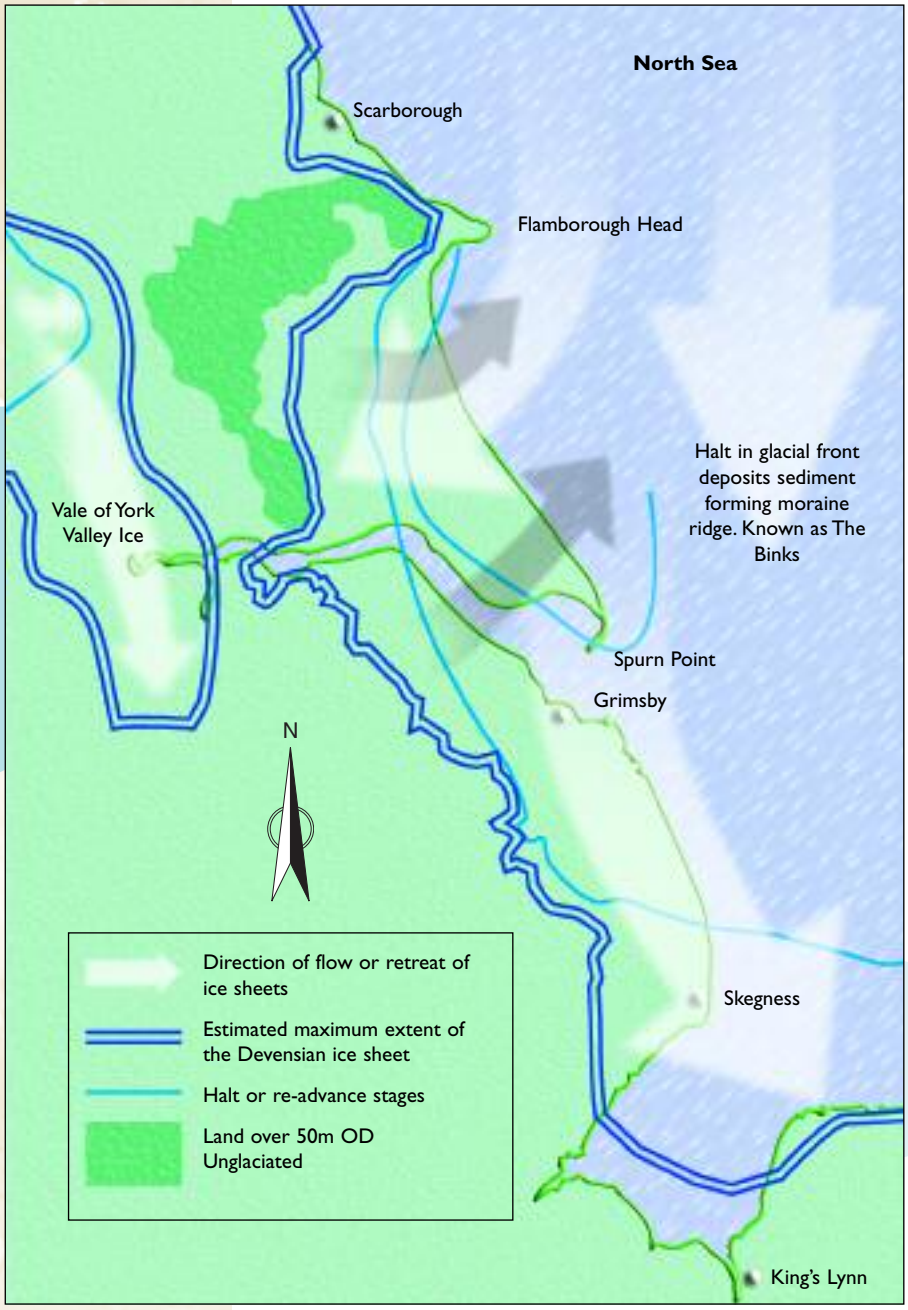
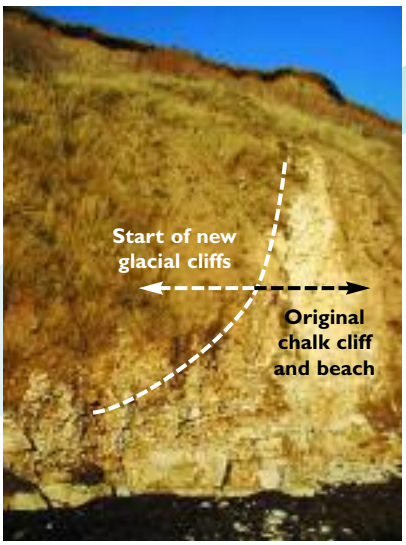
1 Development of the East Riding Coastline

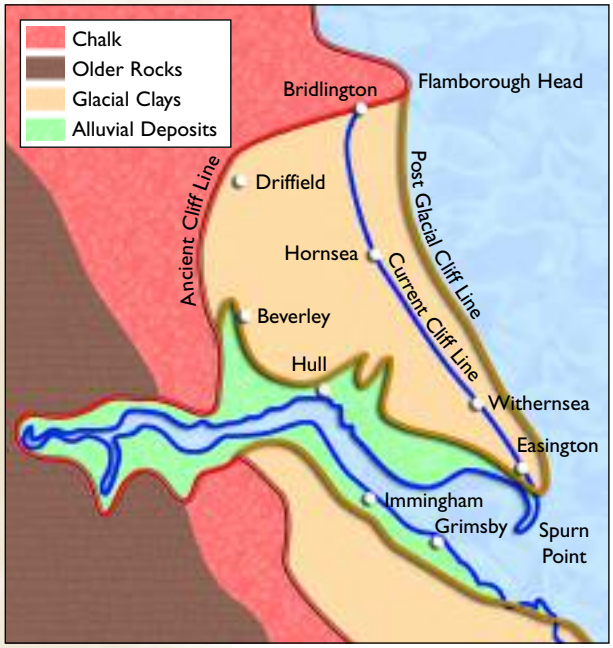
Creation of the East Riding coastline began over 100,000 years ago, a time before the last ice age when the coastline was very different to that which we see today. Then, the chalk cliffs that can still be seen to the north of Sewerby extended westwards through the Yorkshire and Lincolnshire Wolds and the areas that we know of as Holderness and East Lincolnshire did not exist at all. Interestingly this original cliff face and beach can still be seen at Sewerby, as the current cliff now cuts into this ancient cliff at right angles.

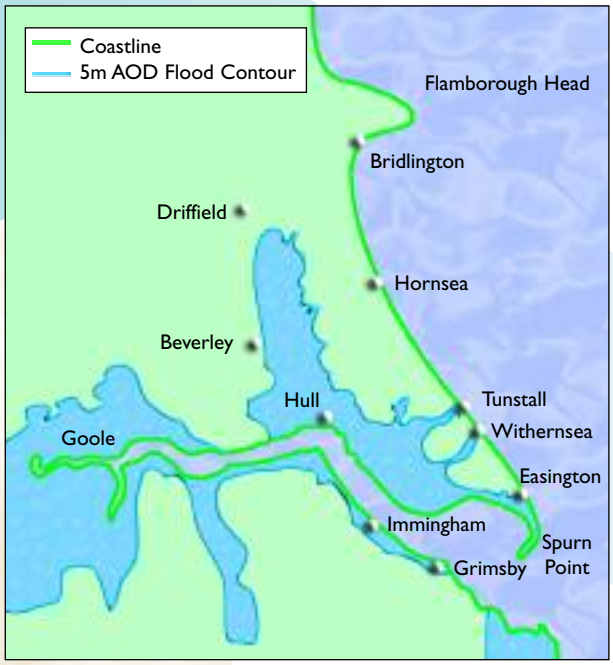


Formation of the current Holderness landforms began during the last ice age some 50,000 years ago. As the advancing glaciers moved southwards they carried beneath them a vast quantity of material eroded from landmasses further north. Later as the ice sheets retreated this material was deposited burying the ancient coastline below a layer of boulder clay some 20 to 50 metres thick. Rather than being a single event this advancing ice sheet ebbed and flowed with the changing climate, depositing then eroding material in a series of waves. By the end of the ice age, about 10,000 years ago the coastline that we recognise today had been formed although it was some 15 to 20km east of its current position.



Sewerby Cliffs





Immediately following its formation this post-glacial clay landmass, which forms the majority of the East Riding coastline, began to erode once again. This secondary erosion was driven in part by weathering but the coastline that we recognise today has largely been governed by the steady erosive power of the sea.

Initially sea levels were much lower as glaciers still locked up a large proportion of the world's oceans. During this time, which lasted until about 6,000 years ago, much of the North Sea was a swampy area fed by the Humber, Thames and Rhine. Later as sea levels rose the deepening waters steadily began to erode the soft Holderness clays giving rise to the cliff lines and beaches that we see today.

On land as well as the coast, Holderness still retains much of its post glacial appearance. The undulating hills of the East Riding were formed by the erratic deposition of glacial till, deposited as the ice sheets retreated. The apparent randomness of their formation also explains why land in this area falls towards the hinterland instead of towards the coast, as is usually the case. Ice melt water runoff over these hills then cut into the deposits interspersing them with streams and numerous lakes or meres, creating a landscape dominated by boggy marshland. It is only quite recently that these areas have been drained to give the rolling farmland that we now see, leaving Hornsea Mere as perhaps the finest lasting example of these early lakes.

Thus the formation and development of the East Riding and its coastline has been inextricably linked to the coming of the last ice age and the gradual process of recovery following the retreat of the ice sheets. Interestingly this historical link with the past still continues to shape its future development as it now plays a part in the rise in local sea levels.

During the last ice age, glaciers several kilometres thick pushed the landmasses in the north of Britain downwards causing land further south to rise. With the removal of this weight land levels are now slowly recovering. As a result land levels in the north are rising as land further south sinks. The lowering of land levels in the East Riding area has effectively meant that sea levels are rising by up to 3mm annually.

The effect of this rise in sea level has been compounded more recently by an additional rise due to the effects of global warming. Global warming of the world's oceans causes expansion of the seawater, which leads to an overall rise in sea levels. Current estimates suggest the rate of this rise could be as much as 5mm per year. The annual rise in sea level for the Holderness area could then be as much as 8mm a year or over 0.4m in 50years. This will have serious consequences for the future, leading to possible increases in cliff erosion rates and the flooding of low-lying areas.

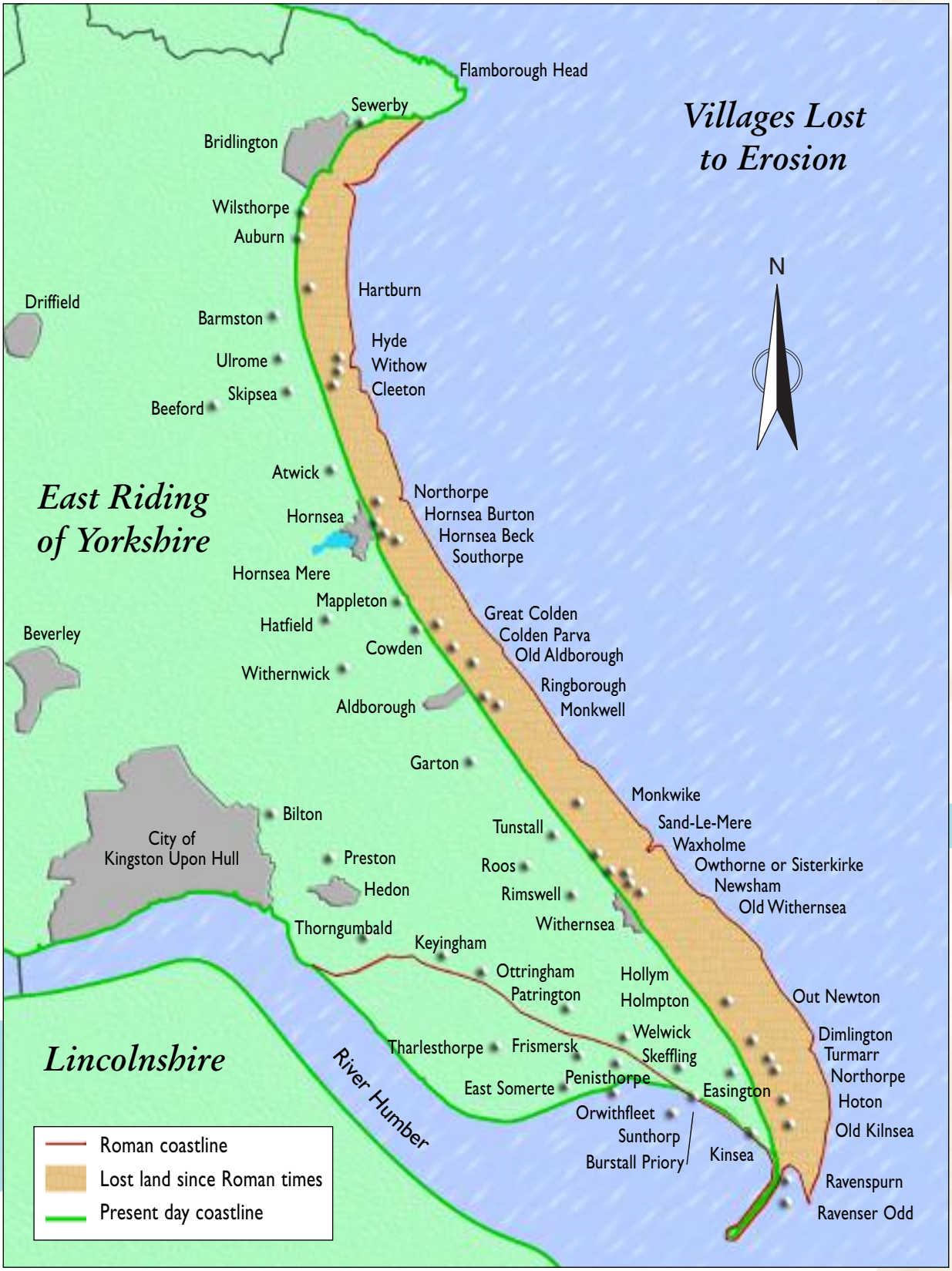
Erosion

The landforms that remained following the retreat of the ice sheets initially determined the orientation and shape of the Holderness coastline. Over the following 10,000 years the frontage gradually changed its shape to that which exists at present in response to the erosive power of the sea. Recent historical records suggest the cliffs are eroding at a rate of between 1.5 to 2.0m per year. Despite this long and obvious history of rapid recession, cliff top development has continued to occur until the present time with the consequent loss of at least 30 villages since Roman times and today, the necessity for regular maintenance of urban defences which are constantly under attack by further erosion and worsening sea conditions as foreshore levels drop.

The reshaping of the cliff line is driven by the energy released on the shoreline by the sea in the form of wave and tidal forces. This energy can re-orientate the coastline if its erosive power is applied with greater frequency and intensity in any one particular direction. Erosion driven by such a directed source will tend to remove material from a frontage and transport it away in the direction of the force. The East Riding coastline is undergoing such a process as tides in the southern North Sea flow southwards and storms from the north east tend to be the most powerful as they can travel in from as far away as the Arctic. The net effect for the East Riding coastline is the creation of an erosion potential that will attempt to drive material southwards.

Whether or not this erosive potential goes on to produce erosion will depend upon the way in which the power is expended on the frontage. This is determined by several controlling factors that can either concentrate the forces or dissipate them harmlessly. Key amongst these factors is the frontage's orientation in relation to the incoming waves and how high and deep its protective sand layer is. These factors are important as they control how effectively a beach can absorb the waves energy without it impacting upon any exposed clay surfaces. Long term change to a frontage only occurs following removal of the underlying clay substrate as this can not be regained in the way that a sandy beach can recover following a storm.

Aldborough


Villages Lost to Erosion
N
Flamborough Head
Sewerby
Bridlington
Wilsthorpe
Auburn
Hartburn
Driffield
Barmston
Hyde
Withow
Cleeton
Ulrome
Skipsea
Beeford
Atwick
East Riding of Yorkshire
Northorpe
Hornsea
Hornsea Burton
Hornsea Beck
Southorpe
Hornsea Mere
Mappleton
Great Colden
Colden Parva
Old Aldborough
Hatfield
Beverley
Cowden
Withernwick
Ringborough
Monkwell
Aldborough
Garton
Monkwike
Bilton
Sand-Le-Mere
Waxholme
Tunstall
City of Kingston Upon Hull
Owthorne or Sisterkirke
Newsham
Preston
Roos
Old Withernsea
Hedon
Rimswell
Withernsea
Thorngumbald
Keyingham
Ottringham
Patrington
Hollym
Holmpton
Out Newton
Dimlington
Welwick
Turmarr
Tharlesthorpe
Frismersk
Skeffling
Northorpe
Lincolnshire
River Humber
East Somerte
Penisthorpe
Easington
Hoton
Orwithfleet
Old Kilnsea
Sunthorp
Kinsea
Burstall Priory
Ravenspurn
Ravenser Odd
Roman coastline
Lost land since Roman times
Present day coastline

On a wide sandy beach that faces the direction of the incoming waves sand will tend be pushed up the beach reinforcing its profile, this high beach will then force waves to break offshore before they reach the cliffs. If such a beach is maintained through the constant supply of sediment no further erosion will occur, however on frontages at a less stable angle sand will by drawn away exposing clay surfaces and allowing them to erode. The long-term result of this sensitivity to cliff line orientation is that the whole coast is gradually attempting to develop a shape that lies at right angles to the predominant north easterly wave direction.

How effectively this shoreline shape can be created is however in turn controlled by the presence of non-eroding 'hard points' as these interrupt the natural formation of this parallel coastline. Initially the relatively resistant chalk cliffs of Flamborough formed the only such hard point; these have since been supplemented by the various defended frontages.

In preventing local erosion these fixed points gradually project further and further seawards as the adjacent coastlines recede. This ever-increasing obstacle to the free flow of sediment helps to retain sand on beaches to the north. Over time this stabilizing influence will work its way northwards as beaches re-orientate themselves parallel to incoming waves, creating a wide bay shape. At some stage as the bay continues to deepen these 'stable' beaches will entirely fill the now stabilized bay preventing any further erosion. Each of the defended frontages will lead to the formation of such a stabilized bay, suggesting a means by which future erosion can ultimately be controlled.

This could only be seen as a long term solution however, as it is estimated that this process would take anywhere between 500 to 1,000 years to develop and involve considerable modification of the coastline. Furthermore as the bays develop, wave energy at the headlands will increase, the cost and difficulty of maintaining them may then become impossible to sustain.

Sub Era	Series		Stage	Time Period	Date	Period	Events
Quarternary	Holocene or Flandrian	Later Holocene	Post or Interglacial period	Present	43 AD to 2,100 BC	Bronze and Iron ages	By the Iron Age up to two-thirds land cleared of forests and the East Riding of Yorkshire is extensively settled.
					2,100 BC	Late Neolithic	During the Late Neolithic to Bronze Ages numerous barrows were built throughout East Riding of Yorkshire. Many present day towns show origins dating back to these early settlements. It is likely however that many more have been lost to the sea through erosion.
					2,500 BC	Middle Neolithic	
					2,900 BC	Early Neolithic	Sea levels at their maximum level at about 4,000 BC. Neolithic farmers begin to clear forests and farm upland areas.
		Early Holocene		5,000 BP (Before Present)	4,200 BC	Late Mesolithic	Holderness area comprised mainly of flooded marshlands with numerous small lakes. Worked flints and other artefacts suggest Megalithic hunter gatherers spread throughout East Riding .
					6,000 BC	Early Mesolithic	5,500 BC climate warming produces a rapid rise in sea level, up to 30mm per year, raising sea levels by up to 100m in total. Flooding of English Channel produces coastline we recognises today and the process of boulder clay erosion began. 7,500 BC Climate similar to present day. Flora returns to UK but removal of larger herbivores by man during Palaeolithic times allows formation of forests.
	Pleistocene or Ice Age	Late Devensian	Glacial	10,500 BP	10,000 BC	Upper Palaeolithic	13,000 BC Ice sheets gone from North England. People start to return to UK after 15,000 BC using land bridge with Europe. 15,000 BC to 25,000 BC Ice sheets at their maximum Devensian extent. At about this time a two-tiered ice sheet deposited the bulk of the Holderness clays, the lower originating in the SE Scotland NE England and the upper from the Lake District. Glaciers continue formation of English Channel.
		Early Devensian		50,000 BP	30,000 BC	Middle Palaeolithic	People retreat out of the UK as ice sheets advance.
				70,000 BP			
		Ipswichian	Interglacial		100,000 BC	Lower Palaeolithic (Old stone age)	Glacial erosion starts formation of English Channel during Wolstonian Ice Age. Earliest peoples in Britain about 450,000 BC
				135,000 BP			
		Wolstonian	Glacial				
				330,000 BP			
		Hoxian	Interglacial				
				425,000 BP	1,000,000 BC		
		Anglian	Glacial				
				480,000 BP			