

Joint Defra/EA Flood and Coastal Erosion Risk  
Management R&D Programme

## Annex B.5:

Case study no.5:

Assessment of the Humber Estuary shoreline  
management plan

R&D Project Record FD2013/PR2

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# 1. Introduction

The Humber case study is based on the economic appraisal undertaken for the Humber Estuary shoreline management plan stage 2 study. This appraisal was undertaken by RPA in association with Black & Veatch for the Environment Agency in 2003. This approach included the completion of Appraisal Summary Tables (ASTs) to ensure that the non-quantified impacts were fully identified and could influence decision-making. For this case study, management unit 6 is used to investigate how the inclusion of multi-criteria analysis may have affected the decision.

## 1.1 Summary of the project area

Management Unit 6 runs from South Ferriby Cliff to North Killingholme and is mainly comprised of medium grade agricultural land for up to 3km inland. The main settlement in the area is Barton-upon-Humber. Clay pits immediately behind the defences between Chowder Ness and New Holland are important environmental and recreation sites, with some designated for their environmental value. There are also a number of small industrial areas, including New Holland Dock. The area is categorised as land use band C, with an indicative standard of 1:10 to 1:100 (taken from FCDPAG3).

## 1.2 Existing defences

About half of the defences between South Ferriby and New Holland Dock provide protection against a 1 in 50 year event. Around Barton Creek, some lengths of the defences give significantly lower standards. East of New Holland Dock, around 70% of the defences protect against an event with a return period of 1 in 20 years. In 50 years, the standard of defence is expected to fall such that about 50% of the defence will no longer protect against a 1 in 10 year event. The overall condition of the defences is fair to good. There is concern that erosion of mudflats may threaten the stability of the defences. There are also some lengths where the crest level of the embankment is low (Environment Agency, 2000).

## 1.3 The policy framework

The Humber Estuary Shoreline Management Plan (SMP) was published in September 2000 (Environment Agency, 2000). This sets out the Environment Agency's vision for managing the flood defences of the Humber Estuary. The SMP has since been further developed in a Stage 2 study, which attempts to provide fully justified decisions on the policy for each management unit. For management unit 6, the SMP identifies that an appraisal is required to determine whether moving the line locally would be worthwhile. Elsewhere, the existing defences will generally be held on their present alignment until a length needs to be repaired or improved.

## 1.4 List of stakeholders and interested parties

A wide range of organisations was represented on the SMP Steering Group and is also involved in the Stage 2 study. As part of the Stage 2 study, a ranking exercise was carried out to identify which are the most important objectives for management of the estuary. The results of this exercise have been used to estimate weights for the Humber Estuary. The organisations involved in the Steering Group and ranking/weighting exercise are listed in Table 1.1.

**Table 1.1 List of stakeholders for the Humber Estuary SMP**

<ul style="list-style-type: none"> <li>• Associated British Ports</li> <li>• British Association for Shooting and Conservation</li> <li>• East Lindsey District Council</li> <li>• English Heritage</li> <li>• Environment Agency (Anglian Region)</li> <li>• Humber Estuary Management Strategy</li> <li>• Kingston upon Hull City Council</li> <li>• Defra</li> <li>• North Lincolnshire Council</li> <li>• Yorkshire and Lincolnshire Wildlife Trusts</li> </ul>	<ul style="list-style-type: none"> <li>• Countryside Agency</li> <li>• Crown Estates</li> <li>• East Riding of Yorkshire Council</li> <li>• English Nature</li> <li>• Environment Agency (Midlands Region)</li> <li>• Environment Agency (North East Region)</li> <li>• Humberside Internal Drainage Boards</li> <li>• Lincolnshire County Council</li> <li>• National Farmers Union</li> <li>• North East Lincolnshire Council</li> <li>• Royal Society for the Protection of Birds</li> </ul>
<p>Source: Environment Agency (2000)</p>	

## 2. Definition of objectives and management options

In the Humber Estuary SMP Stage 2, three options are assessed for Management Unit 6:

- Option 1: Do-nothing;
- Option 2: Hold the Line (low standard of 1:10); and
- Option 3: Hold the Line (high standard of 1:100).

For the case study, the Humber Estuary is to be assessed at the strategy level, such that five options will be assessed:

- Option 1: Do-nothing;
- Option 2: Maintain: standard of defence decreases from current level of 1:20 to a maintainable level of 1:10. The standard of defence decreases to 1:10 by year 9 due to the condition of the defences and to 1:5 by the end of the time horizon (due to sea level rise) (assumed to be equivalent to the 'hold the line (low standard) option from the Humber Estuary SMP Stage 2);
- Option 3: Sustain: standard of defence is sustained at 1:20 throughout the 100 year time horizon;
- Option 4: Improve 1:50: standard of defence is improved to 1:100 throughout the 100 year time horizon; and
- Option 5: Improve 1:100: standard of defence is improved to 1:300 throughout the 100 time horizon) (assumed to be equivalent to the 'hold the line (high standard) option from the Humber Estuary SMP Stage 2).

### 3. Structuring the problem

This section intends to break down the problem into its component parts, identifying the set of impacts and associated criteria that will be used to make the decision. In other words it carries out a screening exercise for management unit 6 of the Humber Estuary SMP.

#### 3.1 Summary of the screening exercise

This screening exercise is used to determine (i) which categories are relevant and (ii) which categories will be appraised by assigning a monetary value to impacts and which will be appraised by assigning a score to the impacts. Relevant categories are those where there is a difference in the impacts of the five options being appraised.

Table 3.1 summarises the results of the screening exercise, where this is based upon the results of the economic appraisal and completion of the appraisal summary table for the Humber Estuary SMP stage 2 study. For this reason, no detail screening AST is presented as an appendix.

**Table 3.1 Table summarising the results of the screening exercise.**

<b>Project name</b>	Humber Case Study: management unit 6		
<b>Category</b>	<b>MU6</b>		<b>Details</b>
	<b>Monetary value</b>	<b>Score</b>	
<b><i>Economic impacts</i></b>			
Assets	✓		Damages on residential and non-residential properties estimated in monetary terms.
Land use		✓	Damages/losses of agricultural land/output estimated in monetary terms.
Transport		✓	Potential impacts on main roads (A15, A1077 and access to Humber Bridge), local roads and railway line. May also be impacts on navigation channels.
Business development		✓	
<b><i>Environmental impacts</i></b>			
Physical habitats		✓	Area contains 8 SNCIs, 6 Wildlife Trust sites and landward SSSI/SPA/Ramsar site at Barton and Barrow Clay Pits.
Water quality		✓	Intensively farmed agricultural land with high nutrient content. Also 19 discharge points within the management unit.
Water quantity		✓	Potential impacts on a locally important groundwater aquifer. Also 7 water

**Table 3.1 Table summarising the results of the screening exercise.**

<b>Project name</b>	Humber Case Study: management unit 6		
<b>Category</b>	<b>MU6</b>		<b>Details</b>
	<b>Monetary value</b>	<b>Score</b>	
			abstraction points within the management unit.
Natural processes		✓	Important intertidal habitats seaward of current defences.
Historical environment		✓	Management unit contains areas of high archaeological potential, one Scheduled Ancient Monument and listed buildings.
Landscape and visual amenity		✓	Current landscape is rural agricultural.
<b><i>Social impacts</i></b>			
Recreation		✓	Barton Clay Pits is an important recreation area, with a Visitor Centre. Intertidal habitats are also important for birdwatching, walking and wildfowling.
Health and safety		✓	People and property are present within the indicative floodplain.
Availability and accessibility of services		✓	Services, including shops, infrastructure, schools, hospitals, etc. present within the management unit (particularly Barton-upon-Humber).
Equity		✓	Current deprivation index of 3,556 (ward of Haven).
Sense of community		✓	Mainly rural communities, but with larger development of Barton-upon-Humber.
<b><i>Cross-cutting impacts</i></b>			
Policy integration		✓	Humber Estuary SMP plus local and regional policies.

## 4. Costs of options

The do-nothing option has zero (£0) costs. The costs of the other options are:

- Option 2: Maintain: £26,744,000;
- Option 3: Sustain (1:20): £40,000,000;
- Option 4: Improve (1:50): £48,000,000; and
- Option 5: Improve (1:100): £59,279,000.

All of these cost estimates include optimism bias (at 60%). The costs of the sustain and improve 1:50 options have been estimated specifically for this case study, while the costs for maintain and improve 1:100 are taken from the Humber Estuary SMP Stage 2 economic appraisal.



## 5. Assessment of impacts

### 5.1. Qualitative and quantitative assessment

The qualitative and quantitative assessment of the different options for each of the management units was carried out using the appraisal summary table for the main assessment (MA-AST) and it is presented in Appendix B5.1 to this Annex. A Summary AST for the main assessment (Summary MA-AST) is presented in Table 5.1, below.

The assessment followed a stepped approach, starting with the qualitative assessment of all impact categories and moving to the quantitative assessment whenever information was available.

### 5.2 Monetary valuation of impacts

Monetary estimation of damages from flooding has been undertaken for the category of assets only. All other categories are assigned a score. The approaches used are in accordance with those set out in FCDAPG3 and the PAG3 spreadsheets have been used to provide the present value (i.e. discounted) estimates of damages over the 100-year time horizon.

#### 5.2.1 Option 1: 'do-nothing'

The 'do-nothing' option assumes that there will be a breach in the defences by year 10, with a current probability of breaching of 0.1. A breach would result in inundation of much of the area, such that 1,615 residential properties, 100 non-residential properties and 1,085 ha of agricultural land would be written off<sup>1</sup>. Sea level rise would result in the number of properties written off by year 99 (the end of the 100 year time horizon for the economic assessment) increasing to 1,730 residential properties, 103 non-residential properties and 1,221 ha of agricultural land.

Around the area written-off, there are additional residential and non-residential properties, and agricultural land that would face intermittent flooding and, hence, damages. The number of properties and area of land affected on different return period events are shown in Table 5.2.

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<sup>1</sup> Write-off is assumed to occur where flooding is more frequent than once every three years. Agricultural land written-off, is assumed to be converted to a different land use type (such as saltmarsh or mudflat). As it is not possible to place a relative value on these different land uses, the write-off cost for agricultural land is not included in the damages of the do-nothing option.

**Table 5.1 Summary appraisal summary table - main assessment (summary MA-AST)**

<b>Project name:</b>	Humber Estuary SMP – Strategy				
<b>Description of area affected:</b>	Management unit 6 (South Ferriby Cliff to North Killingholme)				
<b>Impact category</b>	<b>Option 1: ‘Do-nothing’</b>	<b>Option 2: Maintain</b>	<b>Option 3: Sustain</b>	<b>Option 4: Improve 1:50</b>	<b>Option 5: Improve 1:100</b>
<b>Economic impacts</b>					
Assets	Inundation written off of 1,730 residential properties and 103 non-residential.	Almost 2,000 residences and more than 100 industrial properties would be flooded intermittently.	Assets will be protected.	Assets will be protected.	Assets will be protected.
Land use	1,221ha of agricultural land written off by year 99.	1,221ha of agricultural land flooded.	Impact on agricultural land following a breach.	Small impact on agricultural land following a breach.	Small impact on agricultural land following a breach.
Transport	Loss of A15 (including access to Humber Bridge), A1077, railway line and local access roads. Navigation channels in estuary could also be affected.	The A15, A1077, railway line and local access roads will be flooded fairly regularly. No impact on navigation channels.	Roads and railways protected but flooded every 20 years, which may lead to serious disruption.	Roads and railways and navigation channel would be protected.	Roads and railways and navigation channel would be protected.
Business development	Loss of so many residential and non-residential properties will mean that the area is no longer viable for many businesses.	Almost all businesses will be affected at some time by flooding.	The impacts on future business development only significant for businesses whose investment planning exceeds 20 years.	Business development should be largely unaffected	Business development should be largely unaffected
<b>Environmental impacts</b>					
Physical habitats	Loss of 8 SNCIs, 6 Wildlife Trust sites and landward SSSI/SPA/Ramsar site. Development of new intertidal habitat	Designated sites would be flooded fairly frequently. Loss of 60ha of intertidal habitat as a result of coastal squeeze.	Loss of 60ha of intertidal habitat as a result of coastal squeeze	Loss of 60ha of intertidal habitat as a result of coastal squeeze. Potential impact on integrity of SPA.	Loss of 60ha of intertidal habitat as a result of coastal squeeze. Potential impact on integrity of SPA.
Water quality	Flooding of agricultural land and STW will result in reduction in water quality. Loss of 19 discharge points.	Water quality will generally be maintained, but release of pollutants every 10 years.	Water quality will generally be maintained but release of pollutants every 20 years.	Water quality will generally be maintained.	Water quality will generally be maintained.
Water quantity	Impact on	Protection of water	Potential	Protection of	Protection of

**Table 5.1 Summary appraisal summary table - main assessment (summary MA-AST)**

<b>Project name:</b>	Humber Estuary SMP – Strategy				
<b>Description of area affected:</b>	Management unit 6 (South Ferriby Cliff to North Killingholme)				
<b>Impact category</b>	<b>Option 1: ‘Do-nothing’</b>	<b>Option 2: Maintain</b>	<b>Option 3: Sustain</b>	<b>Option 4: Improve 1:50</b>	<b>Option 5: Improve 1:100</b>
	aquifer. Loss of 7 abstraction points.	abstraction and discharge points	saltwater contamination of aquifer related to sea level rise Protection of abstraction and discharge points.	aquifer abstraction and discharge points.	aquifer abstraction and discharge points.
Natural processes	Natural migration of intertidal habitats.	Landward migration will be prevented.	Landward migration will be prevented.	Landward migration will be prevented.	Landward migration will be prevented.
Historical environment	Loss of areas of high archaeological potential, 1 SAM and listed buildings	SAM and listed buildings flooded on a regular basis. Archaeological sites likely to be affected.	SAM and listed buildings flooded every 20 years.	SAM and listed buildings flooded every 50 years.	SAM and listed buildings flooded every 100 years.
Landscape and visual amenity	Change from rural agricultural to mudflats, saltmarsh and open water	Landscape generally maintained. Visual impact where crest levels are raised by up to 0.6m	Landscape generally maintained. Visual impact where crest levels are raised by up to 0.6m	Landscape generally maintained. Visual impact where crest levels are raised by up to 0.9m	Landscape generally maintained. Visual impact where crest levels are raised by up to 0.9m
<b>Social impacts</b>					
Recreation	Loss of Barton Clay Pits recreation area and visitor centre.	Fairly frequent flooding may affect facilities at Barton Clay Pits	Facilities at Barton Clay Pits will be protected.	Facilities at Barton Clay Pits will be protected.	Facilities at Barton Clay Pits will be protected.
Health and safety	Uncontrolled risk to people.	Risk to people would still be ‘high’.	Risk to people would still be ‘moderate’.	Risk to people would still be ‘low’.	Risk to people would still be ‘low’.
Availability and accessibility of services	Significant reduction in services and access to them.	Services flooded fairly frequently, with impact over time due to flood frequency.	Services would be protected.	Services protected and only flooded very infrequently.	Services protected and only flooded very infrequently.
Equity	Impacts on area with deprivation index of 3,556	Frequency of flooding may affect job distribution.	Flooding 1 every 20 years is unlikely to affect people.	Area likely to retain current or improved status.	Area likely to retain current or improved status.
Sense of community	The loss of properties and jobs will result in loss of sense of community.	Risk to sense of community still ‘high’ due to frequency of flooding.	Risk to sense of community would be low due to frequency of flooding.	Sense of community would be largely unaffected.	Sense of community would be largely unaffected.

**Table 5.2 Assets affected by intermittent flooding following a breach**

Return Period	Residential properties		Non-residential properties		Agricultural (number of farms)	
	Year 0	Year 99	Year 0	Year 99	Year 0	Year 99
1 in 10	74	93	3	6	1	3
1 in 50	132	99	6	7	3	6
1 in 100	169	99	6	7	6	6
1 in 500	214	99	10	7	8	6

Notes: Based on information provided by Black & Veatch and data included in Address-Point  
Excludes those properties that are written off

Of the non-residential properties, two properties (New Holland Bulk Services and Howarth Timber) have been found with rateable value exceeding £100,000. Damages for these properties are estimated based on the rateable value and depth-damage data for 'industry' (from the Multi-Coloured Manual). There is also an important gas terminal, but a rateable value was not available for this. Damages to commercial properties may, therefore, be underestimated.

Overtopping damages to properties prior to breaching are assumed to be negligible and have not been included in the damage estimates.

### 5.2.2 Option 2: maintain

For Land Use Band C, the 'low standard' hold the line is taken as 1 in 10 years (as given in FCDPAG3). The current standard of defence (year 0) is taken as 1 in 20, falling to 1 in 10 by year 9. The timing of intervention is, thus, assumed to be year 9 and to 1 in 5 by year 99. This assumption may not be consistent with the actual requirement for work to be undertaken on the defences. Issues on the timing of intervention will need to be addressed in the next stage of the study.

The damages under flooding events over and above the design standard are estimated by identifying the properties that would be flooded following a breach on a number of different events (1 in 3, 1 in 10, 1 in 50, 1 in 100 and 1 in 500) as a proportion of the total floodable area. The proportion of the total area is given in Table 5.3.

**Table 5.3 Proportion of area flooded for option 2**

Return period	Proportion of area flooded	
	Today	100 years
3	26%	29%
10	57%	62%
50	76%	81%
100	93%	94%
500	100%	100%

Note: An area of the management unit is shown as floodable under the 1 in 3 and 1 in 10 events – this is because the standard in flood compartment 20 is 1 in 2.5 years. This does not affect the damage calculations, however, as no damages are included at or below the design standard.

The total damages are entered into the Annual Average Damage (AAD) sheets of the PAG3 spreadsheet to provide an indication of damages under a 'typical' event.

### 5.2.3 Option 3: sustain

Damages for sustain are based on estimated damages for maintain in year 0. The maintain damages in year 0 are associated with a standard of defence of 1 in 20, which is the same as for the sustain option. Under sustain, the standard of defence remains at 1 in 20 throughout the 100-year time horizon.

### 5.2.4 Option 4: improve 1:50

To avoid the very large increase in standard offered by the Sustain and Improve 1 in 100 options, an intermediate option, improve 1:50, has also been assessed. The damages are estimated based on damages incurred under the sustain option, but with the standard of defence raised to 1 in 50. This means that the average annual damage is reduced, as no damages would occur on events equal or less than a 1 in 50 event.

### 5.2.5 Option 5: improve 1:100

For Land Use Band C, the 'high standard' Hold the Line is taken as 1 in 100 years (as given in FCDPAG3). The number of properties affected under Option 3 is based on the proportion of the Management Unit that is floodable. This is summarised in Table 5.4. The timing of intervention is assumed to be year 0. This assumption may not be consistent with the actual requirement for work to be undertaken on the defences. Issues on the timing of intervention will need to be addressed in the next stage of the study.

**Table 5.4 Proportion of area flooded for option 3**

Return period	Proportion of area flooded	
	Today	100 years
3	0%	0%
10	0%	0%
50	32%	35%
100	62%	67%
500	89%	91%

Note: An area of the Management Unit is shown as floodable under the 1 in 50 and 1 in 100 events – this is because the standard in flood compartment 20 is 1 in 20 years. This does not affect the damage calculations, however, as no damages are included at or below the design standard.

### 5.3 Scoring of impacts

Management Unit 6 of the Humber Estuary shoreline management plan – stage 2 study has been used as a case study for the MCA project and for which a scoring system based on characteristic recovery time has been developed. The aim was to identify a scoring system that reflects the impacts of a flood on each category and where the scores can be calculated numerically using a more flood-focussed basis.

The scores for the Humber case study have been assigned using the basis of ‘recovery times’, where these are the minimum time required between events for impacts on that category to be reduced to zero. If a flood occurs before there has been time for full recovery, the impacts would be much greater than if the next flood event occurs several years after full recovery has been achieved. This approach allows the standard of defence provided by each option to be directly reflected in the score. For each category, it is necessary to determine two factors in order to be able to assign a score:

- characteristic of the category that is affected by flooding; and
- recovery time of that characteristic.

The characteristic is a measure of the amount of a particular category affected and could relate to an area, a number, etc. The recovery time is linked to the amount of years after the flood that the effects would continue to be felt. Once these two factors have been identified (or estimated), the scores can be calculated automatically using the same approach as is used in the Asset AAD worksheet of the FCDPAG3 spreadsheets.

#### ***The categories and their characteristic recovery times (ChaRT)***

The scores for Management Unit 6 of the Humber Estuary SMP-Stage 2 case study have been calculated using a similar approach to that used in the Asset AAD worksheet of the FCDPAG3 spreadsheets. The characteristic recovery time (ChaRT) is used as the basis for estimating the consequence of flooding for each of the return period flood events. The score for each option is based upon the annual average damage as calculated by the worksheet. The worst performing option (that with the highest average annual damage) is assigned a score of zero. The best performing option (that with the lowest average annual damage), is assigned a score of 100. The remaining options are assigned a score according to the damage they would cause in relation to the best and worst options.

The characteristics and recovery times used to estimate the ChaRT scores for the Humber case study are given in Table 5.5.

**Table 5.5 Basis for the characteristic and recovery times for Humber MU6**

<b>Category</b>	<b>Characteristic used</b>	<b>Recovery time used</b>
<b><i>Economic impacts</i></b>		
Assets	Valued in monetary terms	
Land use	Hectares of agricultural fields affected by different return period events	3 years for return period events of <1 in 50; 5 years for floods with a return period of >1 in 50 Represents the time taken for yields to return to pre-flood levels
Transport	Length of roads and railways affected (in km) affected by different return period events	0.5 years for events more frequent than 1 in 20 years and 1 year for events >1 in 20 Represents the time taken for infrastructure to be repaired and disruption reduced to pre-flood levels
Business development	Number of non-residential properties (NRPs) flooded under particular return period events	1 year for events of <1 in 50 and 2 years for events >1 in 50 Represents the time required for the NRPs to return to pre-flood levels of production and output
<b><i>Environmental impacts</i></b>		
Physical habitats	Separated into number of freshwater and intertidal habitats affected under different return period flood events	5 years for events of <1 in 50 and 10 years for events >1 in 50 Represents the time taken for the conservation value to return to pre-flood levels
Water quality	Hectares of agricultural fields affected by different return period events (source of contaminants)	0.5 years for events of <1 in 50 and 1 years for events >1 in 50 Represents the time required for salinity to be reduced and pre-flood water quality to be re-established
Water quantity	Number of waterbodies whose water quality would be affected under different return period events	1 year for events of <1 in 50 and 3 years for events >1 in 50 Represents the time required for salinity to be reduced such that water can be abstracted
Natural processes	Length of coastline affected (km) by change in ability to function naturally (this category is independent of probability of flood events)	5 years to recover to natural situation if defences are removed
Historical environment	Number of Scheduled Ancient Monuments and listed buildings flooded under different return period flood events	5 years to recover to pre-flood conditions for all return period flood events
Landscape and visual amenity	Area of MU that would be flooded	1 year for events <1 in 50 and 3 years for events >1 in 50 Represents the time for the landscape to return to its pre-flood state

**Table 5.5 Basis for the characteristic and recovery times for Humber MU6**

<b>Category</b>	<b>Characteristic used</b>	<b>Recovery time used</b>
<b><i>Social impacts</i></b>		
Recreation	Number of recreational sites affected under different return period events and split into freshwater and intertidal	5 years for events <1 in 50 and 10 years for events >1 in 50 to reflect importance of conservation value on recreation
Health and safety	Population flooded under different return period events (based on number of properties flooded)	1 year for events <1 in 20, 3 years for events between 1 in 20 and 1 in 50 and 5 years for events >1 in 50 Represents the time required for people's health to recover to pre-flood levels
Availability and accessibility of services	Number of services flooded under different return period events	1 year for events <1 in 50 and 2 years for events >1 in 50 Represents the time required for services to return to pre-flood levels of operation
Equity	Population within most vulnerable groups flooded under different return period events (those with long-term illness, in ethnic groups other than white and migrants)	3 years for events <1 in 50 and 5 years for events >1 in 50 Represents the time required for recovery of the most vulnerable groups
Sense of community	Population flooded under different return period events (based on number of properties flooded)	2 years for events <1 in 50 and 4 years for events >1 in 50 Represents the time required for the knock-on effects of flooding to be minimised such that sense of community can be restored
<b><i>Cross-cutting impacts</i></b>		
Policy integration	Number of policies that would be discordant with flooding under each return period	5 years for all events Represents the time required to generate and implement new policies

Table 5.5 highlights the importance of the flood event on the score. This means that the scores assigned are effectively a measure of the risk of flooding, where the characteristic recovery time represents the consequence and the estimation of the ChaRT score brings in the probability of flooding through the use of an AAD-based calculation.

A summary of the scores calculated from the characteristics affected and recovery times given in Table 5.5 is provided in Table 5.6.



**Table 5.6 ChaRT scores for Humber case study (MU6)**

<b>Category</b>	<b>Do-Nothing</b>	<b>Maintain</b>	<b>Sustain</b>	<b>Improve 1:50</b>	<b>Improve 1:100</b>
Land use	0	80	96	99	100
Transport	0	70	96	99	100
Business development	0	88	98	100	100
Physical habitats – freshwater	0	86	98	100	100
Physical habitats – intertidal	100	23	3	0	0
Water quality	0	76	96	99	100
Water quantity	0	89	99	100	100
Natural processes	0	87	99	100	100
Historical environment	0	87	99	100	100
Landscape and visual amenity	0	74	94	99	100
Recreation - terrestrial	0	86	98	100	100
Recreation - intertidal	100	20	3	0	0
Health and safety	0	81	97	99	100
Availability and accessibility of services	0	88	98	100	100
Equity	0	88	98	100	100
Sense of community	0	87	98	100	100
Policy Integration	0	89	100	100	100

## 6. Weighting

### 6.1 Elicitation of weights

As part of the selection of managed realignment sites for the Humber Estuary strategy, stakeholders on the project stakeholder group were asked to rank the scheme objectives in terms of which they considered to be most important and which least important. The sample size was relatively small (based on 12 responses) and was intended to identify which objectives were most/least important to facilitate comparison of qualitative impacts, rather than to assign a specific weight. However, a review of this data has allowed an indicative set of weights to be identified.

Due to the coarseness of the ranking exercise and the small number of responses, it has only been possible to assign weights to the impact types (i.e. economic, environmental, social and cross-cutting impacts). The weights have been identified, by following these steps:

1. the number of objectives within each impact type were summed;
2. the number of objectives ranked as being of 'high' importance by impact type were identified;
3. the number of responses identifying each objective as being of importance were summed;
4. normalisation of responses was undertaken by dividing the number of responses for each impact type by the total number of responses that was possible to give an initial percentage. This was then revised so that the total of the weights was 100%; and
5. the proportion that each impact type makes up of the overall total (as a percentage) is assumed to equal the weight assigned by members of the Humber Estuary strategy stakeholder group.

The weights elicited in this manner are:

- economic impacts: 20%;
- environmental impacts: 17%;
- social impacts: 8%; and
- cross-cutting impacts: 55%.

The spread of weights is very interesting and probably reflects the particular interests of the respondents (where most were national organisations represented on the stakeholder group by local representatives). The weight for social impacts is particularly low but there were no responses from local stakeholders (other than local councils). If people living in and around the Humber Estuary had been involved in the ranking exercise, the weight for social impacts may have been different. It is important to note that the elicitation of weights was not the intention of the ranking exercise, thus, the weights presented here do not reflect actual weights for the Humber Estuary strategy and are likely to include a considerable degree of uncertainty.

## 6.2 Application of the weights

The weights elicited from the stakeholders have been used with the scores to give an indication of the differences between the options in terms of intangible benefits. To do this, the scores for each sub-category have been summed to give a category total. This gives a total score for 'economic', 'environmental', 'social' and 'cross-cutting impacts'. Summing the scores in this way assumes that the sub-categories are of equal weight. This may not be true but weights are not available at the sub-category level, hence, this is assumed to be appropriate for the case study.

The category totals are then normalised by dividing by the maximum score that could be obtained. This gives normalised scores for each category, which removes the effect of having a different number of sub-categories within each category. The weighted scores are then calculated by multiplying the normalised category scores by the category weights given in Section 6.1.

The weighted scores for each option are given in Table 6.1. The intangible-cost ratio is also given, where this is calculated as the weighted intangible score divided by the cost of each option (an intangible-cost ratio for do-nothing is not available as the cost of do-nothing is £0).

**Table 6.1 Weighted scores for Humber case study (MU6)**

Category	Do-nothing	Maintain	Sustain	Improve 1:50	Improve 1:100
Weighted score	4	83	94	95	96
Cost	-	£26,744k	£40,000k	£48,000k	£59,279k
Intangible-cost ratio	Not available	0.0031	0.0024	0.002	0.0016

The weighted scores indicate that there is very little difference between sustain, improve 1:50 and improve 1:100 in terms of intangible benefits. The intangible cost-ratios are very small due to the difference in units between the scores (maximum of 100) and the costs (in millions of pounds)

## 7. Comparison of options

### 7.1 Selecting the preferred option

Table 7.1 presents a summary of the costs and benefits for management unit 6 based on the assumptions described above, over a 100-year time horizon. Also included are the intangible cost ratio and the decision criteria based on this information.

Table 7.1 shows that the preferred option from an economic perspective (i.e. including only the tangible benefits) would be between Option 2 (maintain) and Option 3 (sustain). The FCDPAG3 decision rule states that Option 3 (sustain) would require an incremental benefit-cost ratio over Option 2 (maintain) of robustly greater than 1 (indicated as being greater than 1.5). There may be an argument that the inclusion of 60% optimism bias would mean that an incremental benefit-cost ratio of 1.37 is robustly greater than one.

**Table 7.1 Summary of costs and benefits for management unit 6**

	Costs and benefits				
	Option 1: 'Do-nothing'	Option 2: Maintain	Option 3: Sustain	Option 4: Improve 1:50	Option 5: Improve 1:100
PV costs from estimates (include optimism bias at 60%)	-	£26,744,000	£40,000,000	£48,000,000	£59,279,000
PV damage	£164,163,000	£20,881,000	£2,781,000	£556,000	£247,000
PV damage avoided	-	£143,282,000	£161,381,000	£163,607,000	£163,916,000
Total PV benefits	-	£143,282,000	£161,381,000	£163,607,000	£163,916,000
Net Present Value (NPV)	-	£116,538,000	£121,381,000	£115,607,000	£104,637,000
Average benefit/cost ratio	-	5.36	4.03	3.41	2.77
Incremental benefit/cost ratio	-	-	1.37	0.28	0.03
Weighted Score	4	83	94	95	96
Intangible-cost ratio	Not available	0.0031	0.0024	0.002	0.0016
Incremental intangible/cost ratio	Not available	Not available	0.0014	0.0002	0.0000

**Table 7.1 Summary of costs and benefits for management unit 6**

	Costs and benefits				
	Option 1: 'Do-nothing'	Option 2: Maintain	Option 3: Sustain	Option 4: Improve 1:50	Option 5: Improve 1:100
Required incremental benefit-cost ratio	-	-	1.5 <sup>2</sup>	3.0	3.0
Benefits required to move to higher option	-	-	£163,166,000	£185,381,000	£197,444,000
k	-	-	£1,785,000	£21,775,000	£33,528,000
k per point	-	-	£154,000	£22,737,000	£148,770,000
k as % of tangible benefits	-	-	1.1%	13.3%	20.5%

Inclusion of the intangible benefits requires the consideration of four criteria:

- the benefits required to give an incremental benefit-cost ratio of 1.5 to allow Option 3 (sustain) to be preferred over Option 2 (maintain);
- the 'k' value, where this is the minimum that the intangible benefits must be equal to give an incremental benefit-cost ratio of 1.5;
- the 'k per point' value, which indicates how much each additional point of the weighted score must be equal to (or greater than) for Option 3 (sustain) to be preferred over Option 2 (maintain); and
- the proportion that the minimum 'k' required to change the decision represents of the tangible benefits.

Table 7.1 shows that the benefits of Option 3 (sustain) must be equal to (or greater than) £163,166,000 for Option 3 (sustain) to have an incremental benefit-cost ratio of 1.5 (or above). This means that the intangible benefits (k) must be worth at least £1,785,000. The 'k per point' of £154,000 is less useful in this comparison, but does give an indication of the difference between the two options. For Option 3 (sustain) to be preferred over Option 2 (maintain) in line with the FCDPAG3 decision rule, 'k' must be at least 1.1% of the tangible benefits. It seems reasonable that the additional benefits described in the AST and assigned a score are worth at least 1.1% of the tangible benefits, thus Option 3 (sustain) is selected as the preferred option.

The 'k per point' values become more useful when comparing Option 4 (improve 1:50) with Option 3 (sustain). Here the 'k per point' value exceeds the 'k' value, showing how close the two options are in terms of their weighted

<sup>2</sup> The required incremental benefit-cost ratio is assumed to be 1.5 since Option 2 (maintain) would only provide a 1 in 5 year standard of defence at the end of the 100 year time period, which is below the indicative standard of 1:10 to 1:100 for Land Use Band C. Option 3 (sustain) provides a standard of defence of 1:20, thus Options 4 and 5 require an incremental benefit-cost ratio greater than 3 to become the preferred option.

intangible score. Here, the 'k per point' must be at least £22,737,000 for Option 4 (improve 1:50) to be preferred over Option 3 (sustain). The intangible benefits are not likely to be this significant and Option 3 (sustain) is confirmed as the preferred option.

## 7.2 Use of the comparator table for the Humber case study

To move from maintain to sustain, the intangible benefits must be worth at least £1.8 million. Sustain scores an additional 11 points over maintain on the weighted score. Each of these 11 points has to be worth £155,000 for Sustain to be preferred over Maintain. The additional points are made up as follows:

- economic impacts: 3 points (land use, transport and business development);
- environmental impacts: 2 points (water quality, water quantity, natural processes and historical environment); and
- cross-cutting impacts: 6 points.

The two options have the same weighted score for social impacts.

The score calculator sheet shows that drainage is likely to be affected on 256 ha-yrs under sustain and (one average) 1,649 ha-yrs for maintain<sup>3</sup>. If the damages relate to a change from bad to very bad drainage, or a value per ha of £100 to £200 from the comparator table, the benefits provided by the sustain option can be calculated as £139,000 to £279,000. This is the lowest value change from the comparator table and indicates that the benefits for sustain over maintain are likely to be at least equal to the minimum value required to make sustain the preferred option.

Damages under maintain for transport are given as 2.075 km-yrs, while for sustain the damages are 0.3 km-yrs<sup>4</sup>. The comparator table does not give an indication of costs in kilometres, but, if delays are proportional to the length of railway track affected, the sustain option would have to reduce delays compared with maintain by, at least, 1,940 minutes (or 32.3 hours). This is equivalent to 19 minutes per year. The Multi-Coloured Manual gives approximate delays of:

- up to and including 10 year return period: 0 hours;
- up to and including 25 year return period: 12 hours;
- up to and including 50 year return period: 24 hours;
- up to and including 100 year return period: 48 hours; and
- up to and including 200 year return period: 96 hours.

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<sup>3</sup> The score calculator multiplies area affected by recovery time in years, giving a unit that reflects both area affected and the years during which time it is recovering from the effects of a flood over the 100 year time horizon.

<sup>4</sup> The score calculator multiplies km of road/railway affected by year of recovery, giving a unit that can be expressed as km-yrs.

Sustain provides a 1 in 20 standard of defence while maintain provides 1 in 20 standard falling to 1 in 5. Therefore, three events greater than 1 in 10 and less than (or equal to) a 1 in 20 year return period would account for the required difference between the two options. This is not unreasonable within a 100-time horizon.

The comparator table suggests that indirect damages to industrial and commercial premises may be 30% of direct losses. The damages to NRPs are estimated at 50% of the residential damages, such that damages to NRPs from the maintain option can be estimated at £10.4 million and from the sustain option at £1.4 million. If the indirect damages are 30% of the direct losses, the indirect damages would be worth an estimated £3.1 million under the maintain option and just £0.4 million under the sustain option – a difference of £2.7 million. This far exceeds the £155,000 required per point and even the £1.8 million difference between the two options. Thus, it appears that the sustain option is likely to be preferred over the maintain option when the additional intangible benefits are taken into account.

Further benefits relate to the environmental impacts, particularly water quality and landscape, and to crosscutting impacts. The difference in crosscutting impacts is the most significant (accounting for 6 weighted score points). Sustain is likely to be in line with most policies whereas maintain also most certainly will not be. However, no comparator value is available here.

Overall, therefore, it appears that sustain is robustly preferred over maintain and that the intangible benefits are likely to be worth considerably more than the £1.8 million required to increase the incremental benefit-cost ratio to 1.5.

## 8. References

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## **Appendix B5.1**

### **Appraisal summary table for main assessment – MA-AST for the Humber Estuary SMP – management unit 6**

**Table B5.1.1 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – strategy			
<b>Description of option</b>		Do-nothing			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
<i>Economic impacts</i>					
Assets	Y	Inundation of 1,615 residential properties and 100 non-residential properties. Sea level rise would result in the number of properties flooded increasing to 1,730 residential properties and 103 non-residential properties by year 99. All of these properties would be written off.	There are also properties around the written-off zone that would be flooded intermittently. These vary according to the return period of a flood event from 74 residential and 5 non-residential properties on a 1 in 10 event (year 0) to 214 residential and 12 non-residential properties on a 1 in 500 event (year 0). One non-residential property (a gas terminal) has not been included in the economic assessment as a rateable value was not available.		Write-off and intermittent flooding damages of £164 million (PV).
Land use	Y	In year 0, 1,085ha of agricultural land would be written off. This would increase to 1,221ha by year 99.	However, this land would be converted to saltmarsh or mudflat. It is not possible to place a relative value on agricultural land versus saltmarsh/mudflat, hence, write-off costs to agricultural land are not included in		

**Table B5.1.1 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – strategy			
<b>Description of option</b>		Do-nothing			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
			the damages.		
Transport	Y	Loss of A15 (including access to Humber Bridge), A1077, railway line and local access roads. Navigation channels in estuary could also be affected due to change in estuary shape.			
Business development	Y	Loss of so many residential and non-residential properties will mean that the area is no longer viable for many businesses.			
<b>Environmental impacts</b>					
Physical habitats	Y	Development of new intertidal habitat will maintain conservation status of the estuary. Loss of 8 SNCIs, 6 Wildlife Trust sites and landward SSSI/SPA/Ramsar site (Barton and Barrow Clay Pits).			
Water quality	Y	Flooding of intensively farmed agricultural land and STW will result in initial reduction in water quality locally. Over time intertidal habitat could become sink for contaminants.	Loss of 19 discharge points.		
Water quantity	Y	Adverse impact on groundwater aquifer.	Loss of 7 water abstraction points.		
Natural processes	Y	Natural migration of intertidal habitats due to sea level rise.			
Historical environment	Y	Loss of areas of high archaeological potential, 1 scheduled Monument and listed buildings.			

**Table B5.1.1 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – strategy			
<b>Description of option</b>		Do-nothing			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
Landscape and visual amenity	Y	Change in landscape character from rural agricultural to intertidal mudflats, saltmarsh and open water.			
<b>Social Impacts</b>					
Recreation	Y	Loss of Barton Clay Pits recreation area and visitor centre. Disturbance and loss of access for walking and birdwatching.			
Health and safety	Y	Uncontrolled risk to people and property from flooding which could result in the loss of life.			
Availability and accessibility of services	Y	Significant reduction in services and access to them.			
Equity	Y	Impacts on area with deprivation index of 3,556 (assumed to be Haven). Area likely to be abandoned with people moving elsewhere with loss of property, livelihood and community.			
Sense of community	Y	The loss of properties and jobs will result in an almost complete loss of sense of community with most people moving out of the area.			
<b>Cross-cutting impacts</b>					
Policy integration	Y	Do-nothing is contrary to all policies for this area. Environmental policies are also likely to be discordant with do-nothing due to impacts on the Clay Pits.			

**Table B5.1.2 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – Strategy			
<b>Description of option</b>		Maintain (1:20 decreasing to 1:10 by year 9 and to 1:5 by year 99)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
<i>Economic impacts</i>					
Assets	Y	The gradual decline in standards over time (from 1:20 in year 0 to 1:10 in year 9 and 1:5 by year 99) means that damages to properties increase over time as more and more properties are affected. On a 1:500 year event, all of the indicative floodplain would be affected	Almost 2,000 residential properties and more than 100 non-residential properties would be flooded intermittently on the 1:500 year event under the maintain option.		Flood damages due to breaching of £21 million (PV).
Land use	Y	There may also be intermittent flooding damages following a breach on agricultural land.	Large areas of land will be affected, with 1,221ha of agricultural land flooded on a 1:500 year event.		
Transport	Y	The A15, A1077, railway line and local access roads will be protected but flooded fairly regularly which may lead to serious disruption. No impact on navigation channels anticipated.			
Business development	Y	Protection of the area to a standard of 1:10 reducing to 1:5 will mean that almost all businesses will be affected at some time. This is likely to affect future business development by reducing investment and encouraging businesses to move out of the area.			

**Table B5.1.2 Appraisal summary table for flood management and coastal defence – main assessment**

Project name		Humber Estuary SMP – Strategy			
Description of option		Maintain (1:20 decreasing to 1:10 by year 9 and to 1:5 by year 99)			
Description of area affected by option		Management unit 6 (South Ferriby Cliff to North Killingholme)			
Impact category	Impact likely? (Y/N)	Qualitative description of impacts	Quantitative assessment of impacts (no. units/monetary)	Score	Monetary value
<b>Environmental impacts</b>					
Physical habitats	Y	8 SNCIs, 6 Wildlife Trust sites and 1 landward SSSI (Barton Clay Pits) would be protected but flooded on a fairly frequent basis.(1 in 10 reducing to 1 in 5 year standard). Loss of intertidal habitat as a result of coastal squeeze and flood defence works encroaching on the foreshore will result in loss of 60ha, which will require replacing.	Flooding of some areas with a frequency of 1 in 5 years may encourage localised development of saltmarsh where freshwater habitats cannot recover before flooding recurs. Such areas are likely to be very localised, however.		
Water quality	Y	Water quality will generally be maintained but more regular flooding will result in the release of nutrients from the arable land and STW.	Loss of intertidal habitat will reduce are of contaminant sink. Some waste generation from refurbishment and replacement of existing defences.		
Water quantity	Y	Potential contamination may reduce availability of aquifer. Protection of water abstraction and discharge points.			
Natural processes	Y	Natural processes and landward migration will be prevented.			
Historical environment	Y	The Scheduled Monument and listed buildings will be protected but will still be flooded on a regular basis. The archaeological potential of the area is likely to be significantly affected, with potential loss of sites before they are discovered/excavated.			

**Table B5.1.2 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – Strategy			
<b>Description of option</b>		Maintain (1:20 decreasing to 1:10 by year 9 and to 1:5 by year 99)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
Landscape and visual amenity	Y	Landscape character generally maintained with some small temporary impact during construction phases, although there may be some changes near to the defences where flooding is relatively frequent. Permanent visual impact where crest levels are raised by up to 0.6m.			
<b>Social impacts</b>					
Recreation	Y	Loss of intertidal habitat may affect wildfowling. Fairly frequent flooding may affect facilities at Barton Clay Pits.	Loss of intertidal habitat may reduce enjoyment for birdwatchers. Construction works and more frequent flooding may result in temporary disruption. Potential for footpaths on top of defences.		
Health and safety	Y	Risk of flooding would be less than under do-nothing and would be more controlled but risk would still be 'high' (1 in 10 reducing to 1 in 5).			
Availability and accessibility of services	Y	Services protected but would be flooded fairly frequently. Could have an impact on services over time as the frequency of flooding may encourage some services to move out of the area making them less accessible to some groups.			

**Table B5.1.2 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – Strategy			
<b>Description of option</b>		Maintain (1:20 decreasing to 1:10 by year 9 and to 1:5 by year 99)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
Equity	Y	Frequent flooding may effect agriculture and industry and affect workforce who may not be in a position to move jobs or house.	The movement of services to higher ground may make them less accessible to some groups and may increase their vulnerability.		
Sense of community	Y	Sense of community could be significantly affected with many homeowners and businesses being flooded during their time in any one property. Those who are able to move out of the area may wish to do so, dividing the community.			
<b>Cross-cutting impacts</b>					
Policy integration	Y	Intertidal habitat is likely to be lost due to coastal squeeze. The standard of defence is a long way under the ABI minimum standard of 1:75 years. The local economy will be seriously affected while planning and development of the area will be severely restricted. This option is, therefore, likely to be discordant with many policies for the management unit.			



**Table B5.1.3 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – Strategy			
<b>Description of option</b>		Sustain (1:20)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
<i>Economic impacts</i>					
Assets	Y	The sustain option would provide a standard of defence of 1:20 such that damages would not increase over time.			Flood damages due to breaching of £2.9 million (PV).
Land use	Y	There may be intermittent flooding damages following a breach on agricultural land.			
Transport	Y	The A15, A1077, railway line and local access roads will be protected but flooded on average once every 20 years, which may lead to serious disruption. No impact on navigation channels anticipated.			
Business development	Y	Protection of the area to a standard of 1:20 will mean that only some businesses will be affected at some time.	The impacts on future business development through investment should be reduced and would only be significant for larger businesses whose investment planning would exceed 20 years.		

**Table B5.1.3 Appraisal summary table for flood management and coastal defence – main assessment**

Project name		Humber Estuary SMP – Strategy			
Description of option		Sustain (1:20)			
Description of area affected by option		Management unit 6 (South Ferriby Cliff to North Killingholme)			
Impact category	Impact likely? (Y/N)	Qualitative description of impacts	Quantitative assessment of impacts (no. units/monetary)	Score	Monetary value
<b>Environmental Impacts</b>					
Physical habitats	Y	8 SNCIs, 6 Wildlife Trust sites and 1 landward SSSI (Barton Clay Pits) would be protected but flooded on average once every 20 years. This is likely to be sufficiently infrequent to allow recovery of freshwater habitats.	Loss of intertidal habitat as a result of coastal squeeze and flood defence works encroaching on the foreshore will result in loss of 60ha, which will require replacing.		
Water quality	Y	Water quality will generally be maintained but flooding on average once every 20 years will result in the release of nutrients from the arable land and STW.	Loss of intertidal habitat will reduce area of contaminant sink. Some waste generation from refurbishment and replacement of existing defences.		
Water quantity	Y	Potential saltwater contamination may reduce availability of aquifer; this may be more related to sea level rise than the standard of defence provided, however. Protection of water abstraction and discharge points.			
Natural processes	Y	Natural processes and landward migration will be prevented.			
Historical environment	Y	The Scheduled Monument and listed buildings will be protected but will still be flooded on average once every 20 years. This may require on-going maintenance works to avoid deterioration of the building structure.	The archaeological potential of the area may be affected by repeated flooding.		

**Table B5.1.3 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – Strategy			
<b>Description of option</b>		Sustain (1:20)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
Landscape and visual amenity	Y	Landscape character maintained with some small temporary impact during construction phases. Permanent visual impact where crest levels are raised by up to 0.6m.			
<b>Social impacts</b>					
Recreation	Y	Loss of intertidal habitat may affect wildfowlers. The facilities at Barton Clay Pits may be affected by flooding, but should be sufficiently infrequent to allow full repairs to be made well in advance of the next flood.	Loss of intertidal habitat may reduce enjoyment for birdwatchers. Construction works and more frequent flooding may result in temporary disruption. Potential for footpaths on top of defences.		
Health and safety	Y	Risk of flooding would be less than under do-nothing and would be more controlled but risk would still be 'moderate' (1 in 20).			
Availability and accessibility of services	Y	Services protected and the frequency of flooding is unlikely to result in significant impacts, unless some long-lived assets have to be replaced earlier than would otherwise be the case. It is unlikely that services would move out of the area, although those services requiring high levels of technology (e.g. hospitals) may move to higher ground.			

**Table B5.1.3 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – Strategy			
<b>Description of option</b>		Sustain (1:20)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
Equity	Y	Flooding on average once every 20 years is unlikely to affect most people. Some groups may be disadvantaged more than others where larger companies decide to move out of the area to protect their investments or technology reliant services move to higher ground.			
Sense of community	Y	Most homeowners would be unaffected by flooding once every 20 years. If larger companies move out of the area, this may force some employees to move with the companies but should have only a minor effect on sense of community.			
<b>Cross-cutting impacts</b>					
Policy integration	Y	Intertidal habitat is likely to be lost due to coastal squeeze. The standard of defence is a below the ABI minimum standard of 1:75 years. The local economy may be affected should larger companies decide to move out of the area. This option is, therefore, likely to be discordant with some policies for the management unit.			

**Table B5.1.4 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – strategy			
<b>Description of option</b>		Improve (1:50)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
<i>Economic impacts</i>					
Assets	Y	The damages to properties on the improve 1:50 option would come from flooding following breaching of the defences. The breach would be repaired such that damages are temporary and no properties are written off.			Flood damages due to breaching of £0.56 million (PV).
Land use	Y	There may also be intermittent flooding damages following a breach on agricultural land. The extent of flooding will be less than for the Maintain and Sustain options, but greater than the Improve 1:100 option.			
Transport	Y	The A15, A1077, railway line and local access roads will be protected and only flooded very infrequently. No impact on navigation channels anticipated.			
Business development	Y	Protection of the area to a standard of 1:50 will mean that most businesses will trade normally and that damages will be very infrequent (on average). This should have little or no effect on investment such that business development should be largely unaffected.			

**Table B5.1.4 Appraisal summary table for flood management and coastal defence – main assessment**

Project name		Humber Estuary SMP – strategy			
Description of option		Improve (1:50)			
Description of area affected by option		Management unit 6 (South Ferriby Cliff to North Killingholme)			
Impact category	Impact likely? (Y/N)	Qualitative description of impacts	Quantitative assessment of impacts (no. units/monetary)	Score	Monetary value
<b>Environmental impacts</b>					
Physical habitats	Y	8 SNCIs, 6 Wildlife Trust sites and 1 landward SSSI (Barton Clay Pits) would be protected to a 1 in 50 year standard. Loss of intertidal habitat as a result of coastal squeeze and flood defence works encroaching on the foreshore will result in loss of 60ha, which will require replacing. Also if this option is shown to have an adverse impact on the integrity of the SPA it will be necessary to prove that there are no alternatives to this option.			
Water quality	Y	Water quality will generally be secured and reduced risk of flooding will result in the release of few nutrients from the STW. Loss of intertidal habitat will reduce area of contaminant sink. Some waste generation from refurbishment and replacement of existing defences.			
Water quantity	Y	Aquifer will have high degree of protection. Protection of water abstraction and discharge points.			
Natural processes	Y	Natural processes and landward migration will be prevented.			
Historical environment	Y	The Scheduled Ancient Monument and listed buildings will be protected to a high standard (1 in 50 years). The archaeological potential of the area will be secured.			

**Table B5.1.4 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – strategy			
<b>Description of option</b>		Improve (1:50)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
Landscape and visual amenity	Y	Landscape character maintained with some small temporary impact during construction phases. Permanent visual impact where crest levels are raised by over 0.9m.			
<b>Social impacts</b>					
Recreation	Y	Loss of intertidal habitat may affect wildfowling. Infrequent flooding will protect facilities at Barton Clay Pits. Loss of intertidal habitat may reduce enjoyment for birdwatchers. Construction works and infrequent flooding may result in temporary disruption. Potential for footpaths on top of defences.			
Health and safety	Y	Risk of flooding low (1 in 50 years) and would be more controlled.			
Availability and accessibility of services	Y	Services protected and only flooded very infrequently.			
Equity	Y	Area likely to retain current or improved status with protection afforded to all members of society.			
Sense of community	Y	Sense of community would be largely unaffected with most homeowners and businesses not being flooded during their time in any one property.			
<b>Cross-cutting impacts</b>					
Policy integration	Y	The standard of defence does not meet the ABI minimum standard of 1:75 years and intertidal habitat is likely to be lost due to coastal squeeze. Otherwise, the option is largely concordant with policies for the management unit.			

**Table B5.1.5 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – strategy			
<b>Description of option</b>		Improve (1:100)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
<i><b>Economic impacts</b></i>					
Assets	Y	The damages to properties on the improve 1:100 option would come from flooding following breaching of the defences. The breach would be repaired such that damages are temporary and no properties are written off.			Flood damages due to breaching of £0.25 million (PV).
Land use	Y	There may also be intermittent flooding damages following a breach on agricultural land. The extent of flooding will be less than for the Maintain, Sustain and Improve 1:50 options.			
Transport	Y	The A15, A1077, railway line and local access roads will be protected and only flooded very infrequently. No impact on navigation channels anticipated.			
Business development	Y	Protection of the area to a standard of 1:100 will mean that almost all businesses will trade normally and that damages will be very infrequent (on average). This should have no significant effect on investment such that business development should be largely unaffected.			



**Table B5.1.5 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – strategy			
<b>Description of option</b>		Improve (1:100)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
<b>Environmental Impacts</b>					
Physical habitats	Y	8 SNCIs, 6 Wildlife Trust sites and 1 landward SSSI (Barton Clay Pits) would be protected to a 1 in 100 year standard. Loss of intertidal habitat as a result of coastal squeeze and flood defence works encroaching on the foreshore will result in loss of 60ha, which will require replacing. Also if this option is shown to have an adverse impact on the integrity of the SPA it will be necessary to prove that there are no alternatives to this option.			
Water quality	Y	Water quality will generally be secured and reduced risk of flooding will result in the release of few nutrients from the STW. Loss of intertidal habitat will reduce area of contaminant sink. Some waste generation from refurbishment and replacement of existing defences.			
Water quantity	Y	Aquifer will have high degree of protection. Protection of water abstraction and discharge points.			
Natural processes	Y	Natural processes and landward migration will be prevented.			
Historical environment	Y	The Scheduled Monument and listed buildings will be protected to a high standard (1 in 100 year). The archaeological potential of the area will be secured.			
Landscape and visual amenity	Y	Landscape character maintained with some small temporary impact during construction phases. Permanent visual impact where crest levels are raised by over 0.9m.			
<b>Social impacts</b>					

**Table B5.1.5 Appraisal summary table for flood management and coastal defence – main assessment**

<b>Project name</b>		Humber Estuary SMP – strategy			
<b>Description of option</b>		Improve (1:100)			
<b>Description of area affected by option</b>		Management unit 6 (South Ferriby Cliff to North Killingholme)			
<b>Impact category</b>	<b>Impact likely? (Y/N)</b>	<b>Qualitative description of impacts</b>	<b>Quantitative assessment of impacts (no. units/monetary)</b>	<b>Score</b>	<b>Monetary value</b>
Recreation	Y	Loss of intertidal habitat may affect wildfowlers. Infrequent flooding will protect facilities at Barton Clay Pits. Loss of intertidal habitat may reduce enjoyment for birdwatchers. Construction works and infrequent flooding may result in temporary disruption. Potential for footpaths on top of defences.			
Health and safety	Y	Risk of flooding low (1 in 100 years) and would be more controlled.			
Availability and accessibility of services	Y	Services protected and only flooded very infrequently			
Equity	Y	Area likely to retain current or improved status with protection afforded to all members of society.			
Sense of community	Y	Sense of community would be unaffected with most homeowners and businesses not being flooded during their time in any one property.			
<b>Cross-cutting impacts</b>					
Policy integration	Y	Intertidal habitat is likely to be lost due to coastal squeeze. Otherwise, the option is largely concordant with policies for the management unit. The standard of defence meets the ABI minimum standard of 1:75 years.			