

Case study 54. Alkborough Flats Managed Realignment

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Main driver: Defence improvement and habitat creation

Project stage: Constructed 2005 to 2006; breached September 2006



Photo 1: Alkborough Flats (source: Environment Agency 2005)

Project summary:

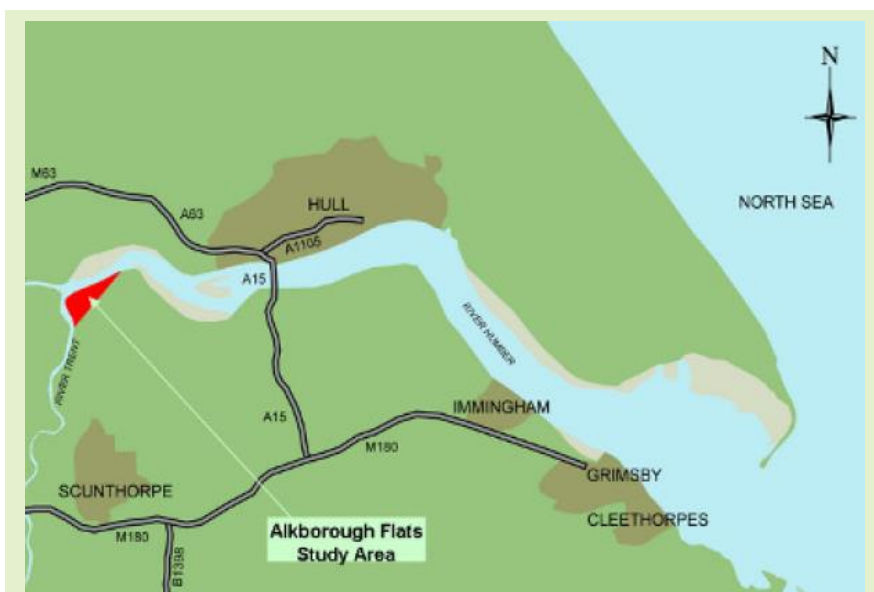
Alkborough Flats is the location of a coastal managed realignment scheme in the Humber Estuary. It is one of the largest managed realignment sites and one of the largest flood storage schemes in Europe, located on the south bank of the inner Humber Estuary at the confluence of the River Ouse and the River Trent. The Flats lie below the village of Alkborough, adjacent to the Trent and Humber and in the parish of Alkborough. To the rear of the Flats is a natural escarpment, which makes the Flats an ideal location for managed realignment as the rising ground contains the floodwaters.

Inundation of the Alkborough Flats provides a massive flood storage area that is sufficient, according to Environment Agency predictions at the time of the site design, to reduce high tide levels over a large part of the upper estuary by up to 150mm (with a pessimistic estimate of 100mm). At a projected annual sea level rise of 4mm per year until 2025, and then 8.5mm per year until 2055, it was thought at the time of construction that the Alkborough Flats scheme would modify the regime to account for perhaps 25 years of this climate change impact.

Providing flood storage at Alkborough makes it possible to defer improvements to other flood defences in the tidal rivers upstream of the site that would otherwise be needed sooner to counter the effects of sea level rise. Work is currently underway to review the rates of sedimentation on the site following 10 years of operation and its operation following the December 2013 tidal surge.

Key facts:

- Over 600 properties were identified as having a reduced risk of tidal flooding due to the provision of the flood storage facilities at the time of scheme development. Subsequent work with the University of Hull looked at the value of the site during the 2013 tidal surge, with provisional results indicating that without Alkborough there would have been 7% more flooding by volume.
- A total of 370ha of Biodiversity Action Plan (BAP) habitat have been created (Environment Agency 2005), 170ha of which is new inter-tidal habitat (Halcrow 2012).
- At the time the business case for the Alkborough Flats scheme was produced, it was estimated that its gross ecosystem services benefits would be £27.9 million (Environment Agency 2009), of which £12.2 million related to natural hazard regulation (that is, storm protection).



Map 1: Location of Alkborough Flats (source: Halcrow 2012)

1. Contact details

Contact details	
Name(s):	The site is being managed by North Lincolnshire Council of behalf of the Management Group which exists to manage the site. The partners are the Environment Agency, Natural England, Associated British Ports and North Lincolnshire Council.
Lead organisation:	Environment Agency
Partners:	Associated British Ports, English Heritage, English Nature (now Natural England), North Lincolnshire Council, Lincolnshire Wildlife Trust, The Countryside Agency
e-mail address:	humber.strategy@environment-agency.gov.uk

2. Location and coastal/estuarine water body description

Coastal/estuarine water body summary	
National Grid Reference:	SE8771522788
Town, County, Country:	Alkborough, North Lincolnshire, UK
Regional Flood and Coastal Committee (RFCC) region:	Trent Some Humber wide matters go to all 3 RFCCs: Yorkshire, Trent and Anglian North
Transitional and coastal water body and location:	Humber Upper and Humber Middle
Water Framework Directive water body reference:	GB530402609203 and GB530402609202
Land use, geology, substrate, tidal range:	Previously arable farmland

3. Background summary of the coastal/estuarine water body

Alkborough Flats (see Photo 1) is situated on the south bank of the Humber Estuary on the eastern side of the confluence between the River Trent and the Humber Estuary. It is bounded to the south-east by the escarpment of Lincolnshire Heights, a line of limestone hills rising to over 50m Ordnance Datum (OD) in level. The remaining boundaries of the site are formed by a tidal defence approximately 6km in length, which tapers out at either end into the limestone escarpment.

Socioeconomic/historic context

The village of Alkborough is located at the top of the limestone escarpment. There are 4 access tracks down the escarpment to the Flats and 2 public rights of way cross part of the Flats. A Scheduled Monument, Julian's Bower (a turf maze), is located on the top of the escarpment. There is evidence of Neolithic, Roman and Civil War finds on the high ground around Alkborough village and the Flats area was identified in desk-based studies as having high archaeological potential. For this reason extensive archaeological investigations were made.

The land surrounding the Humber Estuary contains the homes of more than 400,000 people together with major industrial and commercial properties, the country's largest port complex and extensive areas of highly productive farmland. It also contains a number of sites recognised as being internationally important for nature conservation.

The terrestrial assets within the estuarial plain of the Humber are protected from flooding by some 235km of tidal defences, which are generally in reasonable condition. However, the standard of protection is low in places and will reduce progressively in the future as sea level rises.

Flood and coastal erosion risk management problem(s)

The plains around the Humber Estuary and its tributaries cover approximately 1,500km² and contain areas of great value for industry, commerce, agriculture and wildlife, as well as population centres such as Goole, Kingston-upon-Hull, Grimsby and Cleethorpes. Much of this land is at risk from flooding under the highest tides. The estuarial tidal defences are increasingly threatened by rising sea levels (from global warming and natural sinking of the land) and by complex sediment movement processes that are eroding the foreshore in places.

Assessments of the required future flood defence expenditure in the estuary estimated that the present value cost of improving the existing defences over the next 100 years is approximately £240 million (Environment Agency 2008). Following the tidal surge in 2013, the Humber Flood Risk Management

Strategy is being reviewed and updated. The current government settlement (2015 to 2021) has pledged over £80 million of Flood Defence Grant-in-Aid (FDGiA) investment in the Humber (subject to the necessary approvals). The Local Economic Partnership has also pledged partnership funding contributions to some of the capital schemes.

Pre-construction, the tidal defence consisted of a grassed, earth embankment set back to varying degrees behind saltmarsh and tidal grazing marsh. The side of the estuarial channel formed the limit of the marsh area, seaward of which there is intertidal mudflat. The channel side was protected by rock/stone armour in places, most notably at both ends of the defence. At the northern end, a low unjointed wall of slag had been constructed along the toe of the defence embankment. The site was also drained by a network of ditches and watercourses into the estuary via a tidal sluice.

The site has a total area of 450ha, of which 370ha lie between the tidal defence and the 5m OD contour at the base of the escarpment. The remaining 80ha lie between the tidal defence and the low water mark.

Other environmental problems

The Humber is a major estuary, accepting drainage from a fifth of the land area of England. Studies carried out on the Humber Estuary show that important intertidal and wetland habitats will be lost over the next 100 years as a result of sea level rise. Extensive tidal mudflats make the Humber Estuary internationally important for wildlife including over 160,000 waterfowl annually. Other estuary habitats of importance to wildlife include sand bars, shingle banks, saltmarsh, saline lagoons (an internationally threatened habitat), reedbeds and freshwater marshes. The Humber Estuary includes 7 Sites of Special Scientific Interest (SSSIs), which are further subdivided into a number of habitat units, and is designated a Special Protection Area (SPA) under the EC Birds Directive, and a Ramsar site under the Ramsar Convention on Wetlands of International Importance. Large parts of the estuary are also designated as a Special Area of Conservation (SAC) under the EU Habitats Regulations. Protection of longer term wildlife conservation interests depends on allowing the estuary to change and adapt to sea level rise.

Part of Alkborough Flats is located within the Humber Estuary SSSI designated by reason of nationally important features: saline lagoons; sand dunes; standing waters; geology; geomorphology; breeding birds, wintering and passage waterfowl species; breeding colony of grey seals; river and sea lamprey; vascular and invertebrate assemblage.

The Habitat Regulations Assessment for the Humber Flood Risk Management Strategy (2011) set out the quantum of habitat compensation necessary for the Strategy to be implemented. It set out the need for over 300ha of intertidal habitat over the next 50 years to mitigate against the anticipated losses due to coastal squeeze. The Habitat Regulations Assessment also sets out other losses and necessary compensation for the Strategy. This arises from responsibilities under EU directives.

4. Defining the problem(s) and developing the solution

What evidence is there to define the flood and coastal erosion risk management problem(s) and solution(s)?

Initially, a 250m long breach with a cill level of 2.5m OD in the Alkborough Flats tidal defence was considered. Modelling indicated that there was likely to be up to a 40mm reduction in mean spring tide high water level in the lower River Trent and up to a 60mm reduction in the lower River Ouse as a result of such an arrangement. In addition, the reduction in high tide level could cause shoaling in the River Trent and possibly in the River Ouse. This approach was not considered to be viable due to the adverse effect it could have on other estuary usage, principally navigation and environmental interests.

This led to an alternative approach being developed of a smaller breach to permit inundation of the site by normal tides, together with an adjoining overspill weir to make flood storage within the site easier during extreme events. Breach lengths of 20m, 30m and 60m all with a cill level of 2.8m OD were model tested for the mean spring tide and for the highest astronomical tide.

With a 20m breach, the reductions in estuary high water level were predicted to be around 6–8mm in the River Ouse, 3mm in the River Trent and up to 4mm in the estuary upstream of the Humber Bridge – slightly less than predicted for a 30mm breach.

The use of a 20m wide breach was the preferred arrangement because it met one of the primary project objectives of creating intertidal habitat while limiting the impacts of the scheme on other uses of the estuary, in particular, navigation and environmental interests.

What was the design rationale?

The purpose of the scheme was to:

- provide flood storage to reduce peak tide levels in the estuary during extreme events, thereby providing a saving of approximately £12 million by deferring works to improve the existing tidal defences elsewhere in the estuary
- contribute to habitat creation responsibilities by creating 170ha of new intertidal habitat and 200ha of natural habitats

Reports from the Environment Agency (2005) and Halcrow (2012) described the design rationale as follows:

'The site was formerly drained by a network of ditches and watercourses which discharged to the estuary via a tidal sluice. The managed realignment at Alkborough involved the creation of a 20m tidal exchange structure in the existing defence to permit tidal inundation of the Flats. A distribution channel was also constructed to aid the inundation of the newly created site. Once the scheme was opened, the new tidal defence alignment was set back to a natural defence line provided by the toe of the escarpment of the Lincolnshire Heights, apart from a 1.1km length of new embankment adjacent to Alkborough village which protects the sewage treatment works and the riding stables. The scheme also included the lowering of the crest level of a 1.5km length of the existing tidal defence, thereby allowing overspilling of tidal waters into Alkborough Flats during extreme tidal events.'

Project summary	
Area of transitional and coastal water body or length benefiting from project:	370ha lies between the tidal defence and the 5m OD contour
Types of measures/interventions used (Working with Natural Processes and traditional):	<p>The main construction elements of the schemes included (Halcrow 2012):</p> <ul style="list-style-type: none"> • a habitat separation bund to maintain a proportion of the site as freshwater habitat • refurbishment of rock armour protection of the existing tidal defence • alterations to the sewage treatment works pumping station • demolition of the barn/crop drier and Flats Farm
Numbers of measures/interventions used (Working with Natural Processes and traditional):	<p>The principal construction elements of the development were:</p> <ul style="list-style-type: none"> • breach structure in the existing tidal defence • tidal water distribution channel within the intertidal area • overspill weir in the existing tidal defence • new tidal defence around the sewage treatment works • minor works of the existing tidal sluice structure • refurbishment of the armouring of the existing tidal defence

	<ul style="list-style-type: none"> • bund to separate habitats in the southern part of the site • new permissive footpaths and replacement rights of way • demolition of the barn/crop drier
Standard of protection for project as a whole:	This is being reviewed in light of lessons learnt during the December 2013 tidal surge. A project is underway to develop a hydraulic model of the estuary, including the operation of the Alkborough flood storage site.
Estimated number of properties protected:	Over 600 properties were identified as having a reduced risk of tidal flooding due to the provision of the flood storage facilities at the time of scheme design.

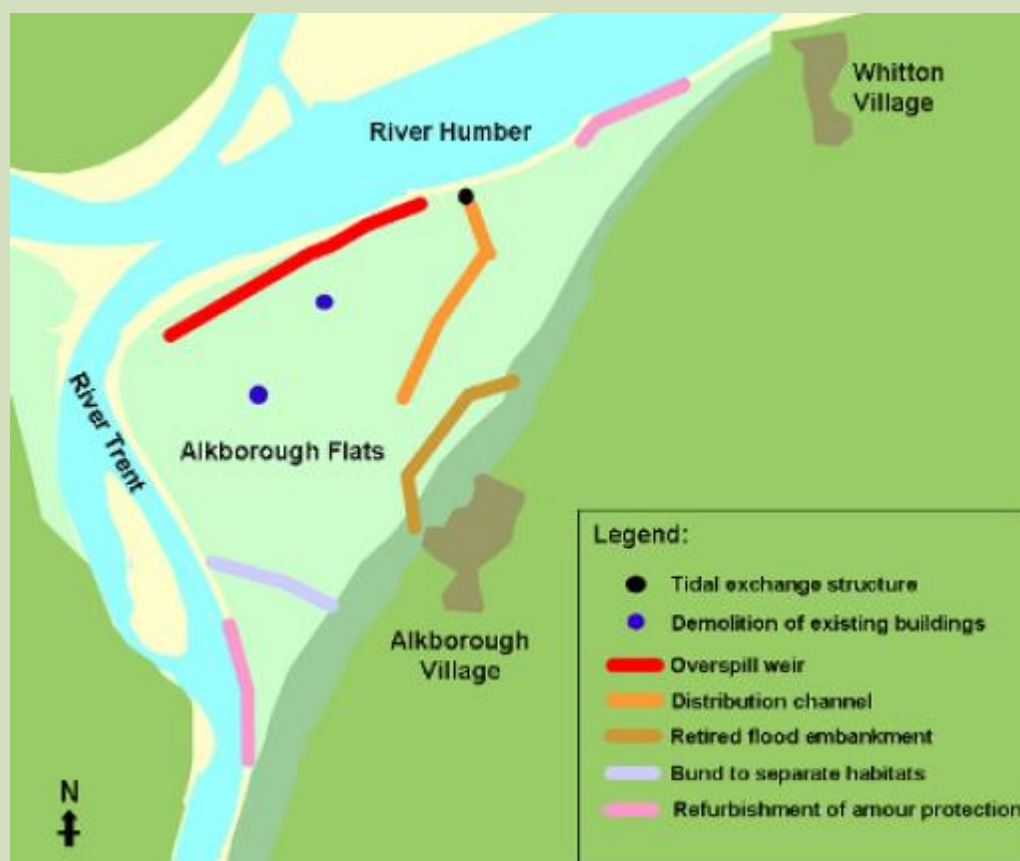


Figure 1: General arrangement of site (source: Halcrow 2012)

How effective has the project been?

The Humber Flood Risk Management Strategy is currently being reviewed. Part of that work includes looking at the effectiveness of Alkborough as a flood storage site and in lowering water levels elsewhere in the estuary. The site has developed as intertidal compensatory habitat and is currently part of the package of compensation measures in place to meet the requirements of the Habitat Regulations. The site is now 10 years' old and so it is appropriate to review its performance including:

- how the process of habitat succession is developing across the site
- the level of siltation that has taken place over the 10 years of operation

This is an evolving picture which the Management Group is discussing. Further details will be made available in due course and any specific enquiries should be directed to the e-mail address given in the contacts section.

5. Project construction

A breach structure was constructed to permit regular tidal inundation of part of Alkborough Flats and a length of the existing defence was lowered to construct an overspill weir, thereby facilitating flood storage within the Flats during extreme tidal events.

How were individual measures constructed?

The tidal defence alignment was set back along the majority of the site to a natural defence line provided by the toe of the limestone escarpment, apart from a 1,100m length adjacent to Alkborough village. Here a new defence embankment was constructed to protect the sewage treatment works and the riding stables. Measures were included as part of the package of works to allow for conveyance of water from the sewage treatment works and land drainage outside of the site as the gravity drainage reduced in performance over time due to siltation. Amendments and refinements were implemented following the tidal surge.

The existing tidal sluice was refurbished in order to extend its life. The armouring of the tidal defence at either end of the site essentially required patching (that is, topping up of areas where the existing protection was 'thin' or not continuous).

A footpath of stone construction was provided along the top of the new defence embankment, which is the main viewing area.

How long were measures designed to last?

No specific time period was put on the measure at the time of scheme development, although it was acknowledged that flood storage effectiveness would decline over time due to siltation. Monitoring is currently in place to help determine the rate at which siltation is actually happening compared with the predicted timescales.

Should it be necessary, it will be possible to extend the lifetime of the functioning compensatory habitat by implementing effective management practices.

Were there any landowner or legal requirements which needed consideration?

The majority of the site was purchased by the Environment Agency and Natural England (at the time known as English Nature) in 2003 using external funding made available by HM Treasury and the Regional Development Agency. This funding coincided with 70% of the site coming on to the market and allowed purchase by agreement at market rates. Defra recommended that the final phase of land purchase was completed in 2004 to maintain confidence in the development of the overall strategy and the ability to deliver habitat creation.

6. Funding

Funding summary for Working with Natural Processes (WWNP)/Natural Flood Management (NFM) measures

Year project was undertaken/completed:	Project construction in 2005 to 2006 Site breached September 2006
How was the project funded:	<ul style="list-style-type: none">• FDGiA• £2 million contribution from and EU Interreg programme and from the Regional Development Agency (Yorkshire Forward)
Total cash cost of project (£):	<ul style="list-style-type: none">• £11.1 million

Overall cost and cost breakdown for WWNP/NFM measures (£):	<ul style="list-style-type: none"> £4.6 million construction costs £4.97 million land purchase and preparatory works £1.4 million other costs <p>The estimated cost of the future management and maintenance of Alkborough Flats following construction of the scheme is £25,000 per year.</p>
WWNP/NFM costs as a % of overall project costs:	43% of total costs relate to the construction of the managed realignment scheme.
Unit breakdown of costs for WWNP/NFM measures:	
Cost–benefit ratio (and timescale in years over which it has been estimated):	<p>The scheme provided flood defence and environmental benefits of present value £23.6 million and had a benefit to cost ratio of 2.72.</p> <p>The scheme has a priority score of 21. This is based on:</p> <ul style="list-style-type: none"> an economic score of 4 a people score of 6 as over 600 properties were identified at the time of scheme design as having a reduced risk of tidal flooding due to the provision of the flood storage facilities an environmental score of 11 as a BAP area of 370ha will be created within the site and an area of 5,286ha of SSSI will be protected

7. Wider benefits

What wider benefits has the project achieved?

At the time the business case was developed, the Alkborough Flats scheme used an assessment period of 100 years at a discount rate of 3.5% for years 0–30, 3.0% for years 31–75 and 2.5% thereafter (Environment Agency 2005). On this basis, the project appraisal report (PAR) noted that: 'The flood defence benefit of the Alkborough Flats development was therefore £12.2 million over 100 years'.

An ecosystem services assessment for this scheme found that the gross benefits of the Alkborough Flats scheme were £27.9 million (Environment Agency 2009).

- Gross benefits of 'natural hazard regulation (that is, storm protection)' = £12.2 million
- Total of annualised benefits for all other ecosystem service benefits = £933,000
- Assessed over 25 years with a discount rate of 3.5%, this equates to a gross ecosystem service benefit of £15.7 million.

Ten years on since site creation, the following benefits have been achieved.

The intertidal habitat has been developing. This has enabled capital flood and coastal erosion risk assessment works to be carried out within the Humber Estuary in compliance with the Habitat Regulations Assessment (2011) for the Humber Flood Risk Management Strategy.

The site has operated twice in flood storage mode, in December 2013 during the tidal surge it was full beyond design capacity and once during a further high tide the overspill weir overtopped and led to storage within part of the site.

The site had numerous other objectives at the time of development, linked to some of the funding sources which helped to implement the scheme. These included increased access, sustainable farming and diversification, and education.

These objectives have been met to varying degrees and the Management Group is now considering the options for the site for the next 10–15 years.

How much habitat has been created, improved or restored?

The scheme has created approximately 170ha of new intertidal habitat (Halcrow 2012). Work in other parts of the site led to the creation of grazing marsh, saline pools, wet and dry reedbed habitats, a freshwater area, hedgerows and areas of grassland/scrub.

The whole site is 370ha, with 170ha lying within the intertidal area. In addition, a freshwater reedbed has been created in part of the flood storage site and a mosaic of wet grassland is developing as the hydraulics and hydrology of the site evolve with time.

The most up-to-date information on the extent of the site habitat can be found in the Habitat Regulations Assessment (2011) balance sheet for the Humber Flood Risk Management Strategy.

8. Maintenance, monitoring and adaptive management

Are maintenance activities planned?

The cost of the future management and maintenance of Alkborough Flats following construction was estimated to be worth £25,000 per year (Environment Agency 2005). In some years costs have exceeded this figure, but this has in some instances been due to unforeseen costs. For example recovery from the tidal surge was extensive and lessons are being learnt to ensure that, when Alkborough Flats operates again as a storage site, the impacts will be less extensive.

Is the project being monitored?

A 5-year monitoring programme began in November 2007. Its purpose was to examine the physical and biological development of the newly created habitat at Alkborough Flats. This monitoring programme assessed the effect of the scheme on:

1. Sediment characteristics
2. Accretion and mudflat development
3. Infaunal community analysis
4. Fish and epifaunal invertebrates
5. Vegetation community analysis
6. Bird community analysis

From this monitoring, Mazik et al. (2013) found the following:

- 'Flooding and sediment regime on the site have created a more diverse mosaic of habitats than on natural mudflats outside the site.
- Habitats present include mudflat, standing water, wet grassland and reedbeds.
- Benthic communities are impoverished throughout this region of the estuary.
- Benthic community inside the site are more diverse than that outside.
- The rate of vegetation cover continues to increase; it did stabilise a little between 2009 and 2012 but has subsequently gone through extensive expansion. Work is underway to determine the degree of intervention/ management that might be required and to establish whether the tidal surge in 2013 played a role in this in terms of spore dispersion and propagation.
- High densities of epibenthic invertebrates and small fish have been recorded inside the site.
- Invertebrates and fish are thought to be the primary food source for the birds using the area.
- A high proportion of the fish using the site are typically freshwater species.

- Alkborough appears to be acting as a nursery area for fish and a feeding and roosting area for birds.'

The first 10 years of monitoring showed that the average annual expenditure was approximately £10,000. Although further work will be needed, it is not anticipated that this level of monitoring expenditure would be required for the next 10 years.

Has adaptive management been needed?

According to Halcrow (2012):

'Managed realignment sites tend to act as sediment sinks due to the shallow water depths and limited wave action. Short term accretion rates are governed by a number of factors including the depth and period of tidal inundation, suspended sediment concentrations, degree of wave action and the presence of vegetation. Many of these factors are influenced by the elevation relative to the tidal frame. Thus higher rates of accretion tend to occur on sites lower in the tidal frame, since they are inundated more often'.

During this study Halcrow looked at the rates of siltation at Alkborough Flats to assess the impact of present and future rates of siltation on the flood storage capacity of the Alkborough managed realignment scheme.

Various options exist to change the scheme layout at Alkborough. Altering breach dimensions or installing a regulated tidal exchange structure could limit the volumes of water entering the site and hence the amount of siltation, but would also affect habitats. It may be worth considering constructing additional distribution channels within the site to see if these areas are subject to lower rates of accretion. Regulated tidal exchange potentially offers greater control over siltation and vegetation development, although this will incur additional construction and management costs. Further investigations of these options would be needed before capital outlay could be justified. Siltation within the scheme and the new sea level rise predictions means that the flood defence benefits of the Alkborough scheme will be different to those calculated at the PAR stage.

Ten years of site development have shown that adaptive management will be needed into the future. What form this will take, when it will be needed and the best way in which to implement this is currently being looked at by the Management Group. Decisions will be taken in due course as part of the longer term review of what the site is seeking to achieve.

9. Lessons learnt

What was learnt and how could it be applied elsewhere?

Immediately following the breach it was necessary to implement some design refinements in the light of how the breach was operating versus what the model had predicted. A monitoring plan and objectives were set up at the site for the first 10 years of its operation. This period has now come to an end and is currently being reviewed in terms of needs for the next 10 years.

Halcrow (2012) recommended that the following for future managed realignments.

- Use LiDAR (light detection and ranging) data to monitor bed elevations.
- Carry out more detailed assessments of the likely siltation rates within schemes, based on representative values of suspended sediment from field measurements and taking account of observed rates for sediment accretion in existing sites around the Humber.
- For flood storage schemes, test the sensitivity of predicted water level reductions to different siltation rates within schemes. Also test the sensitivity of option selection to changes in predicted hydraulic conditions, that is, how does the scheme perform (economically) with reduced peak water levels?

Further information on how flood storage sites respond and recover following utilisation was learnt from the 2013 tidal surge.

All this information is feeding into determining the most effective way to manage and monitor a large and changing site to ensure flood and coastal erosion risk management needs are met in the most effective way.

10. Bibliography

ENVIRONMENT AGENCY, 2005. *Project appraisal report – Humber Estuary tidal defences, Alkborough Tidal Defence Scheme*. Newcastle: Environment Agency, North East.

ENVIRONMENT AGENCY, 2009. *Ecosystem services case studies*. Bristol: Environment Agency.

HALCROW, 2012. *Assessment of siltation at Alkborough*. Swindon: Halcrow.

MAZIK, K., FRANCO, A., BROWN, S., PEREZ-DOMINGUEZ, R., MUSK, W., DAWES, O., SMYTH, K., THOMSON, S., ALVAREZ, M. AND LEIGHTON, A., 2013. *Ecological development of the Alkborough Flats managed realignment site: fifth year of monitoring, September 2011*. Hull: Institute of Estuarine and Coastal Studies, University of Hull.

Project background

This case study relates to project SC150005 'Working with Natural Flood Management: Evidence Directory'. It was commissioned by Defra and the Environment Agency's [Joint Flood and Coastal Erosion Risk Management Research and Development Programme](#).

Appendix 1: Number of tidal inundations per year based on 2003 observed tides

