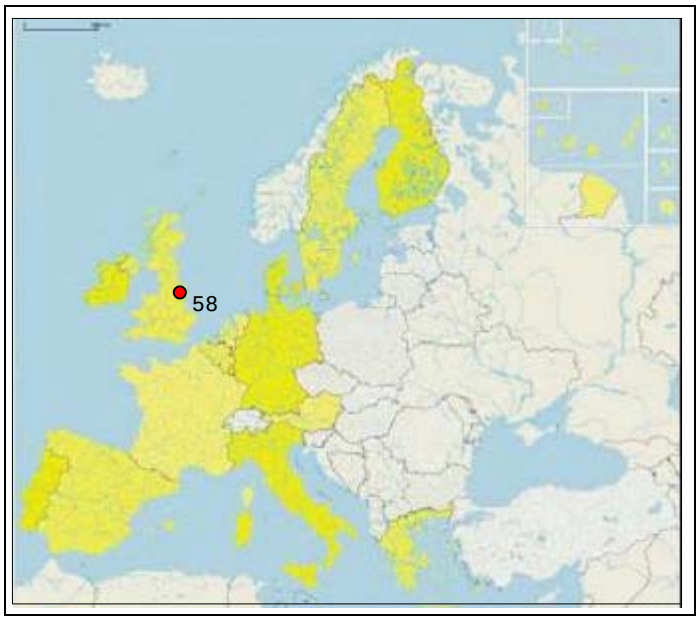
HUMBER ESTUARY
(UNITED KINGDOM)



Contact:

Philip WINN

Environment Agency
United Kingdom

e-mail: philip.winn@environment-agency.gov.uk

1. GENERAL DESCRIPTION OF THE AREA

1.1 Physical process level

1.1.1 Classification

The Humber estuary is located on the east coast of the United Kingdom (see Figure 1) and comprises extensive wetland and coastal habitats. The Humber is formed by the confluence of Yorkshire's River Ouse with the River Trent from the Midlands. The Humber forms the most obvious dividing line between the North of England and the Midlands.

The estuary drains a catchment area of some 24,000 km^2 and provides the largest single input of freshwater from Britain into the North Sea. It has the second-highest tidal range in Britain (7.2 m) and as such, the coast of the Humber is macro-tidal. Approximately one-third of the estuary is exposed as mud- or sand-flats at low tide.

The Humber estuary is about 60 km long and its width varies from about 13 km at the mouth of the estuary to about 1.5 km. Hull and Great Grimsby are chief cities and major fishing ports. The Humber Bridge (1396 m), linking Hull with the estuary's southern shore, was opened in July, 1981 and is one of the longest suspension bridges in the world.The classification conform the scoping study is:

3a. Tide-dominated sediment. Plains. Atlantic & North Sea estuaries.

Fig. 1: Location of case area.

1.1.2 Geology

The outlines of the coast of England reflect its geological structure. The east coast is dominated by pleistocene glacial drifts, especially in Holderness and East Anglia. Tide gauge records show that the south and southeast of England have been sinking at rates of a few millimeters per year. The rivers of England and Wales flow into estuaries formed by Holocene submergence of their late Pleistocene valleys, and fluvial deposition has formed floodplains, but there are no protruding deltas (Bird and Schwartz, 1985).

During the last Ice Age, advancing ice blocked the mouth of the Humber estuary and impounded waters forming Lake Humber whose deposits created the Humberhead Levels. Once the ice melted, the waters from this lake escaped eastwards and cut a channel through the newly deposited layers of till. The river eventually cut a wide, shallow valley, which was later flooded as sea level rose and the estuary was formed. Above the high watermark there would originally have been extensive areas of salt marsh. It is these areas that have been substantially drained and cultivated to create the open, farmed landscape of today. Only a few small remnants now remain of the former marshes.

The Humber estuary is a major site for the accumulation of sediments, but their source is poorly understood. There are three important potential sources of sediment to the Humber estuary: (i) fluvial sediments derived from catchment erosion, (ii) rapid coastal erosion of the Holderness coastline, and (iii) modern North Sea sediments, which can be distinguished on the basis of their geochemical and mineralogical properties.

Qualitative and quantitative contribution estimates indicate that Humber estuary sand sized sediments are derived almost exclusively from marine sources. Source contribution estimates of 92% Holderness till and 8% fluvial for the 63-125 mm fraction, and 98% Holderness till and 2% fluvial for the 125-250 mm fraction were obtained by Cox (1999).

1.1.3 Morphology

Morphological studies show that the estuary can be divided into four main "process" units. The boundaries between these units mark the places where either the nature of the processes taking place or the impact of these processes on the rest of the estuary change significantly. The *outer estuary* extends from Spurn Head to a line across the estuary between Grimsby and Hawkins Point. The *middle estuary* extends as far as the Humber Bridge but is divided into two just downstream of Hull. It leads to the *inner estuary* that extends to Trent Falls but again is divided into two near Whitton Ness. The two *river sections*, the Ouse and the Trent are inland from Trent Falls.

Fig. 2: Overview of the case area.

The processes taking place in the outer estuary are significantly different from those occurring elsewhere and suggest that this unit behaves more as a coastal inlet or bay than as part of an estuary. More typical estuary behaviour begins at the middle estuary boundary.

Approximately a third of the estuary is exposed as mud or sand flats at low water. The inter-tidal area of the Humber Estuary (taken as the area above the mean low water spring tide line) is currently estimated to be about 12,000 ha, although earlier estimates are considerably higher. Of this area, more than 90% is mudflat and sandflat and the remainder is largely saltmarsh. On the north Lincolnshire coast saltmarsh is backed by low sand dunes with marshy slacks and brackish pools.

There are extensive areas of reedbed, about 200 ha, in the inner estuary and areas of mature and developing saltmarshes backed by grazing in the middle and outer estuary.

There are beaches and sand dunes at Spurn and from Cleethorpes to Donna Nook. There are also several saline lagoons with a total area of about 120 ha.

The main physical features of the estuary are:

-Spurn Head, which is connected to shore by a bank of sand and shingle and fed by sediment moving south along the Holderness coastline;
-The narrows at Grimsby, which were formed by the development of Sunk Island (originally as a natural shoal and then by reclamation;
-The Wolds, which provide the foundations for the Humber Bridge and prevents the estuary from widening at this point;
-Trent Falls, where the estuary divides into the river Ouse and Trent.

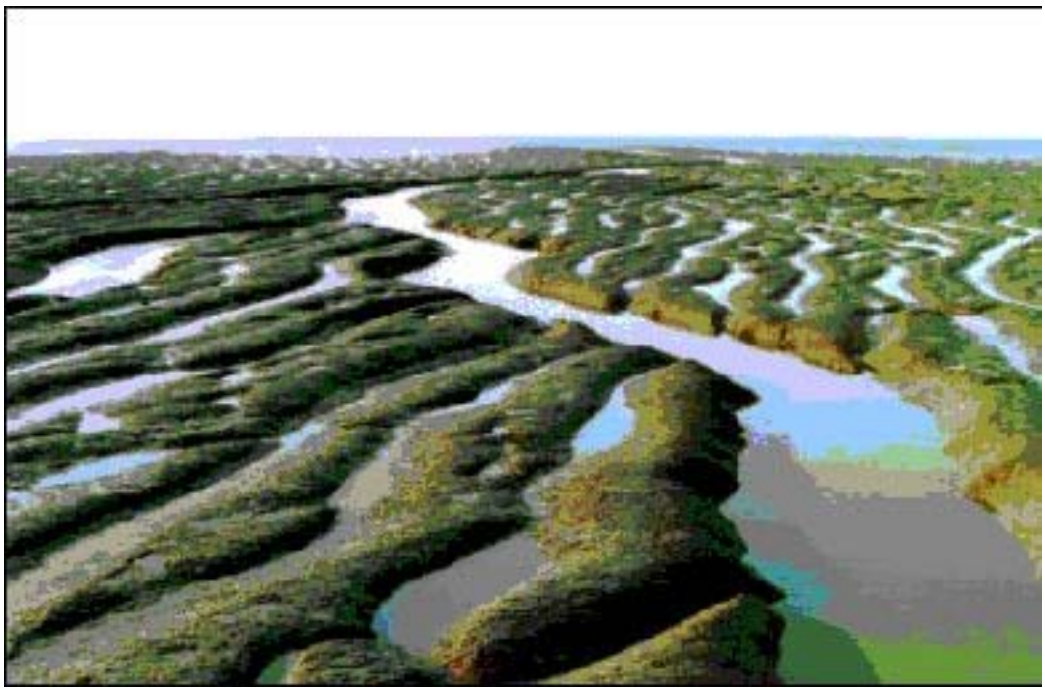


Fig. 3: Mudflat in the Humber Estuary.

1.1.4 Physical processes

Tide

The tidal range in the Humber estuary varies from 3 m during neap tide to 6 m during spring tide. The high water level at Goole on a spring tide is more than 1 m above the level at Spurn. During extreme events, water levels can be up to 3 m above normal levels.

The estuary has a surface area (from Spurn Head to Trent Falls) of about 200 km^2. The tidal prism at averaged tide is in the order of 900 Million m^3, about 80 times the averaged river inflow during a tidal period. These figures indicate that the hydrodynamics of the estuary are dominated by the tidal flow.

River discharge

The rivers Ouse and Trent which converge at Trent Falls provide the majority of the freshwater input into the Humber. Almost every single river in Yorkshire (exceptions being the Esk, Ribble and Tees) feeds the River Humber via the River Ouse. The long-term averaged total river inflow is 240 m^3/s and under extreme conditions it can go up to 700 m^3/s.

Waves

Waves up to 4 m high can occur in the outer estuary between Cleethorpes and Donna Nook on the south bank and near Hawkins Point on the north bank, but reduce to little more than 1 m high upstream of Hull.

Sea level rise and land subsidence

Global warming is causing a sea level rise and increase in storm frequencies and intensities. In addition, as the landmass of Britain continues to respond to the changes that followed the end of the last ice age, it is gradually tilting and eastern England is slowly sinking. The effect of this natural geological process when combined with the effects of global warming means that by 2050 sea level will have risen by up to half a meter.

Historically, sea levels have been rising relative to land levels at an average rate of about 1 mm per year over the last 4000 years. The rate of rise over the last 100 years has been between 2 and 2.5 mm per year. These rates take land subsidence into account. The present rate of sea level rise is superimposed on a number of cyclic changes, one of which has a period of some 18 years and a maximum extent of about 50 mm.

The rate of sea level rise will increase in the future. MAFF recommends that for planning purposes an average rate of 6 mm per year (including land settlement) should be assumed for the next 50 years.

1.1.5 Erosion

Erosion type

The overall volume of the water contained by the estuary appears to have been roughly constant over the last 150 years, implying that the supply of sediment has been adequate to meet the demand imposed by rising sea levels over this period. Localised accretion and erosion occurs however. Foreshore erosion in the outer and middle estuary is currently threatening the stability of the defences in places. These erosion patterns and rates show a huge variability in the Humber estuary. Furthermore, erosion is causing a loss of tidal marshes through a process called coastal squeeze (see Box 1).

Fig. 4: Foreshore erosion.

Box 1: Coastal squeeze in the Humber Estuary.

Within the Humber Estuary, the rising sea level will result in a relative increase in wave height and threaten to over-top existing flood defences. As a result of a rise in sea level the height of the low and high water marks rise. Within an undeveloped estuary this would cause the sea to inundate low-lying land around the estuary and the intertidal mudflats and salt marshes would gradually migrate further inland. However, within the Humber Estuary the existing flood defences and new development encroaching onto the mudflats hold the existing high water mark in place. Therefore as sea level rises the width of the intertidal zone will be reduced, with significant losses of the intertidal habitats. This phenomenon, which is known as coastal squeeze, also reduces the buffering protection afforded to the flood defences by the presence of the intertidal mudflats and marshes and can result in erosion and undermining of defences.

If the erosion is linked to sea level rise, it will become more serious as the rate of rise increases, threatening more of the defences and increasing the expenditure needed to keep them in an acceptable condition. Ultimately the difficulty of maintaining the defences could become so great that measures are necessary. The timing of this will depend mostly on the rate of sea level rise and the estuary's response to this rise. Although some progress has been made, a clear link between foreshore levels and sea level rise has not yet been established.

Natural estuary processes can, as discussed earlier, change erosion and accretion patterns and affect the area of inter-tidal habitat found in the estuary. The response to sea level rise in particular could lead to significant losses of inter-tidal habitats, especially in the outer estuary.

Sediment drift

About six millions tonnes (dry solid weight) of sediment enter the estuary each year, most of it either as background material from the North Sea or from erosion of the Holderness coast and only a small proportion (less than 3 %) from the rivers. Much of the marine material returns to the North Sea on the subsequent tide but some remains in the estuary, moving upstream along the shoreline and either accumulating there or entering the channels and being carried back towards the sea. About three million tonnes of sediment are dredged each year from the docks, port approaches and the main shipping channel. All dredged material is returned to the estuary, generally close to the point from which it was removed. Dredging also takes place off the coast and this may affect the supply of sediment to the estuary.

A sediment budget for the estuary based on the data available within the EMPHASYS project (ABP, 1999) indicates that the long-term averaged sedimentation in the whole estuary is about 170 ton/tide, or about 0.1 million m^3/year, which is only a small fraction of the flood and ebb sediment transport at the mouth. The sedimentation in the estuary cannot compensate the volume increase due to relative sea-level rise in the estuary which is about 0.4 million m^3/year. The ability of the estuary to adjust to the changing sediment supply may be limited by natural features, such as the local geology, and by the presence of the defences. In particular the defences in the inner estuary and the river sections will prevent any significant landward movement of the shoreline.

1.2 Socio-economic aspects

1.2.1 Population rate

Humberside County covers an area of 1,356 square miles, centred around the Humber estuary. It serves a resident population of almost 900,000 people. The averaged population rate is 660 persons/km^2. However, the population is mostly concentrated in the cities. Around the Humber estuary the population density is higher in Kingston-upon-Hull, Grimsby and Scunthorpe. The rest of the area has a much lower population density.

Fig. 5: Humber Bridge, connecting the north and south shore.

1.2.2 Major functions of the coastal zone

- **Industry, transport and energy:** The two main areas of industry on the Humber are in Hull and nearby at Salt End on the north bank and between Grimsby and North Killingholme on the south bank. British Aerospace has a major facility at Brough that includes Brough airport. Other concentrations of industry are found beside the Ouse and the Trent, particularly at Goole and Flixborough.

  The port facilities in the Humber are of prime importance because of the wealth and employment they give and the attraction they provide for other industries to locate in the area. The ports of Goole, Grimsby, Hull and Immingham are operated by Associated British Ports (ABP) Ltd, and there are smaller independent operations at various locations throughout the estuary. The port facilities of the estuary handle some 13% of the UK's trade, a total of around 74 million tonnes of cargo annually.

- **Fisheries and aquaculture:** Hull and Great Grimsby are major fishing ports. In the estuary, fishing is one of the main activities.

Fig. 6: Nature in the Humber estuary.

- **Nature conservation:** The Humber Estuary, UK, is home to a wide range of valuable wildlife habitats and species, the national and international importance of which have long been recognised through statutory site protection. The estuary is regarded by ornithologists as one of the five most important in Britain and one of the 10 most important in Europe. The estuary is of international significance for eight bird species. As part of their work they have calculated that, over a five year period, the average number of birds on the Humber flats, marshes and coast came to about 105,000, of which about 20,000 were wildfowl and 85,000 waders.

In Figure 7 it is shown that most of the flats in the Humber estuary are Sites of Special Scientific Interest. These sites are the best sites for wildlife and geology in England. Much of the Humber is designated as a Special Protection Area (SPA) under European legislation and also under the Ramsar Convention on Wetlands.

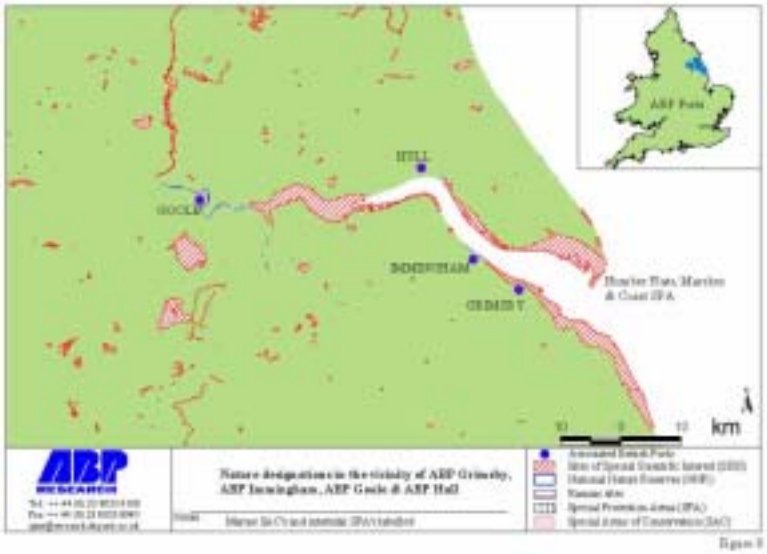


Fig. 7: Nature conservation around the Humber estuary.

Furthermore, the Humber supports a seal population which remains at about 800 in total, living mainly at Donna Nook. At least 28 other species of mammal have been recorded living on the Humber, including Britain's largest summer roost of Noctule bats, at North Ferriby.

- **Agriculture and forestry:** The Humber is also located within some of the country's most productive farmland. The land by the Humber Estuary is among the best and most productive in the country. Most of the holdings around the estuary are mixed or arable in nature and many are run intensively, with cropping patterns, farm operations and supporting industries geared closely to the area and type of land available.

- **Tourism and recreation:** The Humber estuary is regionally important for recreation. Cycling, walking and water activities are the main recreational activities around the estuary.

1.2.3 Land use

Outside the built up area of Hull and the developed areas along the shores of the estuary, the predominant land cover is arable farmland. Some grassland remains and is grazed by cattle. There are a few relict areas of salt marsh and reedbeds along the tidal channels which cross the drained marshes and there is also some remaining marshy grassland. The water filled Barton clay pits, which once supplied the brick-making industry and now lie disused below the Humber Bridge, contain open water, reedbeds and other wetland vegetation and are of considerable value for birds. In the estuary itself mudflats cover extensive areas and are exposed at low water. They are of international importance because of their role in providing feeding areas for birds. Woodland cover is relatively sparse but there are a few blocks of medium sized, regularly shaped deciduous woodland, which are particularly prominent in the flat, open and uniform farmed landscape.

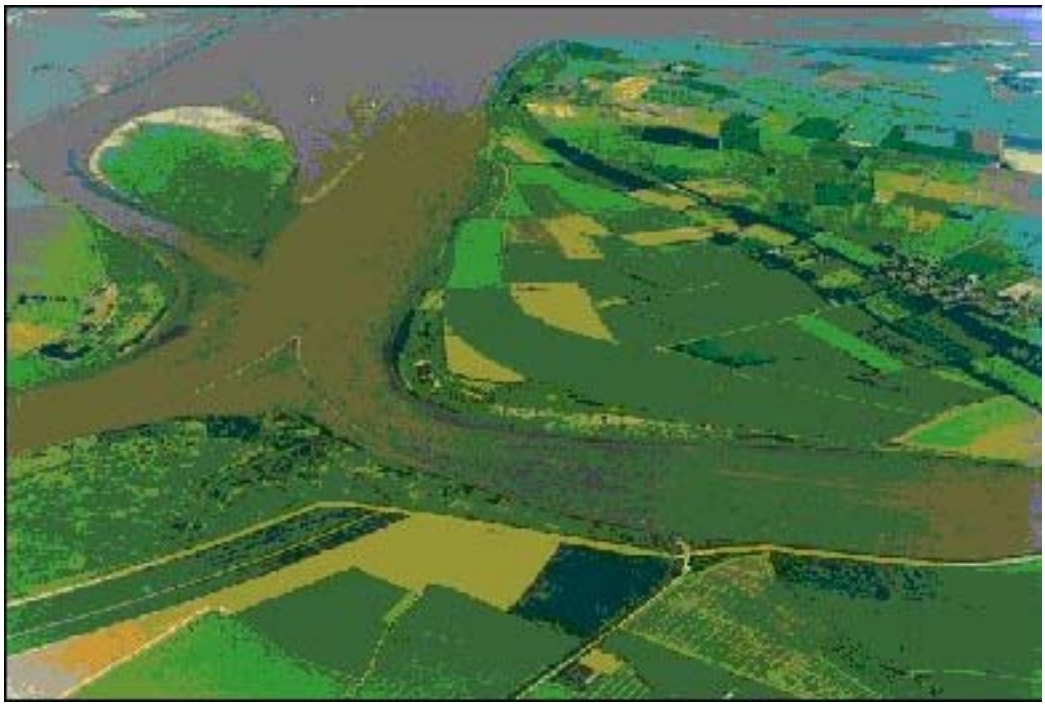


Fig. 8: Farmland at the entrance of Trent river into the estuary.

1.2.4 Assessment of capital at risk

The Humber is one of the country's main estuaries and drains more than one fifth of England's land area. Nearly 90,000 hectares of land around the estuary lies below the level of the highest tides and, although it is protected by defences, this 'flood plain' is still vulnerable to flooding during extreme tidal events. The homes of more than 300.000 people and property worth several billion pounds are below high water level.

Approximately 85% of the flood plain is farmed and about 3% is used for other commercial or industrial purposes. Housing and other urban areas occupy some 8% while the balance is used for a variety of other activities including recreation and nature conservation.

According to Bryant *et al.* (1995), the coast of the Humber is at high risk.

High risk: city or major port or > 150 persons/km2 or >150 m road/km2 or > 10 m pipeline/km2
Moderate risk: 150 < persons/km2 > 75 and 150 < m road/km2 > 100 and 10 < m pipeline/km2 > 0
Low risk: persons/km2 < 75 and m road/km2 < 100 and no pipelines

2. PROBLEM DESCRIPTION

2.1 Eroding sites

2.1.1 Current situation

Erosion is described below for every Management Unit. The management units were defined in the Humber Shoreline Management plan, and are shown in Figure 9.

Fig. 9: Management Units in Humber estuary, as defined in Shoreline Management Plan.

MU 1: Erosion is taking place on the foreshore near Paull and further south towards Hawkins Point, the erosion may threaten the toe of the present defences.

MU 2: Minor works are required to protect against erosion.

MU 3: At East Clough the foreshore is eroding and had exposed numerous wooden structures, mostly dating to the Bronze Age. Some erosion and rutting at the crest is occurring at this stretch.

MU 4a and 4b: Near Saltmarshe and from Reedness to Whitgift bank erosion is threatening the stability of the defences. At Swinefleet the embankment revetment is damaged by erosion.

MU 4c en 4d: Erosion is taking place in front of the defence line at Alkborough Flats.

MU 5: The foreshore is eroding at Whitton Ness, Winteringham Haven and Ferriby Sluice and there is concern that this may threaten the stability of the defences.

MU 6: Erosion of the mudflats is occurring in this area, this may threaten the stability of the defences. Erosion is taking place on the foreshore at Halton Marshes and protection works there.

MU 7: Erosion taking place on the foreshore at North Killingholme and between Immingham Dock and Pyewipe, which may undermine the toe of the embankment.

MU 8: The shoreline here is accreting, no erosion takes place.

2.1.2 Future scenario

Extensive studies suggest that if sea levels rise as expected, about 450 hectares of inter-tidal habitat of outstanding value for wildlife will be lost through a process called 'coastal squeeze' (see Box 1 page 4). Since there is some uncertainty about this figure, a loss of 850 hectares is anticipated, which will have to be replaced if the estuary's conservation value is not to be affected. Furthermore, foreshore erosion linked to the sea level rise will become more serious as the rate of sea level rise increases.

2.2 Impacts

2.2.1 Current situation

Foreshore erosion in the outer and middle estuary is currently threatening the stability of the defences in places, particularly on the south bank between Grimsby and North Killinghome where repairs are needed urgently. The standard of protection is shown in Figure 5 for the current situation, due to erosion the defence system is already unsatisfactory in a significant part of the system. The main problems occur in management units 3 and 5.

2.2.2 Future scenario

The increasing foreshore erosion, with sea level rise, will threaten more of the defences and increase the expenditure needed to keep them in an acceptable condition. Ultimately the difficulty of maintaining the defences could become so great that it will be necessary to set them back to a new line or carry out other works elsewhere which will achieve the same effect.

In Figure 10 the standard of protection is shown as expected in 50 years. The threat of flooding has increased significantly. It is clear that measures are needed to guarantee sufficient protection in the flood area of the Humber estuary.

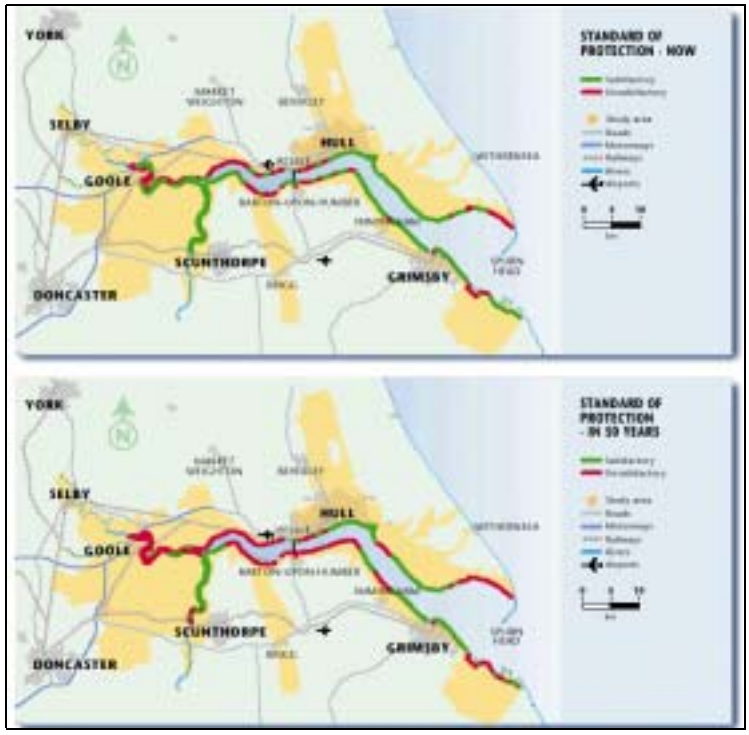


Fig. 10: Standard of protection, current situation and future scenario.

3. SOLUTIONS / MEASURES

3.1 Policy options

3.1.1 Current situation

In the current situation the policy option is hold the line, the defence system is aimed at keeping the coastline at a fixed position.

3.1.2 Future scenario

The future policy options are given in the Humber Shoreline Management Plan (Environment Agency, 2000), two different policy options are proposed for the future management of the Humber estuary:

1. Hold the line
2. Managed realignment

These policy options can be executed in different ways and for different reasons. For the different management units, the proposed policy options are shown in Figure 11.

Fig. 11: Policy options in the Humber, as defined in the Shoreline Management Plan.

3.2 Strategy

3.2.1 Approach related to the problem

In the current situation, the present defence line is fixed and maintained by repairing the present defences if needed.

As sea level rises, the cost of providing ever-bigger defences is escalating, with economic implications for the country as a whole. It is not economically viable to continue increasing the size of existing defences in every location so it is important to look at developing flood defence strategies which are economically, socially and environmentally acceptable.

The policy for the long term development was given in the Humber Shoreline Management Plan. The number of people and the value of property within the floodplain mean it is essential to continue to provide a line of defences around the estuary. It may be worthwhile moving the line locally however, if this will provide benefits (such as reduced costs). The overall flood defence strategy therefore has three main features:

1. Hold the line of the existing defences where there is no justification for moving them.

Beside the greater part of the estuary the existing defences are satisfactory and the overall costs of moving them, taking economic, social and environmental considerations into account, would be greater than any resulting benefits.

2. Identify sites where moving the defences will provide flood defence benefits, taking social, environmental and economic issues into account, and establish a programme for moving these defences. Two types of sites will be identified:

    a. sites where moving the defences will provide flood defence benefits directly.
    b. sites where moving the defences will provide flood defence benefits indirectly, by reducing the effects of sea level rise.

The defences are inspected regularly and standard maintenance works are carried out as required. More extensive works may be needed, where the structure is deteriorating, the foreshore is eroding, or defence levels are low. Moving the defences may lead to savings if the new line is cheaper to build or maintain, for example if it is shorter, lower or avoids the need for costly erosion protection measures. Any decision to move the line will take into account the loss of land or property that will result and the need to provide compensation for habitat losses due to flood defence works elsewhere in the Humber.

3. Support the creation of new inter-tidal habitat to maintain the estuary's conservation status.

The estuary is important for nature conservation, both in general terms and in terms of the number and variety of birds it supports. There are legal implications, requiring the creation of new inter-tidal habitat to compensate for losses due to coastal squeeze.

Fig. 12: Humber Flats.

3.2.2 Issues concerning threat to life and property

Any land in the floodplain is liable to be flooded, whatever standard of protection is provided, since there is always a risk that an event capable of overwhelming the defences will occur. Current legislation does not (except in special circumstances) require the Environment Agency either to provide or to maintain a particular standard of protection. As a result there is no general provision for compensating anyone whose land or property is affected either by flooding or by erosion.

3.3 Technical measures

3.3.1 Current defence system

There are about 235 km of flood defences in the area covered by the plan. Most are simple earth embankments, varying between 2 and 5 metres in height. Many of the banks have stone or concrete protection on their seaward faces and in some places wave walls have been built on top to improve the standard of protection. By urban areas many of the defences include vertical reinforced concrete or sheet piled walls.

Fig. 13: Stone protection in Humber estuary.

The defences are surveyed regularly to check their condition. The most recent surveys show that most are in “good” or “fair” condition overall, although there are problems with individual parts of the structures in places, such as where foundation are being

undermined by erosion. The Agency is responsible for most of the defences but a significant length of Sunk Island is owned by the Crown Estate and lengths elsewhere are the responsibility of Associated British Ports, Kingston-upon-Hull City Council and North East Lincolnshire Council.

3.3.2 Future scenario

In general, the most urgent work proposals concern:

- Setting back the defence lines;
- Raise the present embankments;
- Build new defences;
- Rebuild sections of the embankment;
- Improve protection against erosion of embankments.

Some examples of planned, or recently executed measures at the most urgent sites are given below:

- **Barton**

Significant improvements will be made next year to the defences at Barton Haven. The defences currently provide a poor standard of protection. They are low, and in a poor condition. They protect housing, a supermarket and the new Waters Edge development. The improvement work will consist of a combination of bank-raising and driving steel sheet piles through the present embankment to form a higher defence. The work will cost about 4 million euro.

- **Brough Haven**

The defences around Brough Haven and in front of the British Aerospace factory have just been radically improved following an eighteen month long project. The £3.2M scheme means the area is now protected to a better than 100 year standard, and will therefore be safe from all but the most severe flooding events. New brick-faced walls have been built on top of the existing embankment in front of the aircraft factory, and again sheet piles form the heart of the new defences around the haven itself. The recently built defence wall at Saltmarshe has been extended as part of the same contract. Further projects are planned either side of the new work at Brough.

- **Winteringham**

There has been a long history of aggressive bank erosion on the south bank at Winteringham, opposite Reads Island. Emergency sheet piling work was carried out in 1996, and the Agency has recently completed a further project to maintain the defences here. This time the flood embankment has been moved back over a short length, to provide a breathing space while the Shoreline Management Plan is finalised, and a long-term solution can be planned for the site. The work was carried out by the Agency's Anglian Region Emergency Workforce at a cost of £200,000.

- **Swinefleet**

Planning has just commenced for improvements to the flood defences on the River Ouse at Swinefleet in what will be one of the last individual sites to be investigated prior to the Shoreline Management Plan setting the priorities. Engineering Consultancy services will again be provided by Sir William Halcrow and Partners who have led on the design of the majority of the recent Humber construction projects. The Agency will consult on the options next year, and construction is planned for 2005/06.

In Figure 14 the possible areas where setting back the defence line are possible are shown. Before setting back the defences the affected land has to be bought. Discussion with the owners and occupiers should be started with the aim of agreeing a price, in some cases compulsory purchase will be needed. Two sites so far have been identified where the coastline will be set back:

- **Alkborough Flats**

The Alkborough Flats is an area of 440 hectares of agricultural land at the head of the estuary, where the Rivers Trent and Ouse join the Humber. The Environment Agency is looking in detail at opportunities to re-align the defences at this site.

Setback here could be relatively easily achieved because there is high ground at the back of the Flats. This means that cost savings could be made locally, and because of the changed flow patterns that would result from the setback, it is possible that future flood defence costs could be lessened further upstream in the river system as well.

Setback would also result in the creation of a big area of new wildlife habitat that would contribute to enhancing the internationally important conservation status of the Humber, and link with wider re-generation initiatives in North Lincolnshire.

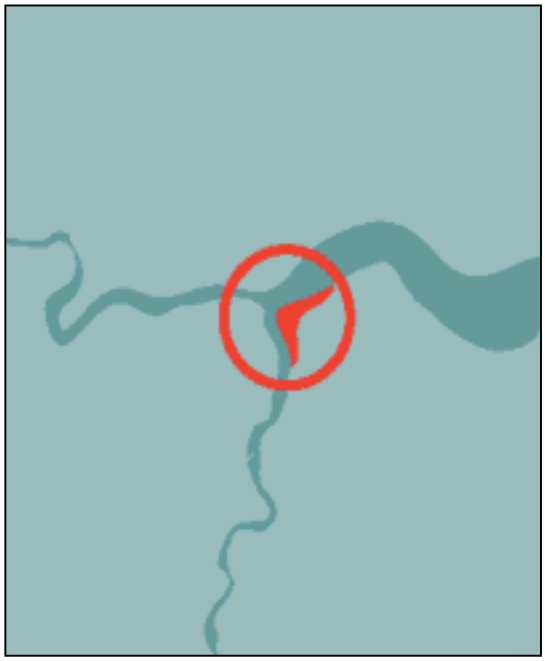


Fig. 14: Location Alkborough Flats.

- **Thorngumbald**

An important flood defence improvement project is about to commence at Thorngumbald, a few kilometres to the east of Hull. Here we will shortly begin work on building a new line of defences some distance back from the shoreline with the aim of both improving the standard of flood protection being provided, and of creating around 80 hectares of new inter-tidal habitat. This is exciting for two reasons: it will be the first setback scheme in the estuary, and so will provide a test-bed for examining such things as how quickly new habitats become established, and how they are affected by different ways of managing the sites. Also it represents the first use by the Agency in the Humber of a project to compensate for the loss of foreshore at other sites where flood defence repairs can only be achieved by moving the defence line forward into the estuary. This is very encouraging as it gives us the opportunity to manage the estuary defences as a unit, with gains at one site being used to offset losses elsewhere, rather than simply treating each site on its own merits.

The scheme itself will involve building a new bank up to 500 metres behind the present line. In 2003 gaps will be formed in the old flood defence embankment beside the present shoreline, allowing sea water to flow into what will become a new estuarine habitat. The two lighthouses on the bank form part of the shipping navigation system, and these will remain as striking and historically significant features beside the shoreline.

3.3.3 Costs

The overall cost of continuing to provide acceptable standards of defence is likely to be of the order of 300 million to 450 million euro over the next 50 years (Environment Agency, 2000).

4. EFFECTS AND LESSONS LEARNT

4.1 Effects related to erosion

4.1.1 Current situation

In the estuary human interference is of great importance. Embankments have fixed the coastline; this influences the response of the estuary on relative sea level rise. The natural landward movement of the coastline is made impossible, this causes erosion of the tidal marshes and erosion of the foreshores. Furthermore, in the estuary dredging takes place at the harbour, but since the dredged sediment is returned in the estuary this does not influence the overall sediment budget of the estuary. Dredging off the coast however also takes place and this may affect the supply of sediment to the estuary.

The defences are surveyed regularly to check their condition. The most recent surveys show that most are in "good" or "fair" condition overall, although there are problems with individual parts of the structures in places, such as where foundations are being undermined by erosion.

4.1.2 Future scenario

For the Humber case it is not yet possible to evaluate the effects of the measures described in the management plan, due to the fact that, although the problem is clear, the measures will be taken in future. These measures are summarised in the Humber Shoreline Management Plan.

Sea level rise is expected to be the most important parameter concerning the erosion in the Humber. As a result the surface area of valuable intertidal salt marshes and mud flats is expected to decrease. Additionally, the safety of the hinterland will decrease as the water level in the estuary rises. In the United Kingdom it is acknowledged that a large-scale strategy needs to be adopted to deal with the erosion and safety problems the Humber faces now and in the future. Intensive monitoring is necessary to provide information on the development of the estuary and on the effectiveness of the measures to be taken.

4.2 Effects related to socio-economic aspects

The current defence system keeps the hinterland, consisting of people and investments, safe. Foreshore erosion is a threat to the defence system and therefore to the safety of the people and investments in the flood plain of the Humber estuary. The planned extra protection against foreshore erosion and undermining of the current defences is necessary to maintain sufficient protection.

Furthermore another measure, setting back the defence line, can compensate for the expected loss of tidal marshes and flats because of sea level rise (coastal squeeze). Complementary advantage of this measure, when applied in the inner estuary, is the lowering of water levels in the estuary, decreasing the risk of flooding.

4.3 Effects in neighbouring regions

Measures in the Humber estuary can change the net in- and outflow of sediment to and from the estuary. This can influence neighbouring coasts, especially downstream of the estuary mouth. Since the net transport along the coast is directed southward, the coast south of the estuary mouth can be influenced the most.

4.4 Relations with ICZM

The need for an integrated and co-ordinated approach to management of the estuary and an associated strategy is widely recognized. Issues to be considered might include the development of new flood defence strategies in the face of changing sea levels, as well as the many complex development issues. There may, through this or other more modest mechanisms, be scope to recreate some inter-tidal habitats and other types of habitat, which have virtually disappeared because of drainage and agricultural intensification. The Spurn peninsula offers scope to demonstrate best practice in coastal management.

4.5 Conclusions

Effectiveness

The current defence system functions properly, however rising sea levels are causing local foreshore erosion and loss of tidal marshes through coastal squeeze. In the future, due to sea level rise, supplementary measures are necessary to provide a sufficient protection standard of the flood plain.

Extra measures are needed to combat the foreshore erosion at the current defences. The loss of intertidal marshes through the coastal squeeze process has to be compensated with new intertidal areas. This can be done by changing the policy option from the hold the line to managed realignment, the coastline can be set back in some places thus creating new intertidal marshes.

The measures are not taken yet, so the effects can also not be described yet.

Gaps in information

The response of the estuary to expected rise in the rate of sea level rise is not known exactly. Processes in the estuary up until now suggest that the estuary may respond to sea level rise by accreting and eroding in different parts so that it seems to rise and move landward, or as it is called “roll over”. The estuary’s ability to roll over with a rising rate of sea level rise is uncertain. It might be limited by natural features, such as the local geology, and by the presence of the defences.

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