons.

First, GIS measurements are continuous for the period July 1992 to March 1998, a period of 5³/₄ years. Mr Bate's measurements, however, were taken over varying periods at each point and therefore lack the overall consistency in Dr Maddrell's figures. Mr Bate has used 10 different measurement periods for his 19 locations at Grange Farm compared to one measurement period for all Dr Maddrell's locations. Secondly, Mr Bate's highest erosion figures cover short periods of time. At the house wall erosion of 9.33 metres a year is calculated and at HBC post 17 8.86 metres

a year, but for periods of only $1^{1}/2$ and $1^{3}/4$ years respectively. It is common ground that erosion rates vary considerably and can be high over short periods of time. We note that Dr Maddrell's figures for these two locations, each measured over a $5^{3}/4$ year period, are 3.9 metres and 4.8 metres a year, figures likely to be more accurate. Mr Bate has attempted to deal with the time problem by weighting for time and changing clifftop frontage but he conceded that he has had to "mix and match" his readings to apply them over the whole of the period and frontage. We prefer the consistency of Dr Maddrell's figures of 4.5 metres and 4.7 metres a year and accept Mr Furst's submission that we should take the average of these two figures, i.e. 4.6 metres a year.

10 We find as follows:-

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- (i) The average long-term rate of erosion along the Holderness coast has been 2 metres a year.
- (ii) The average short-term rate of erosion along the cliff frontage at Grange Farm between 1991 and 1998 was 4.6 metres a year.
 - (iii) Accordingly, the short-term rate of erosion at Grange Farm between 1991 and 1998 was 2.6 metres a year above the long-term rate for the Holderness coast.

The assessor commented in his report that precise analysis of erosion data is not feasible but that a figure of 4.7 metres a year would not be unreasonable. The minor difference on this issue is not material to our decision, but for the reasons given above, we prefer to look solely at Dr Maddrell's GIS data and use the Council's average figure of 4.6 metres a year.

Have the Mappleton works caused the whole or part of this increased erosion at Grange Farm (issue 6)?

This is the crucial question in this reference. We have found that the short-term rate of erosion at Grange Farm since the Mappleton works has been 2.6 metres a year above the long-term average rate for the Holderness coast. This is not in itself proof that the works have caused increased erosion at the Farm. The burden of proof is on the claimants to show that on the balance of probabilities the Mappleton works have caused the rate of erosion at the Farm to rise to 4.6 metres a year. In short, there must be a causal connection between the Mappleton works and the increased erosion. For the purposes of this issue we consider whether the construction and continued existence of the works have caused erosion. There is a separate issue as to whether the right to compensation under section 19 of the 1949 Act is limited to loss or damage caused by the construction of the works, excluding loss which is due to their continued existence after initial construction. We deal with this question at the end of our decision. For this current issue (issue 6) we look at the existence of the Mappleton works as a possible cause of increased erosion at Grange Farm.

Our first observation is that a comparison between a long-term rate of erosion for the whole of the Holderness coast over 150 years and short-term erosion along a short stretch of coast (between 485 and 500 metres at Grange Farm) is not helpful. It is clear from Dr Maddrell's Table 3.1 and Figures SS2a and b in his third report that annual erosion between Hornsea and Cowden has been steadily increasing since 1852. Between 1852 and 1890 erosion was only 0.8 of a metre a year over a 38-year period; by 1952-72 (20 years) it has risen to 2 metres a year and for 1972 to

1989 (17 years) it was 2.4 metres a year. For 1989-92 and 1992-95 it was 3.4 and 3.3 metres a year respectively. Leaving to one side the erosion for the short periods after 1989 it is clear that average erosion increased about threefold between 1852 and 1989. Part of this increase may be due to the shorter periods between 1952 and 1989 (17 and 20 years compared to 38 years) and some part may be due to the effect of the Hornsea works but the upward trend is clearly seen.

The average long-term rate of 2 metres a year for the whole of the Holderness coast over 150 years is, in our view, little or no guide to the erosion which would have occurred at Grange Farm after 1991 if the Mappleton works had not been built. Clearly this figure would have been above 2 metres a year but we were given no evidence as to what it might be. We sound a note of caution therefore against comparing 2 metres and 4.6 metres and then drawing the conclusion that erosion increased by 2.6 metres a year after the Mappleton works. This is not a comparison of like with like. The figure of 2.6 metres a year must be the maximum increase which might have been due to those works.

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We look now at erosion generally along the Holderness coast to see whether an average rate of erosion of 4.6 metres during a 6 to 7 year period is exceptional, thus giving some indication that the cause may be other than natural erosion. Dr Maddrell said that this rate was not exceptional and gave examples of high rates of erosion over six-year periods, including measurements taken at Mappleton Church between 1836 and 1861 (before any groynes were built along the coast) which show average erosion of 4.6 metres a year. We agree that there have been higher rates of erosion from time to time but, on Dr Maddrell's figures, it is unusual to find a six-year period where erosion at any one point on the coast from Bridlington to Kilnsea has been equal to or above 4.6 metres. Of course, erosion in any one year has often exceeded this figure at points along the coast. Dr Maddrell has shown erosion in graph form at various points along the Holderness coast in six-yearly periods from 1955 to 1996 (Figures 1-7). 116 measuring posts have been used. The results are as follows:-

30	Period	Erosion of at least 4.6 metres
	1955-60	3 posts
	1961-66	2 posts
35	1967-72	none
	1979-84	1 post
	1985-90	1 post
	1990-96	3 posts

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In our view, these figures show that average erosion of 4.6 metres a year over a six-year period, although not unique, is high when considered in the context of the whole of the Holderness coast. It is also high when considering Grange Farm and the areas immediately north and south of Mappleton.

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At Grange Farm Dr Maddrell's figures are as follows (Figure 22):-

Period	Average annual erosion m/year		
	Northern boundary (54)	Southern boundary (55)	
1955-60	1,63	1.78	
1961-66	4.11	4.63	
1967-72	3.20	2.39	
1973-78	2.52	1.66	
1979-84	2.3-3.18	2.1-2.76	
1985-90	1.68-2.3	1.02-2.1	
1991-96	6.23-6.67	2.83-5.83	

These figures show an increase in erosion after the construction of the Mappleton works.

Dr Maddrell showed in graph and tabular form annual erosion rates for the coastline 1.8 kilometres north and south of Mappleton. The overall figures are:-

Period	North of Mappleton (metres per year)	South of Mappleton (metres per year)	
1972-89	3.0	2.2	
1989-92	3.7	3.5	
1992-95	2.5	4.9	
1995-98	1.4	4.2	

Dr Maddrell then extended his analysis by dividing the areas north and south of Mappleton into three equal lengths of coastline to produce the following figures:-

Coastline Zone	1972-89 m/yr	1989-92 m/yr	1992-95 m/yr	1995-98 m/yr
North	шу	шуг	im y i	in ye
A	2.7	4.7	3.6	1.1
В	2.7	5.6	3.1	1.0
C	2.7	2.6	1.8	2.6
A, B and C	2.7	4.3	2.9	1.6
South				
D	2.4	4.3	4.9	4.2

D	2.4	4.3	4.9	4.2
E (Grange Farm)	1.8	3.0	4.7	4.4
F	1.8	2.0	5.9	3.7
D, E and F	2.0	3.4	5.0	4.2

Finally, Dr Maddrell looked at the position north and south of Mappleton for the period 1992-98, i.e. after the completion of the Mappleton works. The average rate north of Mappleton was 1.95 metres a year and to the south 4.55 metres a year. These figures might also indicate that erosion south of Mappleton increased after the construction of the Mappleton works.

The above figures appear to support the claimants' argument that the Mappleton works have caused increased erosion at Grange Farm. However, as Dr Maddrell said in his evidence, there are other possible reasons for the increase in short-term erosion at the Farm. We also refer to the Holderness Coastal Defence Report by the Institute of Estuarine and Coastal Studies, University of Hull dated January 1994. In this report mean cliff recession rates for the coastline from Mappleton to Cowden were calculated to be 2.27 metres a year from 1952 to 1990 and 5.84 metres from 1992 to 1994. The report concluded:-

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"Although the results are necessarily tentative, the monitoring has shown no significant increase has taken place in the retreat rates ... south of Mappleton due to the Mappleton defences construction work in 1991.

The report has highlighted the fact that temporal variations in the retreat rate mean that firm statistical conclusions as to the effect of the Mappleton defence works cannot be achieved until at least six years of data have been assembled (i.e. by the year 2000 AD)."

In our judgment the figures set out above cannot be regarded as clear evidence that the Mappleton works have caused increased erosion at Grange Farm. We consider that we cannot reliably base our decision solely on the factual evidence of erosion rates. The evidence we heard on erosion data and its subsequent analysis has shown us that this is an unreliable basis on which to reach a decision on causation. The basic facts were in dispute, e.g. as to the erosion at any one point and as to the accuracy of historic data. The analysis of these facts was in dispute also and has varied between the parties by reference to such matters as periods of time, measuring points, etc, each party putting its own interpretation on the raw material. It is impossible for us to draw a reliable conclusion solely on the erosion data. We must therefore also consider the opinion evidence of Professor Burcharth and Dr Maddrell as to the causes of the erosion at Grange Farm.

We set out at the start of this decision our understanding of the process of coastal erosion.

The crucial questions are: have the Mappleton works interrupted the littoral drift and/or caused rip currents, thereby removing sediment from the longshore drift and diverting it off-shore to the detriment of the downdrift coast and thus causing increased erosion at Grange Farm? Our answer to this question rests ultimately on the opinion evidence of Professor Burcharth and Dr Maddrell.

Professor Burcharth relied mainly on general principles. His argument has an attractive simplicity. He said that erosion has increased at Grange Farm; the Mappleton works interrupt the longshore drift; such interruption causes downdrift erosion; therefore the Mappleton works are responsible for the increased erosion at Grange Farm. Although the groyne bay at Mappleton is in equilibrium it is not full and therefore sediment is still intercepted to the detriment of the downdrift coastline. In this situation the length of the groyne field is less important than it was initially and an important factor is the amount of sediment in the longshore drift passing the groynes. At Mappleton there is little sediment passing due to the nearness of the Hornsea groynes to the north. At Mappleton the groyne bay will never be full and there will therefore be continual obstruction of the longshore drift. In addition to the interruption of the longshore drift groynes divert sediment offshore and create rip currents. Again applying general principles, Professor Burcharth said that rip currents at Mappleton carry significant amounts of sediment offshore where it is deposited at depth and lost to the downdrift beaches. During the hearing this became a major part of Professor Burcharth's opinion as to the detrimental effect of the Mappleton works.

Dr Maddrell applied a more analytical approach to the problem. Although he accepted the general principles relied upon by Professor Burcharth, he attempted to analyse the position he found at Mappleton and on the Holderness coast. This is clearly seen in the length and complexity of his three expert reports and his oral evidence. He accepted that groynes interrupt the littoral drift but attempted to analyse the conditions at Mappleton to ascertain the effect on downdrift erosion and to locate the site of that erosion. He said that the groyne bay quickly achieved equilibrium, thus reducing interference with the littoral drift. Furthermore, the groynes above the core are permeable, which also tends to reduce this interference.

A major difference between the two experts was the effect of the groynes in diverting sediment offshore and, in particular, the formation and effect of rip currents. Dr Maddrell did not accept the significance of these currents as a cause of downdrift erosion at Mappleton. He said that the important factor to concentrate on when arriving at a view on downdrift erosion is the amount of material taken out of the system by diversion offshore by the groynes and deposited at depths at which it could not return to the shore. Rip currents occur in storm and swell conditions but their impact on transported material is really a phenomenon of storms. It is important to remember that, although rip currents can develop along groynes, they also occur naturally and independently of coastal structures.

Dr Maddrell put forward four reasons why rip currents are not significant at Mappleton. First, there are stronger tidal currents moving parallel to the coast which will divert the rip currents and themselves transport greater quantities of sediment. The velocity of a tidal current is approximately double that of a rip current and a rip current occupies a narrow zone of about two metres whereas a tidal current is everywhere. Dr Maddrell observed a rip current at Hornsea which moved offshore and was then diverted by the tidal current so that within half a groyne bay length it was running parallel to the shore. Secondly, erosion pools seen at Mappleton indicate that material is moving along the coast and not offshore. There is a concentration of tidal flow at the end of the groyne which, combined with the stirring action of the waves, causes erosion. This indicates the dominant effect of the tidal current. Thirdly, even using Professor Burcharth's worst case of offshore diversion of material of half the length of the groyne, a 100 metre groyne at high-water would only divert material 150 metres offshore. At Mappleton the groynes are about 60 and 100 metres long. Fourthly, there is no physical evidence that rip currents are transporting large

amounts of sediment offshore, either in the form of offshore deposits or banks, seen at low-water, or loss of beach material downdrift. Beach levels to the south have been maintained.

In Dr Maddrell's opinion the effect of the Mappleton works was limited to the coast immediately downdrift of the works. This is supported by erosion data reflecting the effect of the works at Hornsea and Withernsea; data for erosion south of Mappleton; the published material which indicates that downdrift erosion is local to sea defence works; and the Halcrow BPSM which predicts that erosion will not extend more than 600 metres to the south of Mappleton. It will not reach Grange Farm.

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Dr Maddrell suggested other reasons for increased erosion at the Farm. These included the inherent variability of short-term rates of erosion; lower erosion in the past leading to the formation of a promontory with subsequent increased erosion (catching up); bathymetric changes showing greater erosion offshore from 1948 to 1984 leading to more wave energy; greater storm energy after 1990; the southward movement of the effect of the Hornsea defences; a major reorientation of the coastline over a 60-year period; and rising sea levels.

We therefore have two conflicting answers to the question whether the higher than average erosion at Grange Farm between 1991 and 1998 was caused by the Mappleton works. Neither can be conclusive. Which do we adopt? We must decide which expert witness, Professor Burcharth or Dr Maddrell, is most likely to be right. We must compare the nature and quality of their evidence.

Both Professor Burcharth and Dr Maddrell are well-qualified and experienced in the field of coastal protection. Professor Burcharth, however, has had no previous experience in the United Kingdom and had only visited the Holderness coast three times before the hearing, including attendance at our inspection last September. Dr Maddrell and his firm have considerable experience in this country and Dr Maddrell has visited the Holderness coast every two months since February 1996. This is clearly seen in his evidence which was often based on his observations on site.

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We were told that groynes are not now used as coast protection works in Denmark, although this was not explained in any detail, e.g. whether this is due to different conditions on the Danish coast or to an inherent dislike of groynes as a potential cause of downdrift erosion. Whatever the reason Professor Burcharth clearly had a dislike of groynes: he preferred beach breakwaters. We believe that this difference of approach, it could be called a difference of engineering culture, coloured his evidence. On this issue we believe that Professor Burcharth started from the premise that, because groynes interrupt longshore drift and can cause rip currents, then the Mappleton groynes must be the cause of increased erosion at Grange Farm. Essentially he based his opinion on these general principles - interruption of drift and rip currents - without a detailed investigation as to whether the Mappleton groynes did in fact produce these conditions, leading to increased erosion at Grange Farm.

Dr Maddrell, on the other hand, while acknowledging the general principles, recognised that they do not necessarily apply in every case. He investigated the position at Mappleton in detail to see whether these undesirable side effects of groynes actually applied to Mappleton. He considered the filling or equilibrium of the groyne bay and rip currents, and produced a reasoned opinion as to why they did not apply to Mappleton.

On all matters likely to affect erosion at Grange Farm - erosion rates on the Holderness coast, the effect of the Hornsea and Withernsea defences, the actual impact of the Mappleton works on littoral drift and offshore currents, bathymetric changes, storm energy and the like - Dr Maddrell's investigations were in much greater detail than those of Professor Burcharth and Mr Bate. It is clear that Dr Maddrell not only prepared his evidence in more depth but that the technical resources and experience of Sir William Halcrow & Partners on which Dr Maddrell was able to draw were much greater than the resources of Professor Burcharth and Mr Bate.

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Finally, we must record the impressions we received of Professor Burcharth and Dr Maddrell as expert witnesses. We express our admiration at the way in which Professor Burcharth prepared his reports and gave oral evidence on highly technical matters in a foreign language. This led to some minor difficulties of meaning but the main problems we have in accepting his evidence arise out of his general attitude towards groynes as a solution to coastal erosion problems; his lack of experience and investigation of conditions on the Holderness coast; and therefore his almost universal reliance on general principles. Dr Maddrell was an impressive witness. His written reports are comprehensive and supported with a wealth of data, clearly presented in graph and tabular form. His oral evidence was clear and authoritative. It was essentially unshaken in cross-examination. The issues in this case have changed since the start of the reference as new theories and data were put forward. Dr Maddrell was not afraid to revise his opinions in the light of changing conditions and we gained the impression that he approached his task in a spirit of objective and scientific enquiry.

For these reasons we prefer Dr Maddrell's evidence on this fundamental issue. We accept his opinion that, when the groyne bay at Mappleton reached equilibrium (agreed to be within one year of the start of construction i.e. by February 1992), then the sediment in the littoral drift bypassed the groynes and flowed uninterruptedly to the south, and that rip currents were not significant and did not divert and deposit sediment offshore to the detriment of the downdrift beaches. If, as we have now found, these two causes of interruption of the littoral drift did not operate at Mappleton, then it should follow that we reject Professor Burcharth's opinion that they were the cause of increased erosion at Grange Farm.

It is our conclusion that the claimants have failed to discharge the burden of proof, that is to say to show that on the balance of probabilities the Mappleton works were the cause of increased erosion and therefore loss or damage at Grange Farm between 1991 and 1998.

In paragraph of 30 of his report the assessor expressed a contrary conclusion on this issue. We set out below our reasons for not accepting this conclusion.

In paragraph 16 of his report the assessor agrees that the burden of proof is on the claimants but then indicates that "it is convenient to approach the question from the other end, namely through an examination of Mr Furst's propositions rather than those of Mr Hand." In paragraph 17 he considers the reasons put forward by Mr Furst in his closing submissions (based on the evidence of Dr Maddrell) as to why the short-term rate of erosion at Grange Farm between 1991 and 1998 was higher than the long-term rate. We do not disagree with the observations which he makes.

The assessor appears to base his affirmative answer to issue 6 on a consideration of erosion rates rather than on an analysis of the underlying causes of the increased erosion. We disagree with this approach. He suggests that general average erosion since 1990, in the absence of the

Mappleton works, would have been about 3 metres a year i.e. 1 metre higher than the long-term average for the Holderness coast of 2 metres a year. We do not disagree with his higher figure. although we have not found it necessary to make a finding as to this rate. However, our conclusion is that erosion of 2 metres a year for the whole of the Holderness coast over 150 years is little or no guide to what erosion at Grange Farm would have been after 1991 in the absence of the Mappleton works. We have already expressed caution against drawing conclusions from a comparison of short-term and long-term rates and the use of erosion figures as the basis for a decision on causation

10 We consider that the evidence does not justify us in concluding that it must necessarily follow that the additional 1.7 metres per year (i.e. 4.7 metres less 3.0 metres) is attributable to the Mappleton works. The assessor, correctly in our judgment, is cautious in his approach and suggests in paragraph 18 of his report only that this "may be the cause, and even then that the rate will probably fall away quite quickly as the littoral drift is re-established".

Our decision on issue 6 is that the Mappleton works have not been shown to be the cause of the whole or any part of the erosion at Grange Farm between 1991 and 1998 and that the claimants have been unable to prove that any loss or damage suffered at Grange Farm was in consequence of the carrying out of the Mappleton works. The effect of this finding is that the claim fails and no compensation can be awarded in this reference.

For the purposes of a decision in this reference it is unnecessary for us to determine the remaining issues. We understand, however, that there are other similar claims outstanding and at least one of them has been referred to this Tribunal. We think it would be helpful, therefore, if we set out briefly what our decisions would have been on other issues (mainly of law) which have arisen in this reference and which may be of general application.

OTHER ISSUES

Proviso to section 19(1) of the 1949 Act (issues 14, 15 and 17)

Submissions

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It was common ground that the claimants will only be entitled in principle to compensation 35 if they can satisfy the proviso to section 19(1). The claimants' case, expressed shortly, is that they rely on the carrying out of the works (i.e. their actual construction) as the "act" and the failure of the Council to have any, or any proper, regard to the damaging effects on the Farm resulting from the continued existence of the works following their construction and/or failure to take any steps to avoid such effects, as "omissions". There is no complaint about the way in which the work was carried out. The claimants' case rests on alleged failures by the Council and their consultants, Lewis & Duvivier, to appreciate the likely risk of increased downdrift erosion if a conventional groyne system were employed and to consider properly, and to employ, an alternative approach i.e. an off-shore breakwater scheme as advocated by Professor Burcharth.

The claimants' main contention was, initially, that, if these allegations are made out, they would have had a cause of action against the Council in nuisance or negligence, had the works not been carried out with the benefit of statutory immunity arising from the exercise of their powers in section 4 of the 1949 Act. However, in his closing submissions Mr Hand accepted that nuisance would have been the primary remedy and that, if no such action could have succeeded, it was unlikely that it would have succeeded in negligence. This accorded with the Council's submissions and for that reason we have concentrated on the position in nuisance.

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The Council's main response to this aspect of the case was that:-

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(i) A person who carries out work to protect his land from the common enemy, the sea, cannot be liable in nuisance to a person who establishes that such work adversely affects his land: see R v Pagham cited with approval in Gerrard v Crowe and Clerk & Lindsell on Torts (17th edition) at paragraph 29-19.

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(ii) There is no absolute rule of law which requires a landowner to refrain from any activity on his land which injures his neighbour: see Bradford v Pickles; Home Brewery Co Ltd v William Davis & Co (Leicester) Ltd; Stephens v Anglian Water Authority.

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The claimants cannot succeed in nuisance unless they can show that in 1989-91 the advice of Lewis & Duvivier was advice which no competent expert could reasonably have given and that the Council acted unreasonably in relying on it.

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For the claimants it was argued that:-

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Pagham is either not good law or should in any event be distinguished. The modern law is that the Council would have been liable in nuisance if they had put their land (i.e. the foreshore) to an unreasonable use: see Cambridge Water Co v Eastern Counties Leather plc.

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The scheme of works chosen was not reasonable when an alternative off-shore breakwater scheme could have been constructed which would have been likely to reduce the adverse effects of downdrift erosion at Grange Farm. The concept of reasonableness dictates that as between two comparable schemes, one of which would be damaging to the Farm and the other not, the scheme that would minimise the damage should have been chosen. The Council should have been aware of the effect that the works would have on the coast south of Mappleton. Such effect was reasonably foreseeable when the scheme was chosen.

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Decision

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We consider first the *Pagham* case. Commissioners, acting wholly within their statutory powers, took away several small groynes and erected one large one together with other sea defence work. The owner of neighbouring land (a mill) claimed that the effect of the new groyne was to cause the sea to flow with increased force against his land causing it to be gradually washed away. The effect was to reduce the value of his land. There was evidence that, before carrying out the works, the Commissioners had endeavoured to ascertain the best position and shape for it. There was no evidence that it could have been carried out in any other way to achieve the same result without affecting the neighbouring land. The whole coast was eroding and the neighbouring land

could be protected by constructing its own works. The sole issue was who should bear the cost of doing so.

Lord Tenderden CJ, looking at the evidence before the court, stated that (page 360):-

"... it is not by any means clear that [the Commissioners] did not do the very best that under the circumstances could be done to attain the object they had in view".

Against that background he then said (page 360):-

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"Now is there any authority for saying that any proprietor of land exposed to the inroads of the sea, may not endeavour to protect himself by erecting a groyne or other reasonable defence, although it may render it necessary for the owner of the adjoining land to do the like? I certainly am not aware of any authority or principle of law which can prevent him from so doing."

It is to be noted that Lord Tenterden used the expression "reasonable defence". He concluded his judgment (page 361):-

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"I am, therefore, of opinion that the only safe rule to lay down is this, that each land-owner for himself, or the commissioners acting for several land-owners; may erect such defences for the land under their care as the necessity of the case requires, leaving it to others, in like manner, to protect themselves against the common enemy."

25 Bayley J, in agreeing, made the observation that (page 361):-

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"If, indeed, [the Commissioners] made unnecessary or improper works, not with a view to the protection of the level, but with a malevolent intention, to injure the owner of other lands, they would be amenable to punishment by criminal information or indictment, for an abuse of the powers vested in them. But if they act bona fide, doing no more than they honestly think necessary for the protection of the level, their acts are justifiable and those who sustain damage therefrom must protect themselves. ... If a man sustains damage by the wrongful act of another, he is entitled to a remedy; but to give him that title those two things must concur, damage to himself, and a wrong committed by the other."

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We accept the generality of the Council's second submission (i.e. there is no general obligation on a landowner to refrain from injuring his neighbour) but in our judgment Pagham is not authority for the proposition that a landowner can never be liable in nuisance in respect of any works carried out by him or on his behalf to protect his land from attack by the sea. At most it is authority for the proposition that if the works were the best that could be devised in the circumstances, and there was nothing otherwise unnecessary or unreasonable or improper about them, there was no liability to a neighbour for the cost of protecting his land from increased erosion resulting from the works. It was, in effect, an attempt to obtain compensation from the Commissioners where no right to compensation arose.

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We also accept the claimants' submission that the correct approach to a claim in nuisance, even in the present circumstances, which are different from those he was considering, is as set out by Lord Goff in the *Cambridge Water* case (page 299D):-

"Of course, although liability for nuisance has generally been regarded as strict, at least in the case of a defendant who has been responsible for the creation of a nuisance, even so that liability has been kept under control by the principle of reasonable user - the principle of give and take as between neighbouring occupiers of land, under which "those acts necessary for the common and ordinary use of land and houses may be done, if conveniently done, without subjecting those who do them to an action" see Bamford v Turnley per Bramwell B. The effect is that, if the user is reasonable, the defendant will not be liable for consequent harm to his neighbour's enjoyment of his land; but if the use if not reasonable, the defendant will be liable, even though he may have exercised reasonable care and skill to avoid it."

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Reasonableness is, therefore, an important element in establishing liability in nuisance. Cambridge Water, although primarily a decision concerning the rule in Rylands v Fletcher, also established that foreseeability of harm of the relevant type is a prerequisite of the recovery of damages in nuisance. Lord Goff said (page 300F):-

"Here, as I have said, it is still the law that the fact that the defendant has taken all reasonable care will not of itself exonerate him from liability, the relevant control mechanism being found within the principle of reasonable user. But it by no means follows that the defendant should be held liable for damage of a type which he could not reasonably foresee; and the development of the law of negligence in the past 60 years points strongly towards a requirement that such foreseeability should be a prerequisite of liability in damages for nuisance, as it is of liability in negligence."

Accordingly, if it had been necessary to consider the proviso to section 19(1) for the purposes of our decision, we would have held that, although the construction of groynes and sea walls as sea defences is *prima facie* a reasonable user by the owner of the foreshore, as a matter of law it was open to the claimants to show, if they could, that this particular scheme at Mappleton was not reasonable.

The claimants brought evidence directed at showing that the Mappleton works were not a reasonable use of the foreshore because there was an alternative scheme (the Burcharth alternative scheme) which could have been carried out. Such a scheme, it was said:-

- (a) had not been properly considered by the Council or its consultants (issue 10);
- (b) would have been as effective as the groyne scheme in protecting the coast against erosion (issue 11);
- (c) would not have been significantly more expensive such that the Council would have been justified in rejecting it on that ground (issue 12);
- (d) would not have given rise to the same adverse consequences in terms of downdrift erosion at the Farm (issue 13).

However, even if we had been satisfied that the claimants had made out their case on each of these issues, it would still have been necessary for them to satisfy us on a balance of

probabilities that the Mappleton works caused the rate of erosion at the Farm to increase (issue 6). We have already found against the claimants on this issue and we do not therefore find it necessary to make any further findings in respect of issues 10-13.

The Council's reliance on independent consultants (issue 17)

Submissions

The Council argued that it acted entirely reasonably in seeking the advice of experienced experts in the field of coastal protection. The Council's officers told us that they did not possess the degree of technical qualifications or experience which would have enabled them to offer advice to the Council. In asking for, and following, Lewis & Duvivier's advice and implementing groyne scheme designs prepared by them, the Council, through its officers, was not in a position to judge for itself whether such advice was correct or the designs appropriate. The Council had no reason to think that in carrying out the works their consultants' advice was not good advice.

The claimants rely on the proposition that the Council were exercising their powers under section 4 of the 1949 Act and could not avoid the consequences if a nuisance was caused e.g. by delegation: Robinson v Beaconsfield RDC. However, the Council argued that, in the "no statutory powers" world postulated by the proviso to section 19(1), this is not to the point. It has to be assumed that the Council had no statutory immunity in carrying out the works from any action against it at common law.

Decision

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We accept the Council's evidence as to their reliance on the advice and designs of Lewis & Duvivier. However, this is not a case of vicarious liability for the acts or omissions of an independent contractor; Lewis & Duvivier were the Council's consultants, not their contractor. The question is whether in the absence of statutory immunity a local authority can avoid liability for nuisance by the employing consultants to advise it as to the design and likely consequences of a coastal protection scheme which it wishes to carry out and carries out the work in reliance on that advice. No authority for such a proposition was cited to us.

We take the correct position in law to be that set out in the Cambridge Water case to which we have referred i.e. that reasonable user and foreseeability are the fundamental considerations, not whether the Council exercised reasonable care. The quality of Lewis & Duvivier's advice is no doubt relevant in reaching an opinion as to the reasonableness of the scheme of works chosen, but we would have held that, at least in the circumstances before us, if the works carried out by the Council gave rise to an actionable nuisance, they would not have had a defence to it on the grounds that they employed and acted on the advice of independent consultants.

Can compensation be claimed for partnership losses (issue 19)?

Submissions

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For the claimants it was argued that, assuming that the Tribunal finds that the farmland was lost prematurely as a consequence of the works, it was an irreplaceable asset. We were referred to McGregor on Damages (16th edition) at paragraph 1368 and to cases involving the destruction of

ships. The principle which it was contended we should apply was stated by Lord Wright in the leading case of Leisbosch Dredger v SS Edison (pages 463-4):-

"The true rule seems to be that the measure of damages in such cases is the value of the ship to her owner as a going concern at the time and place of the loss. In assessing that value regard must naturally be had to her pending engagements, either profitable or the reverse."

It is to be noted that "such cases" concerned the loss at sea of working ships but the claimants argued, by analogy, that the land lost was at all material times part of a working farm in which the claimants were partners. The profitability of the farm (if any) over the period of assessment should be taken into account in assessing compensation. There is nothing in section 19 which, on its true construction, excludes such losses. Even if Ms Earle is not entitled to claim, Mr Earle as her partner is so entitled and indeed is obliged to claim for all partnership losses (if any) subject to accounting to Ms Earle for her share in accordance with the partnership agreement.

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Ms Earle had a non-exclusive contractual licence to enter on the farm in order to carry on the partnership business: see *Harrison-Broadley v Smith* and Lindley on Partnerships (13th edition) at paragraph 10-38. This is an "interest" for the purposes of section 19; alternatively she was "disturbed in her enjoyment" of the Farm as a partner entitled to enter the land to carry on the partnership business. Mr Earle was the owner of the land but was also "disturbed in his enjoyment" so that partnership losses could also be claimed on that basis.

Section 19(1)(a) refers to depreciation or disturbance in consequence of the "carrying out" of the works. This extends to the consequences of both their construction and their subsequent continued existence. The claim crystallised at the moment when the works were completed which included all heads of claim. It is a matter of causation of the erosion which determines what may be claimed. The measure of loss should reflect the beneficial use to which the land would have been put had it not been destroyed. A claimant having an "interest" can assess his loss by reference to the loss of a profit-making capacity as a measure of its depreciation: Lakeman v Bournemouth Corporation.

For the Council, it was argued that the time limit for the making of claims in section 19(2) shows that only disturbance suffered while the works are being constructed can be the subject of a claim e.g. by reason of noise, dust, vibration and the like which would otherwise be an actionable nuisance. Loss of profits, whether suffered by a partnership or in any other way, are not claimable per se but only insofar as they may depreciate the value of the land (see e.g. the compensation cases in respect of injurious affection where no land has been taken, particularly Argyle Motors (Birkenhead) Ltd v Birkenhead Corporation).

The words "has suffered damage" in section 19(1)(a) indicate a suffering of damage which has already occurred by the relevant date but do not include future damage. Furthermore, the claim can only be made for disturbance caused by the "carrying out" of the works. This should be construed as referring to the immediate consequences of their physical construction and not to their retention and subsequent effect (compare the interpretation of the expression "by the construction thereof" in Hammersmith and City Railway Co v Brand and Biard v Deal Corporation, and other cases decided under section 68 of the Lands Clauses Consolidation Act 1845 and section 10 of the Compulsory Purchase Act 1965).

Lakeman's case was an example of loss of profit suffered during the actual carrying out of the works, not a claim for loss of profits alleged to arise in consequence of the works after they had been completed. The submitted claim in this reference entitles Mr Earle to claim for any depreciation to his interest in the land but the land was not part of the assets of the partnership (see the partnership agreement) and neither the partnership nor Ms Earle enjoys a tenancy of any kind (Harrison-Broadley v Smith).

Decision

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In the absence of any binding authority directly in point, the starting point for our consideration of these arguments must be the terms of section 19 itself. It is clear that section 19(1)(a) provides for two different situations: first, where an interest in land is depreciated, and second, where damage is suffered by disturbance in the enjoyment of land. It is no doubt possible that the same person may be entitled to claim under both limbs, but it seems to us that the claimant must, at the material time, be entitled either to some interest in, or legal right to "enjoy", the land. The claimants have placed their business relationship on a legally defined basis by virtue of the partnership agreement under which the land is not vested in the partnership.

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We would have found that Mr Earle is both the owner of the land and occupies, with Ms Earle, for the purposes of the farming partnership and, subject to the further issues considered below, would have been entitled to maintain a claim under both limbs of section 19(1)(a). His claim to partnership losses, if any, would be limited to the extent of his entitlement in accordance with the partnership agreement.

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We would also have found that Ms Earle, as both parties appear to agree, is at most a contractual licensee: see Lindley on Partnership (17th edition) paragraph 10-38. However, it seems to us that she was nevertheless legally entitled to "enjoy" the land for the purpose of carrying on the farming partnership and prima facie would have been entitled to claim under the second limb of section 19(1)(a). We can see no reason to construe the section so as to exclude persons entitled to occupy land pursuant to a bona fide partnership agreement from being able to claim compensation. Subject to the issues we consider next, we would have found that Ms Earle would have been entitled to have made a claim for compensation had she in fact done so.

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However, the more fundamental issue which arose is whether on the true construction of section 19(1)(a), it excludes any claim based on loss of business profits. We find this a point of some difficulty, but we have come to the conclusion that the language of section 19, read as a whole, does not exclude such claims under the second limb of section 19(1)(a). The expression "suffered damage by being disturbed in his enjoyment of land" in our opinion extends to all losses which flow from being disturbed, be they damage caused by environmental factors, such as noise, fumes, dust etc (as in Biard) or economic losses due to the interruption to business activities carried on on the land affected (as in Lakeman). It was accepted by the claimants that there must not, of course, be any double counting, so that if loss of profits were used for valuation purposes as the basis of assessing depreciation in value under the first limb, then a separate claim could not be maintained for such losses under the second limb of section 19(1)(a).

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The decision in Argyle is not applicable, in our judgment, to section 19 of the 1949 Act. That case concerned section 68 of the Land Clauses Consolidation Act 1845 (now section 10 of the

Compulsory Purchase Act 1965) which refers to injurious affection to "any lands or any interest therein". It was held that a claim for temporary and permanent loss of profits caused by the interference with an access to business premises by the execution of works was not a valid claim under section 68, which only applied to injurious affection to land or interests in land which did not include loss of business profits or goodwill. However, we note that the decision was reached with some reluctance and, in the event, turned solely on the wording of that section. It seems to us that section 19 is wider in its scope in that there was no equivalent in section 68 of the 1845 Act to the second limb of section 19(1)(a) of the 1949 Act.

The Council also argue that both limbs of section 19(1)(a) are subject to the requirement that any depreciation or damage must be "in consequence of the carrying out of coast protection work" which limits claims solely to the effects of the physical construction of the works and excludes anything which flows after they have been completed which is due to their continued presence. They contend that this provision is not simply one of causation, in the sense that there must be a direct link proved between the carrying out of the works and any loss or damage. Indeed, no dispute arose as to the need to prove causation in that sense. The Council argue that the words "in consequence of the carrying out of" the work serve to limit any claim to loss or damage arising during the construction phase but not beyond. It would not include any continuing losses due to the long-term acceleration in erosion at the Farm even if that could be proved to be the consequence of the Mappleton works. This is supported, it is argued, by the requirement in section 19(2) of the 1949 Act that claims must be submitted within one year of completion of the work.

If it had been necessary to do so, we would have come to the conclusion that the Council's argument is correct. While we doubt that there is any sensible or logical distinction to be made between expressions such as "the carrying out of" the works and "the execution of" the works (as in section 68 of the 1845 Act and section 10 of the 1965 Act) it seems to us that the expression "the carrying out of coast protection work" should be given its ordinary meaning which suggests that it is the actual construction of the work and its immediate consequences for which compensation is to be paid. Section 19(1)(a) does not provide simply that compensation shall be paid for any loss or damage caused "by the exercise of the powers" of the coast protection authority, which would be much wider in its scope. The words "the carrying out of coast protection work" are included and should be given some meaning and effect.

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We derive some support for our opinion from part of the judgment of Lord Chelmsford in

Hammersmith and City Railway Co v Brand. Referring to the words "injuriously affected by the construction thereof" in section 6 of the Railways Clauses Consolidation Act 1845, he said (page 204):-

"Now, as to the words 'by the construction thereof' it seems to me that it would be doing violence to language ... to extend them to any injury which is not the immediate consequence of the construction of the railway...

To argue that, as the injury could not have occurred unless the railway had been previously constructed, therefore it was caused "by the construction thereof" is certainly a strong example of the illogical reasoning of "post hoc, ergo propter hoc", and would extend to every accident or injury occurring upon the railway after its construction, which, of course, could not have happened if it had not been constructed."

The Council also pointed out that the language of section 19 is in the past tense ("has been depreciated" and "has suffered damage"). We accept that this lends further support to their submissions as to the limited scope of the right to compensation in that it suggests that claims are restricted to depreciation, loss or damage which has occurred by the date of the claim which must be made within 12 months of the completion of the works.

If it had been necessary to do so, therefore, we would have held that compensation under section 19(1)(a) of the 1949 Act is limited to depreciation or damage (including partnership losses) caused by the actual carrying out of the coast protection work but does not include compensation for loss or damage in consequence of their continued existence.

However, even if the claimants had proved that the increase in erosion at Grange Farm between 1991 and 1998 was caused wholly or partly by the Mappleton works and they could satisfy the proviso to section 19(1) of the 1949 Act, they would have failed to recover compensation because it is clearly their case that the loss or damage suffered was caused by the existence of the Mappleton works following their completion in September 1991 and not restricted to loss or damage arising out of the construction of the works between February and September 1991 as is required in order to satisfy section 19(1)(a) of the 1949 Act.

Was a valid claim made for partnership losses (issue 21)?

Submissions

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The Council dispute Ms Earle's entitlement to claim for partnership losses on the grounds that she did not make a claim within 12 months of the completion of the works as required by section 19(2) of the 1949 Act. We have set out elsewhere our findings as to the relationship between the claimants, the terms of the partnership agreement and the letter of claim dated 10 July 1992 and the letter of confirmation dated 7 August 1992 (see paragraphs (8) and (11) of the Facts).

The contention on behalf of Ms Earle is that there is no requirement in section 19 for the claim to be lodged on behalf of any particular person or persons, but only in respect of the land i.e. Grange Farm. Ms Earle is undoubtedly one of the persons within the scope of the compensatory provision as she is sufficiently interested in the property in one or other or both of the limbs in section 19(1)(a) so as to be a claimant in her own right. Mr Earle as her partner is entitled to claim on her behalf as well as his own, subject to a duty to account to her for her proper share of whatever may be received. The fact that the land is vested in him only is purely incidental; the Tribunal should look at the substance not the form.

The Council contend that the letters dated 10 July and 7 August 1992 were not capable of constituting a valid claim by her or the partnership. It is not suggested by the claimants that there are any other relevant documents and no argument arose based on any kind of estoppel. The Council argue that it is not a correct interpretation of the section that the only requirement was for the land to be identified but not the identity of the claimants. Section 5 of the Partnership Act 1890, referred to by the claimants, relates to acts done by partners inter alia "for carrying on in the usual way the business of the kind carried on by the firm". That did not assist in the present circumstances.

Decision

We heard no other evidence relating to the making of the claim and must therefore decide this issue on the documents before us. It is clear to us, and if it had been necessary to do so, we would have found that the letters dated 10 July and 7 August 1992 were written only on behalf of Mr Earle. There was no express reference to Ms Earle or the partnership.

We recognise that section 19 does not make express provision for the requirements of a claim and that no form is specified (compare section 6 of the Land Compensation Act 1973). However, in our judgment the section does require that, at the very least, the claim be made by the person or persons who contend that they are entitled to compensation under one or other or both of the limbs of section 19(1)(a). We accept that it is not necessary to identify precisely the heads of compensation or the amounts, but the claim must, to be validly made, be in such terms as will enable the Council, as compensating authority, to understand who is making the claim and in what capacity e.g. as owner, occupier, partner etc. No particular form of words is necessary provided these basic requirements are met. Merely identifying the land to which the claim relates means that thereafter, perhaps many years later, previously unidentified persons claiming previously unidentified interests of one sort or another, or even no interest at all, could claim to be entitled to compensation. We cannot accept that this was the intention of the statute.

It is not for us to speculate as to why no mention was made of Ms Earle or the partnership by Mr Earle's solicitors in their letter of claim dated 10 July or their confirmatory letter of 7 August 1992. We heard no evidence on this matter. It may well be that it was a simple oversight but, unfortunate as it may be, we would have held that no valid claim was made by or on behalf of Ms Earle as required by section 19. Even if Mr Earle had authority to claim on her behalf as her partner, we do not accept that on their true construction the letters were effective to make such a claim.

30 We would also have found that the letters were completely silent as to any claim for partnership losses and that accordingly no valid claim was made in this respect by either of the claimants.

SUMMARY

For the purposes of this reference we have made the following decisions:-

We find that:-

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- The average long-term rate of erosion along the Holderness coast is 2 metres a year.
- (ii) The average short-term rate of erosion along the cliff frontage at Grange Farm between 1991 and 1998 was 4.6 metres a year.
- 40 (iii) Accordingly, the short-term rate of erosion at Grange Farm between 1991 and 1998 was 2.6 metres a year above the long-term average rate for the Holderness coast.

(2) We find that the Mappleton works did not cause the whole or any part of the increase in the rate of erosion at Grange Farm between 1991 and 1998.

Having regard to the above findings of fact the claim fails on the grounds of causation. Any loss or damage at Grange Farm, including depreciation in land value and damage by disturbance in the enjoyment of land, are not the consequences of the carrying out of the Mappleton works or the continued existence of those works. The claimants have failed to prove that on the balance of probabilities there was a causal link between erosion and any loss or damage at Grange Farm and the Mappleton works. No compensation is awarded in this reference.

In order to assist in the consideration of other outstanding claims, however, we set out below the decisions we would have made on other issues (mainly of law) raised in this reference if it had been necessary to do so for the purposes of our decision:-

- (1) The decision in R v Pagham is not authority for the proposition that a landowner can never be liable in nuisance in respect of any works carried out by him, or on his behalf, to protect his land from attack by the sea. Although the construction of groynes and sea walls as coast protection works is, prima facie, a reasonable user by the owner of the foreshore, it would, as a matter of law, have been open to the claimants to show, if they could, that this particular scheme at Mappleton was not reasonable and gave rise to an actionable nuisance.
- (2) If the Mappleton works give rise to an actionable nuisance, the Council would not have had a defence to it on the grounds that they employed and acted upon the advice of independent consultants, Lewis & Duvivier.

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- (3) Compensation under section 19(1)(a) of the 1949 Act is limited to depreciation or damage (including partnership losses) which is the immediate consequence of the actual carrying out of the coast protection work and does not include compensation for loss or damage which is in consequence of the continued existence of that work.
- (4) Compensation under section 19(1)(a) of the 1949 Act can include loss of business profits provided this is not included in the calculation of depreciation in the value of an interest in land.
- (5) If a valid claim for compensation for partnership losses under section 19 of the 1949 Act had been made by Mr Earle, and subject to the loss arising out of the actual carrying out of the Mappleton works and not from their subsequent continued existence, he would have been entitled to claim compensation for the depreciation in the value of his interest in Grange Farm and for partnership losses limited to the extent of his entitlement in accordance with the partnership agreement.
- 35 (6) If a valid claim for compensation under section 19 of the 1949 Act had been made by Ms Earle, and subject to the loss arising out of the actual carrying out of the Mappleton works and not from their subsequent continued existence, she would have been entitled to claim compensation for partnership losses.
 - (7) The letters of claim dated 10 July and 7 August 1992 were written only on behalf of Mr Earle. A claim must be in such terms as will enable the coast protection authority to

understand who is making the claim and in what capacity. No valid claim in this reference has been made by or on behalf of Ms Earle.

- (8) The claimant are not entitled to the compensation claimed which related to loss or damage due to the continued existence of the works and not their construction.
- (9) A valid claim for partnership losses had not been made by either of the claimants.

We express our appreciation to the assessor, to counsel and the witnesses for their assistance in this reference.

This decision determines the substantive issues raised between the parties and our decision is final. The parties are invited to make submissions as to the costs of this reference and a letter accompanies this decision as to the procedure for submissions in writing. We will, in due course, incorporate an order as to costs in an addendum to this decision. Rights of appeal under section 3(4) of the Lands Tribunal Act 1949 and Rules of the Supreme Court order 61 will not accrue until the decision has been thus completed, i.e. from the date of the addendum.

DATED 17 MAR 1999

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(Signed) A Dinkin

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(Signed) P H Clarke

TH.M.

MATERIAL PARTS OF ASSESSOR'S REPORT

Rates of Erosion

- 10 11. As stated in paragraph 7, above, "historical" rates of erosion of the Holdemess coast can be estimated over the last 150 years in various ways. However, actual erosion at any particular location on the coast is highly erratic, often proceeding by "fits and starts" to no discernible pattern. That this is so is amply demonstrated by the various charts and graphs submitted to the Tribunal in the course of the Hearing. On the other hand, it is clear that 15 reasonably firm estimates of erosion rates can be arrived at either over an extended period of time or for sufficiently long sections of coastline (and preferably both). Unfortunately, the data adduced since commencement and/or substantial completion of the Mappleton Works cover at most some eight years and a few hundred metres of coastline. Moreover, when considering what might have been the rate had the Works not been constructed, it is 20 exceedingly difficult to be sure that like is being compared with like. Nevertheless, the Parties' Experts - Professor Burcharth for the Claimants and Dr. Maddrell for the Compensating Authority - are agreed that an appropriate method of evaluating any shortterm erosion that the Mappleton groyne scheme may have had would be to compare the erosion during the longest possible post-construction period (1991 - 1998) with the erosion 25 during any pre-construction period of the same length. They are also agreed that the groyne bay at Mappleton reached its stable degree of filling or equilibrium state within one year after construction started (Joint Memorandum of Agreed Issues, paragraphs 8.4 and 8.5). As the first barge delivery of rock to the foreshore arrived on 19th March, 1991 (B/214, paragraph 3.3), equilibrium would thus appear to have been achieved by the end of 30 March, 1992.
- 12. In their written closing submissions both Mr. Hand (Counsel for Claimants) and Mr Furst (Counsel for the Compensating Authority) put the long - term rate of erosion at Grange Farm, Cowden at 2 metres per year, a figure which, both on the basis of the "raw" data 35 before the Tribunal and the respective analysis by Dr. Maddrell and Professor Burcharth, would appear reasonable. For the corresponding rate of actual erosion between 1991 and 1998 Mr Hand drew attention to Mr Bate's "weighted" figures of 4.5, 4.7 and 5.13 (or 5.08 if the two shortest - and therefore suspect - readings were removed) and suggested a "firm (albeit artificial) figure" of 4.75 metres per years. Mr Furst preferred the "GIS data" with 40 an average annual erosion rate of either 4.5 or 4.7 metres per year and suggested a "midpoint" figure of 4.6 metres per year. It is clear that precise analysis is not feasible but, as both sides have "happened upon" the figure of 4.7 metres per year as one of their alternatives, and as that figure would appear to be not unreasonable in the light of the "raw" data before the Tribunal, it seems appropriate to adopt it for the purpose of these 45 proceedings.
 - 13. As for future erosion (i.e. post-1998), Professor Burcharth took the view that erosion at Grange Farm would continue for some 50 years at or about the 1991 1998 figure,

although he was prepared to concede some slight diminution towards the end of that period. Dr. Maddrell's view was that, once the groyne bay reached equilibrium, the littoral drift would resume round the seaward ends of the groynes and would return to land about 400 to 600 metres down-drift of the southernmost groyne (i.e. to a point up-drift of Grange Farm), so that the situation would revert more or less to what it was before. The root of this difference of opinion seems to lie in the effect (if any) of tidal and rip currents within a groyne system. It seems clear that the finest material will be taken out to sea, never to return and that, during very severe storms, a like fate could befall coarser material. But whereas Professor Burcharth considers that, even in normal conditions, the tidal and (especially) the rip currents will take a proportion of the coarser material out into water too deep for it to be recovered by "lazy" seas, Dr. Maddrell sees the effect as merely displacing the normal littoral drift to seawards of the groynes, without a significant overall loss of material.

- 15 14. A review of the technical literature available to the Tribunal would appear to support Dr. Maddrell's view rather than that of Professor Burcharth, save that the point where a resumed littoral drift at Mappleton may be said to return to land might well be further south than Dr. Maddrell's 400 to 600 metres from the southernmost groyne probably as much as a kilometre or so thus placing Grange Farm at the point where Mappleton's "erosion shadow" peters out. It seems likely, therefore, that while the rate of erosion at Grange Farm may remain fairly high for the next few years, the prognosis must be that the situation will revert quite quickly to what it would have been if Mappleton scheme had not gone ahead.
- 15. However, in his closing submission Mr Furst reviewed experience at other locations along the Holderness coast and concluded that, if groynes did have more than a local effect, the highest annual rate of erosion would be 2.5 metres. On that basis, he was willing to concede an increase in the 50-year rate of erosion attributable to the Mappleton groynes of 0.5 metres per year. So be it.

30 Causation

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- 16. It follows that the increase in the rate of erosion at Grange Farm over and above the longterm rate of 2 metres per year may be deemed to be an average of 2.7 metres per year for the period 1991 to 1998, falling fairly rapidly thereafter to a 50-year average of 0.5 metres 35 per year. The question is thus whether this excess is entirely the result of the establishment of the Mappleton groynes or whether some or all of this excess would have occurred in any event had the Mappleton scheme never gone forward. Mr. Hand advanced a number of arguments to show that virtually all of the excess was due to the groynes, whereas Mr Furst sought to establish causes which would have operated whether or not the groynes existed. 40 As a matter of law, the burden of proving (upon a balance of probability) that any increase in the rate of erosion was caused by the establishment of the Mappleton groynes is, of course, on the Claimants. However, it is convenient to approach the question from the other end, namely through an examination of Mr Furst's propositions rather than those of Mr Hand.
 - 17. In his written closing submission Mr Furst sets out four main reasons (or combinations of reasons) as to why the short-term rate of erosion at Grange Farm is higher than the long-term rate, namely:-

- (a) the inherent variability of rates of erosion along this coast over the short-term;
- (b) the fact that, since 1983, erosion at the Farm had been much lower than the average for the coast as a whole, so that there was scope for some "catching up";
- (c) bathymetric changes (i.e. the proposition that accretion of sandbanks off-shore leads to less severe wave action and a reduction in cliff erosion rates, and vice versa); and
- (d) greater storm energy during the relevant period.

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At first sight, reasons (c) and (d) appear to conflict in that it is not in issue that storms tend to draw beach material out to sea, thereby building up the sandbanks and reducing wave action and cliff erosion. However, it seems clear that the frequency of storms has been much higher since 1990 than before, postulating higher in-storm erosion and less opportunity between storms for "lazy" seas to reinstate the beach. Reason (b) is more speculative; there does appear to be some basis for thinking that erosion at Grange Farm had been slower for a time, but there is no evidence as to why that should be so or, indeed, why any "catching up" should have occurred (if it did) when it did. As for reason (a), this "inherent variability" is an undoubted fact of Holderness life, but Mr Furst's conclusion that "the rate of 4.6 metres per year over a period of 5 3/4 years (July, 1992 to March, 1998) is far from exceptional" is difficult to verify for the reasons set out in paragraph 11, above. However, although in their preliminary comments of 21st January, 1987 Lewis and Duvivier state that "... The figures for Mappleton show an average erosion rate of 2 metres a year since 1951..." (El /137), by March, 1989 they were revising that figure upwards (El /362) as follows:-

"Inspection of the measurements taken from 1979 to 1988 show an increased rate over that period. The figures indicate an average rate of erosion of 3 metres per year over the past 9 years we believe that ... our initial assessment ... is over conservative and does not take into account the interruption of littoral drift by the groyne field at Hornsea."

Of course, erosion effects due to Hornsea groyne field would have affected Grange Farm whether or not the Mappleton scheme had been put in hand. Again, in an "actioning of minutes" note dated 26th February, 1991 (E3/817) - when the Mappleton Works were just starting and before any groyne materials have been delivered - it is noted that:-

"Unprecedented amounts of erosion have taken place over the last twelve months at Mappleton which have outstripped the tolerances allowed in the original design. A new survey of the cliff has just been completed which suggested that the whole works would have to be moved some 5 to 6 metres westwards ..."

whilst in a note dated 12th November, 1990 entitled "Coast Protection at Mappleton - Technical Details for E.R.D.F. Submission" erosion at a reference point in Cliff Road, Mappleton over the ten years 1981 to 1990 is stated to have averaged 3.4 metres per year (E2/803). In the light of his contemporaneous evidence, and with the known incidence of more frequent storms since 1990, it seems reasonable to adopt a "base" figure for general average erosion since 1990 of about 3 metres per year.

18. It follows that, of the excess increase of 2.7 metres per year for the period 1991 to 1998 (see paragraphs 12 and 16 above), at least 1 metre per year would have occurred whether or not the Mappleton scheme had gone ahead. It would seem, therefore, that up to 1.7 metres per year may be attributed to the Mappleton groynes over that period, and even that rate will probably fall away quite quickly as the littoral drift is re-established. Moreover, it would be unsafe to conclude that the higher 3 metres rate will prove permanent, or whether (at least over the next 50 years) it will go either down or up. In view of paragraph 15, above it is probably appropriate to leave Mr. Furst's estimate of a 0.5 metre per year excess in place for the 50-year period.

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The Disputed Issues

30. Turning now to such of the Schedule of Disputed Issues as are properly the concern of a Specialist Assessor, the appropriate responses would appear to be as follows.

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Issue No. 5 Has there been any increase in the rate of erosion at the Claimants' land since the completion/commencement of the Works?

Yes. (see paragraph 16 above).

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Issue No. 6 If the answer to Issue No. 5 is in the affirmative, have the Works caused the whole or any part of the increase?

Yes. (see paragraphs 16 to 18 above).

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30 GF Hawker FICE

Assessor

February 1999