Initial Assessment Report

Scheme or project location name	Southwold FCRM Southwold, Suffolk

Top (April 2018): Damage to sheet pile wall at transition between Waveney District Council and Environment Agency frontage

Bottom Left (June 2018): Beach levels significantly below top of sheet pile toe

Bottom right (June 2018): transition to Easton Bavents Cliffs – Risk of outflanking

Date	(December 2018)

Version	0

Version control

Version	Status	Originated	Checked	Approved	Date signed	Date issued
1.2	Final	D. Hunt	A. Schofield	L. Oldfield-Trim	06/12/2018	06/12/2018

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Project Sponsor Approval:				

Executive Summary

Initial Assessment

This Initial Assessment (IA) informs the viability of a working business case for a flood and coastal erosion risk management (FCRM) scheme at Southwold.

Initial Assessment forms one of a number of 'gateways' where the viability of the project is tested as assumptions are validated or strategic objectives change. If the IA indicates that the scheme presents a working business case, this would be developed and taken forward into an Outline Business Case (OBC) to provide an appraisal of FCRM options in line with Flood and Coastal Erosion Risk Management – Appraisal Guidance (FCERM-AG).

Scope of the Initial Assessment

The purpose of the IA is to develop the information to:

1. Confirm the need for a project.
2. Identify the issues, drivers and opportunities related to the need.
3. Determine whether the scheme should proceed to appraisal stage (OBC).
4. Scope the extent of services required to undertake the appraisal stage.

Confirmation of Need for a Project

The sheet piled support to the Environment Agency (EA) seawall in front of Easton Marshes is exposed, deteriorating, and in need of repair. Due to persistent erosion pressure across this frontage, protective beach levels adjacent to the seawall within the rock groyne bays in front of the wall have dropped to levels comparable with those prevalent during the 2005 PAR which led to the implementation of the 2006 defence scheme. If nothing is done, failure of the seawall is predicted to occur within 5 years. Similar issues to those at the EA seawall are present at the northern extent of the WDC Easton Marshes seawall close to the transition to the EA wall.

The 2005 PAR assumed that following the 2006 scheme implementation, recharge campaigns would be undertaken every 15 years to replenish the beaches along this frontage. However, in the light of post-scheme experience, the application of recharge (even if applied with increased frequency) is not considered to be a cost-effective approach due to anticipated increases in erosion pressure and existing beach volatility along this frontage as the Easton Bavents cliffs continue to erode to the north and the hard defences at Southwold become ever more exposed and act increasingly like a headland.

As time passes, it is anticipated that the increasing erosion pressure currently felt most severely over the EA's Easton Marshes frontage will extend further south to Waveney District Council's frontage north of the Pier and ultimately WDC's defences south of the Pier (although the latter is felt to be still some way off). Although WDC's Town frontage defences south of the Pier experience volatility in beach levels and beach width, especially within the groynes bays nearest to the Pier, beach levels within the bays adjacent to the seawall remain sufficient to cover the supporting toe piling, but in general remain lower than anticipated post-scheme.

Drivers, Issues and Opportunities Related to the Need

- To maintain the existing flood defences across the northern (EA) Easton Marshes frontage requires protection by means of a rock revetment in combination with other works to prevent failure of the defence in the short term.
- Similar protection works are likely to be required across the WDC frontage north of the pier in the medium term as erosion pressure moves further south.
- Opportunities exist in the short to medium term to better manage the transition between the hard frontage and cliff transition, to harness the erosion of the cliffs and to maintain and control the supply of sediment across the Easton Marshes frontage to feed the beaches to the south.
- Opportunities exist to improve access for maintenance plant and for safer public beach access at the northern end of the EA Easton Marshes frontage.

- Beach management opportunities exist to supplement the beach material in the embayments along the Town frontage through the regular re-cycling of material from the Denes (subject to confirmation of Denes quantity available).

Preferred Technical Solution

The preferred technical solution identified by this IA through the long-list to short-list optioneering exercise, identified the preferred technical solution to be as follows:

- Reduce the spacing of groynes across the Town frontage by the introduction of slightly shorter timber groynes within the most volatile embayments.
- Modify the existing groynes across the WDC frontage north of the Pier with rock T-Head additions.
- Construct a rock revetment to protect the seawall toe across the EA Easton Marshes frontage, with the existing rock groynes remaining intact.
- Periodically extend the rock revetment across the WDC frontage north of the Pier to replace the existing beach protection before the end of the appraisal period, in response to anticipated increased erosion pressure.

Although it is not considered necessary or cost-effective in the short-term (to 2025) or even in to the medium-term (2055), the managed realignment of the Easton Marshes defences back to a point more compatible with the alignment of the cliffs to the north will likely be required in the longer-term as holding the current Easton Marshes defence alignment becomes ever more unsustainable.

The preferred technical option presented within this Initial Assessment recognises that holding a protective beach along the EA section of the Easton Marshes seawall is not feasible in the longer-term, and that the provision of a rock toe defence in place of a protective beach is an intermediate stage in the evolution of the defences at this location. This approach would be compatible with the management policy stated in the current SMP and can be seen as the first step towards the realignment of the Easton Marshes defence.

Option Costs

The whole life PV costs of the preferred technical option is £9,217k (combination 3).

Deferring all capital works along the WDC frontage for 15 years results in whole life PV costs of £7,215k (Combination 8).

For comparison the cheapest feasible technical option (combination 2) resulted in whole life PV costs of £8,797k, within 500k of the preferred technical option.

Options include optimism bias at 60%.

Alternatives Options Considered

Options explored using the rock from the existing groynes to reduce the cost of forming a revetment across the EA frontage. However, a considerable amount of rock was required to construct an adequate revetment in addition to the rock contained in the existing groynes. The need for additional rock to construct a revetment cannot therefore be avoided which, combined with the need to dismantle the existing groynes, negates what would otherwise be an advantageous re-use approach. Additionally, the removal of the existing rock groynes would increase the erosion pressure on the WDC Easton Marshes frontage to a greater degree than if the groynes were to remain. This would result in increased whole life costs from a requirement for increased nourishment and the earlier need for a revetment to combat lowering beach levels across the WDC Easton Marshes frontage which would eventually drop to a point that threatened the stability of the seawall. This increase in whole life costs offsets the saving that can be made from reusing rock from the groynes. The preferred option does assume the eventual removal of the existing rock groynes, but not until later in the appraisal period when the rock can be used to supplement the rock within the revetment.

Alternatives considered in the IA included reverting to the 2005 PAR policy of regular and increasing beach recharge. However, as has been shown and explained in this report, erosion pressure across the northern parts of the frontage has increased such that the maintenance of a protective beach as primary defence with regular recharge is no longer considered feasible, sustainable or cost effective. South of the Pier, the frontage has performed better post-scheme and some PAR assumptions have been shown to be conservative e.g. full groyne rebuild every 15 years along with full recharge to PAR quantities. A rudimentary consideration of the cost of implementing the PAR policy was undertaken which indicated a PV cost of £7,880k.

Scheme Benefits

The benefits identified for a Do Something option at Southwold are £55,731k. In addition to flooding and erosion benefits, a significant amount for recreational and amenity benefits were identified, based on tourism to Southwold, and amounted to £28,124k. An amount of £2,760k has been included for the repairs to the road into Southwold from flood damages, since the road is the sole access route into/out of the town.

Viability of Scheme Progressing to Appraisal Stage (OBC)

There are significant problems at Southwold, caused by coastal processes, that a scheme would help to alleviate; however, **the FCRM Raw Partnership Funding Score of 17% for scheme option combination 3 and 27% for combination 8 would not be sufficient to support a viable scheme for Southwold** and significant partnership funding would be required to get the go ahead for such a scheme. Schemes throughout the country also adopt the PF calculator and priority will be given to those schemes that provide the highest scores. Therefore, it is important that potential sources of partnership funding are established if appraisal were to move to the next stage, **otherwise it is difficult to see a viable economic case for progressing to OBC.**

Sensitivity on Residual Life Estimate for WDC Easton Marshes Wall

The flood benefits assessment in this IA (above) reflects an assumed residual life of 5 years for the Easton Marshes seawall. The 5 year estimate is based on the assumption that the proposed toe pile plating repair works over the most severely deteriorated section of piling will be completed and extend the residual life estimate from 1 year to 5 years. As a sensitivity, the flood benefits assessment was re-calculated to reflect a 1 year residual life for the WDC Easton Marshes wall, and this resulted in an FCRM Raw Partnership Funding Score of 28% for combination 8.

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TABLES AND FIGURES

1. Introduction and Background

The objective of this Initial Assessment (IA) is to inform the viability of a working business case for a flood and coastal erosion risk management (FCRM) scheme at Southwold. Initial Assessment forms one of a number of 'gateways' where the viability of the project is tested as assumptions are validated and scheme detail is developed.

If the Initial Assessment indicates that the Southwold scheme presents a working business case this will be developed and taken forward into an Outline Business Case (OBC). The Outline Business Case will provide an appraisal of FCRM options in line with Flood and Coastal Erosion Risk Management – Appraisal Guidance (FCERM-AG).

The purpose of the Initial Assessment is to:

1. Review the historical information
2. Confirm the need for a project
3. Identify the issues, drivers and opportunities related to the need
4. Determine whether the scheme should proceed to appraisal stage (OBC)
5. Scope the extent of services required to undertake the appraisal stage.

No consultation with stakeholders or the wider public is to be undertaken at this stage.

Location Description and Background

Southwold is an historic town situated on the north Suffolk coast, fronted by the sea on its eastern edge and by the River Blyth estuary to the south (Figure 1). Southwold's image as a high quality, traditional English seaside resort with Blue Flag status (Southwold Pier Beach (Whitehead, 2018)) makes it a popular tourist location with high amenity value. The town provides a centre for commercial properties such as hotels, shops, public houses and restaurants and other town attractions as well as being a large residential area.

The 1.8 km long coastal frontage considered in this IA comprises the low-lying Easton Marshes, and Southwold Town which is situated on higher ground to the south of Southwold Pier. The extents of this Initial Assessment study (see Figure 4) relate to the Waveney District Council (WDC) managed Southwold Town seawall and fronting timber groyne field (T1-T8) to the south of the pier and WDC Easton Marshes seawall and Environment Agency (EA) seawall both fronted with a rock groyne field (R1-R8), which protect the low-lying Easton Marshes' wetland area. To the south of the town frontage is 'The Denes' which is a relatively wide, sand and shingle beach, backed by well vegetated low dunes and marshland which extends to the north side of the mouth of the River Blyth. At the northern extent of Easton Marshes, Easton Bavents cliffs continue northwards for approximately 2 km and are composed of sand with thin shingle layers.

The frontage is protected from erosion and possible breach by means of a seawall/promenade and a timber groyne field south of the pier and rock groynes to the north of the pier. Present beach levels north of the pier are consistently low, worsening northwards along the Easton Marshes frontage where the steel toe piling has become exposed with significant degradation, and the seawall is at imminent risk from undermining. Immediately south of the pier, the seawall and promenade are not under immediate threat since beach levels are generally higher, but levels are volatile within some groyne bays, particularly those closest to the pier.

Over the past century, there have been several serious flooding events at Southwold involving major breaches of the sea defences at Easton Marshes and Southwold Denes (the beach frontage between the Blythe estuary and Southwold Town). During these events, Southwold effectively became an island, cut-off from nearby Reydon, as floodwaters encircled the town and flooded the main access road over Easton Marshes. Since the last major event in 1953 and following construction of the Easton Marshes seawall in the 1960s and the build-up of the sand dunes forming Southwold Denes, there have been no major flood events. Prior to construction of the 2006 coastal erosion and flood defence scheme, localised flooding of the Town Marshes to the south of

Southwold due to high water levels in the River Blyth had occurred, and wave overtopping of the seawall over the Easton Marshes and Town frontage had become a more frequent occurrence due to the lowering of beach levels (EA and WDC, 2005a). The addition of an embankment at Botany Marshes in 2007 has reduced the risk of flooding from the Town Marshes but the occurrence of overtopping at Easton Marshes will likely become more frequent as the trend for beach levels to continue to lower due to volatility becomes more prevalent. Although the majority of Southwold Town is situated on higher ground, the northern and southern fringes of the town lie within the flood risk area, as do the southern fringes of Reydon (See Figure 2).

Figure 1 Aerial view of Southwold and surrounding locations (inset – extent of study area) (Google Earth, 2018)

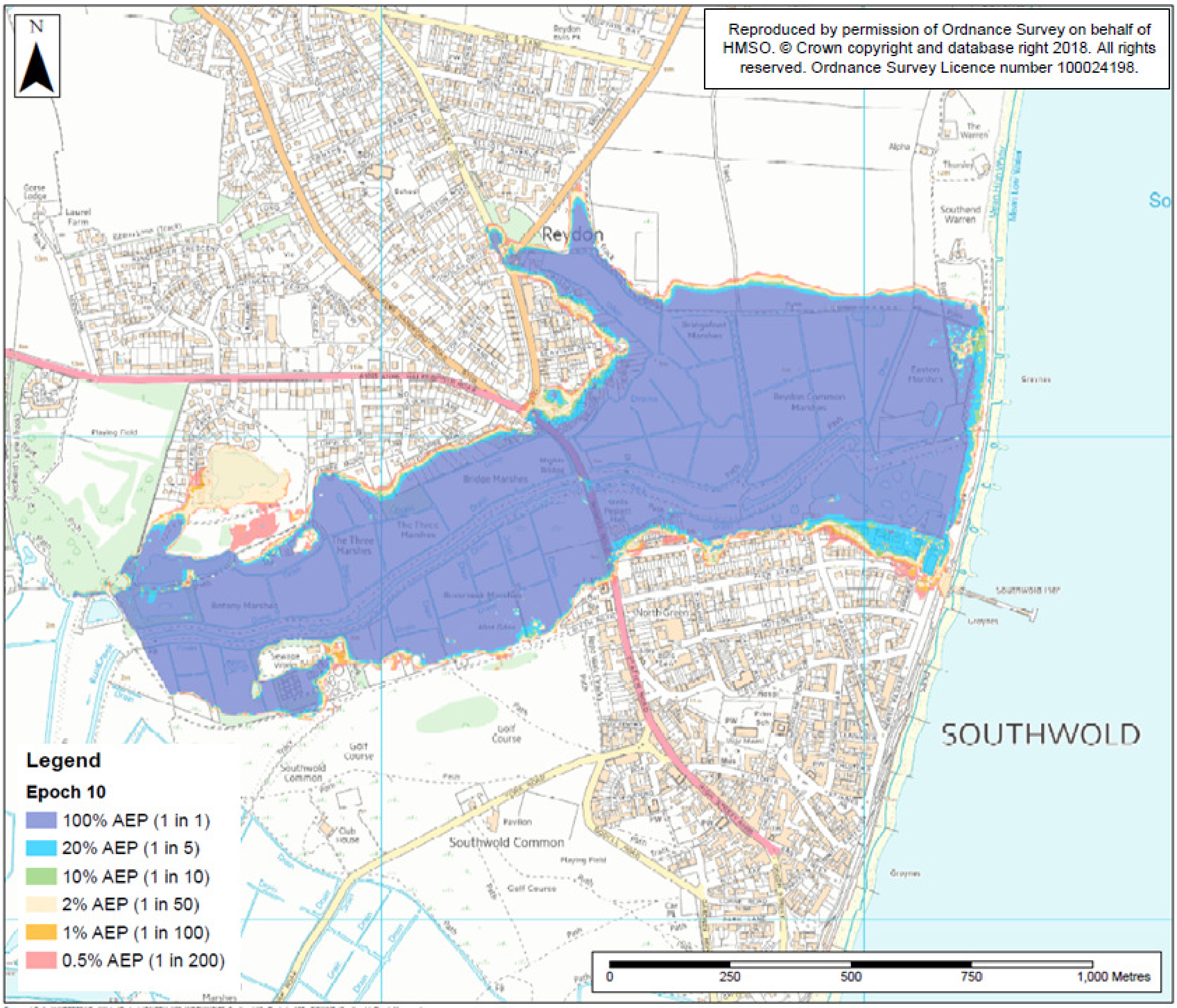

Figure 2 Flood outline Epoch 10

The Southwold frontage is part of a larger sediment transport area which extends from Benacre Ness in the north to the harbour arm on the entrance to the Blyth Estuary in the south (ENBE, 2016). Net drift across the Southwold frontage is southerly, but there can be significant drift reversal and annual drift values (northerly or southerly) can be order of magnitude greater than the net southerly drift value (Halcrow, 2001). Due to the net southerly drift, material tends to accumulate at the Denes to the north of the harbour arm, where the beach has historically built over time. In addition to the longshore transport, significant storms can occur from the east which can strip bays of material moving it off shore and this material may move back under conducive conditions or be lost from the system entirely.

Under a Do-Nothing scenario, it is expected that the defences at Easton Marshes will fail by year 5 resulting in breach and tidal flooding as shown in Figure 2. At Southwold Town, under a Do-Nothing scenario, it is expected that ongoing erosion of the defences will result in progressive failure of the defences from year 18 to year 28 with subsequent erosion of the hinterland. Figure 3 shows the erosion trendlines for this frontage.

Under a Do-Nothing scenario, there are approximately 61 residential properties and 39 non-residential properties affected under a 0.5% Annual Exceedance Probability (AEP) 1 in 200 return period on breach of the Easton Marshes frontage. With regard to erosion damages, between year 18 and 28 then 81 non-residential properties are assumed lost to erosion (the majority of these are beach huts) but 0 residential properties are predicted to be affected up to year 28.

There are several International and National nature conservation designations within or close to Southwold, including two Sites of Special Scientific Interest (SSSI) (Pakefield to Easton Bavents and Minsmere-Walberswick Heath and Marshes). At the time of the 2005 PAR there were also seven County Wildlife Sites (CWS). The entire study area is designated as an Area of Outstanding Natural Beauty (AONB) and the coastline is also designated as Heritage Coast (see Figure 3).

Within Southwold Town and the vicinity there are two Grade I and five Grade II* Listed Buildings and many Grade II listed buildings. There are also two Conservation Areas. There are several ship-wrecks (not listed as protected) off the coast at Southwold and many archaeological sites and finds recorded on the County Sites and Monuments Record for the area (EA and WDC, 2005b).

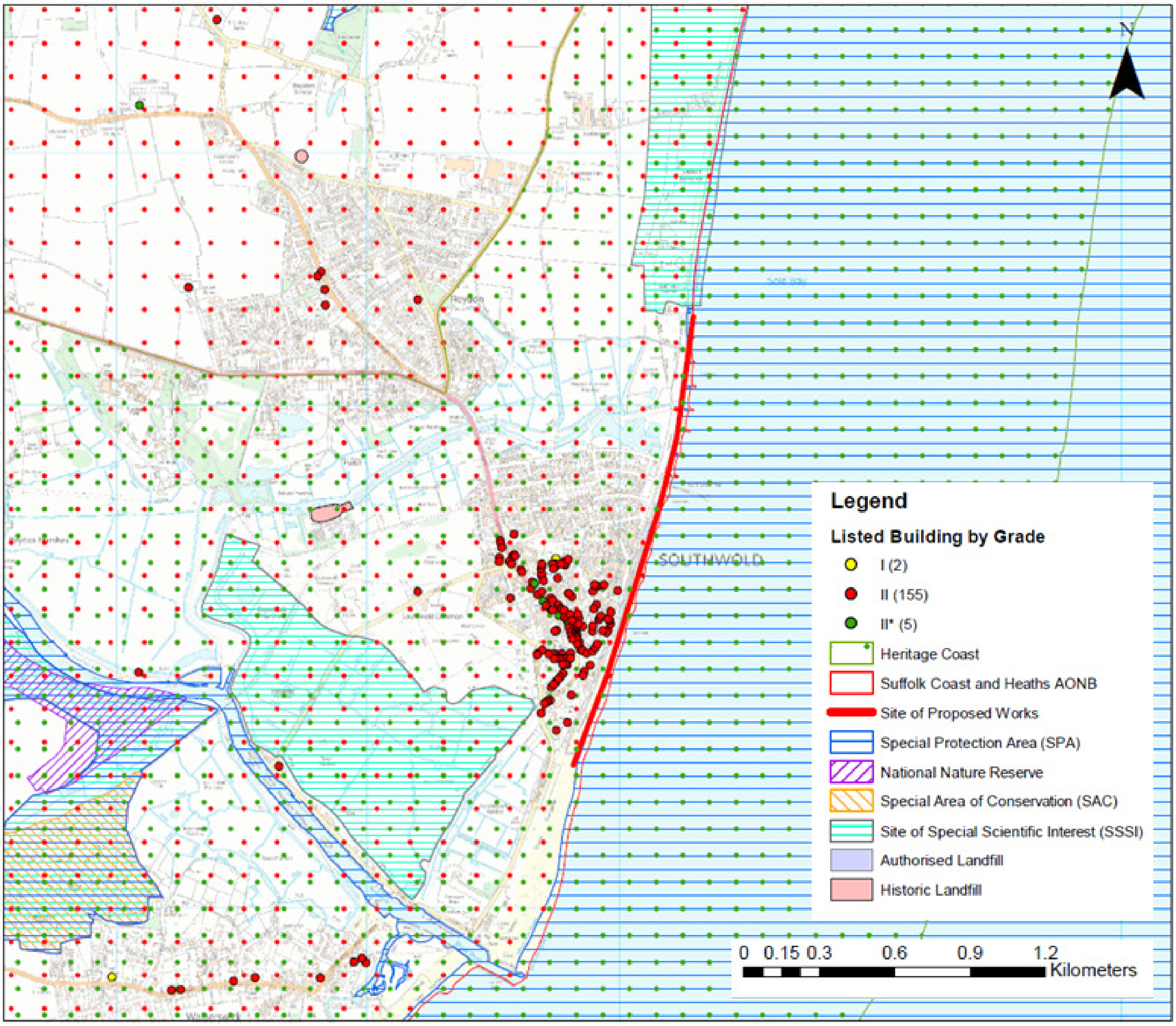

Figure 3 Environmental constraints map (2018)

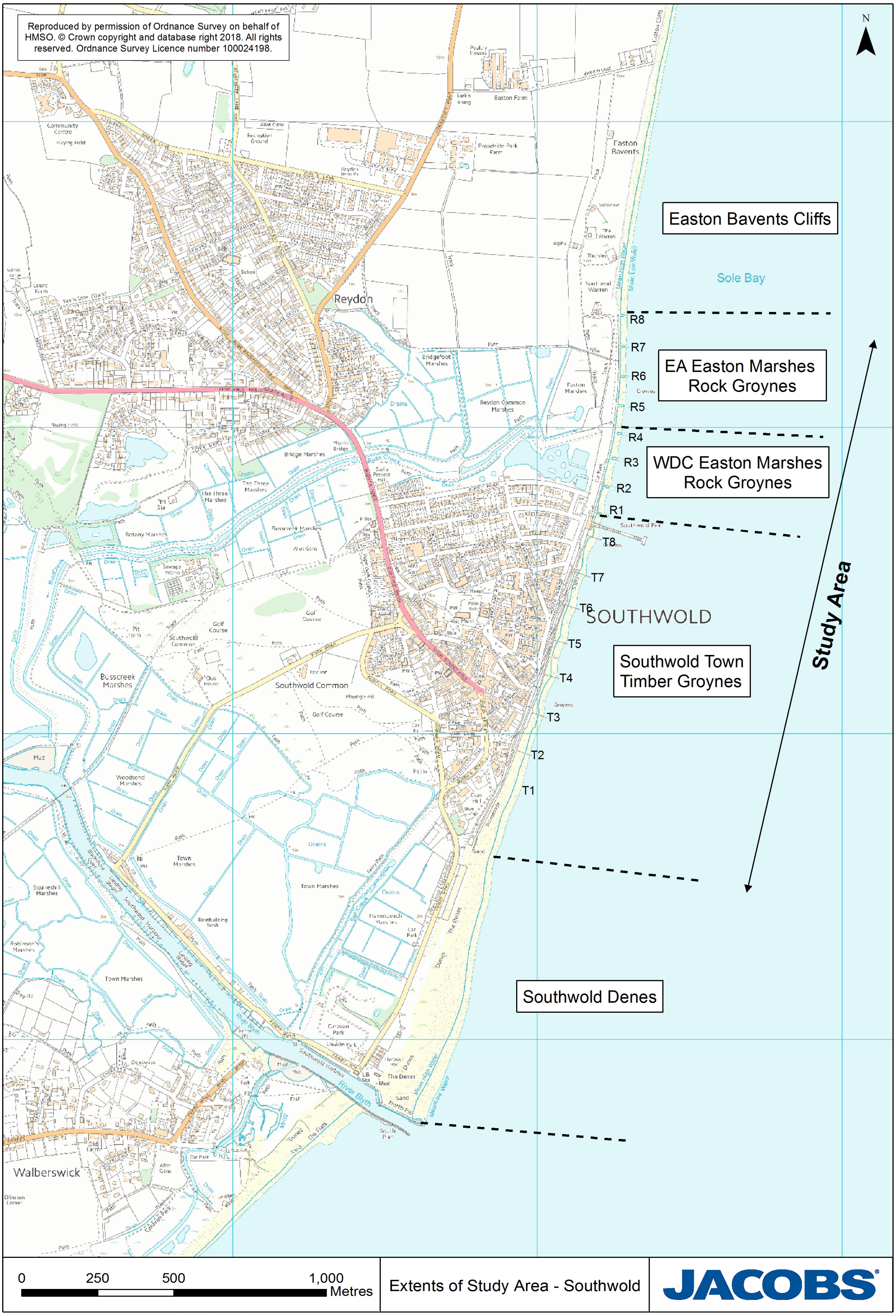

Figure 4 Details of key locations and study area extents

Current defences and management

The existing seawall and promenade at the town frontage was constructed around the 1940s and 50s and consists of a mass concrete bull nose wave return wall with steel sheet pile toe which protects a reinforced concrete promenade along with a groyne field which has been modified and re-configured several times, most recently as part of the 2006 works where the timber and steel groynes were replaced by timber only groynes (see Figure 5). Buried remnants of the old steel piled groynes remain.

Figure 5 Left - looking along the Southwold Town frontage towards the pier (taken 16 July 2018), Right - Typical timber groyne (taken 16 July 2018)

The WDC seawall at Easton Marshes north of the pier was constructed around the 1960s. Fronting the defence was a timber and steel groyne field. These groynes were replaced with rock groynes as part of the 2006 works and included timber roots to allow plant access between bays. As with the section to the south of the pier, the seawall is a bull nose wave return wall with a sheet pile toe and promenade (see Figure 6). At the transition between the Waveney and Environment Agency frontage is a sloped beach access ramp with a flood gate at its crest.

Figure 6 Left - WDC Easton Marshes seawall (taken 16 July 2018), Right - Typical WDC Easton Marshes groyne with timber root (taken 11 April 2018)

The Environment Agency (then Anglian Water Authority) seawall along the Easton Marshes frontage was constructed in the 1970s and consists of a stepped concrete seawall/revetment with a bull-nose wave return wall and a sheet pile toe. This structure was extended to the north in the 1980s (See Figure 7).

Figure 7 Left - EA Easton Marshes concrete stepped seawall (taken 14 June 2018), Right - where the 1980s seawall extension joined existing seawall (taken 20 June 2018)

The groynes were renewed in the 2006 scheme, with the existing deteriorated timber and steel groynes removed and replaced with eight timber groynes along the town frontage and eight rock groynes along the Eastern Marsh frontage (four in each of the WDC and EA managed sections of the Easton Marshes frontage) supplemented with 66,500m^3 of beach nourishment.

At the northern extent of the Easton Marshes seawall, concrete tripod armour units were installed prior to the 2006 works, to provide some protection to the terminal sheet pile of the seawall. These tripods are still present (see Figure 8).

In addition to the concrete tripods, unapproved private cliff protection works in the form of an earth bund was placed along the front of the exposed cliff (between 2002 and 2005) in an attempt to protect the clifftop properties above from erosion. The approximate amount of material added to the beach during these private works was around 1 km in length by 15-20 m wide by 8 m in height; however, this material has now largely been eroded away (EA, 2010) and no further dumping was undertaken. Some of the dumped material remains, protected by the tripod units, off the northern end of the EA frontage (see Figure 8). North of the tripods there is a band of concrete rubble which can be seen in Figure 8 (right hand side photo).

Figure 8 Concrete tripods at transition (taken 12 December 2017), Right - Looking towards Easton Bavents (taken 20 June 2018)

North of the study area the Easton Bavents beach and cliffs have no defences (see Figure 8) and the current SMP dictates a preferred management policy of no active intervention/managed realignment along this frontage. There is consequently an abrupt transition between the two frontages and management policies at this point.

South of the study area (south of the town frontage) a wide sand/shingle beach with dunes landward, historically known as the Denes, has formed updrift of the harbour pier which acts as a barrier to the net southerly drift. The Denes coastal defence is managed by the EA (ENBE, 2016).

In 2018, at the time of writing, limited remedial repair works are planned for a 24m long section of sheet toe pile close to the access ramp at the WDC/EA Easton Marshes interface. The works involve the application of steel plates with concrete infill to the existing corroded toe piles, to protect against pile failure along the worst eroded length. Investigation and repair works are also planned for the worst parts of the WDC sheet pile and concrete apron north of R4 in Spring 2019.

Drivers, constraints and opportunities

Table 1 details the drivers, constraints and opportunities within the study area identified through desk study. They are divided into political, economic, social, technological and environmental drivers, and their respective considerations.

Table 1 Drivers, constraints and opportunities

<table>
<tr><th>Political Drivers</th><th>Summary Description</th></tr>
<tr><td>Shore Line Management Plan (SMP) (Suffolk Coastal District Council, 2010)</td><td>
Policy Development Zone 3 – Easton Broad to Dunwich Cliffs.
Outlines preferred shoreline management policy to implement.
SMP2, Subcell 3C
For present day, Hold the Line to the Southwold Town frontage in line with the strategy for groyne replacement and recharge. Hold the Line of defence to Easton Marsh and undertake no works to the north along the eroding cliff section.
In the medium term, Hold the Line to the Southwold Town frontage in line with the strategy for groyne replacement and recharge. Review the approach to Easton Marshes, but with the intent to allow failure of the wall while developing a transitional approach to defences across the Easton Marshes frontage in the longer term. This will involve management of the shoreline in front of the marshes and potentially to the north. Construct secondary defences around the rear of Easton Marsh and to the A1095.
In the long term, Hold the Line to the Southwold Town frontage in line with the strategy for groyne replacement and recharge. Allow realignment within Easton Marshes, but to reinforce the north defence to Southwold and manage the natural realignment of the shoreline across Easton Marshes.
SUMMARY OF SPECIFIC POLICIES
<table>
<tr><th colspan="2">Policy Unit</th><th colspan="4">Policy Plan</th></tr>
<tr><th></th><th></th><th>2025</th><th>2055</th><th>2105</th><th>Comment</th></tr>
<tr><td>SWD 8.1</td><td>Easton Bavents</td><td>MR</td><td>MR</td><td>MR</td><td>Managed realignment of this area is for the specific purpose of establishing a sustainable defence at Southwold. This would not preclude local private intervention in line with this intent, where it was demonstrated that works neither constrained sediment drift to the south nor had a material impact on nature conservation interests.</td></tr>
<tr><td>SWD 8.2</td><td>Easton Marsh</td><td>HTL</td><td>MR</td><td>HTL</td><td>Retired flood defence and transitional control at northern end</td></tr>
<tr><td>SWD 8.3</td><td>Southwold Town</td><td>HTL</td><td>HTL</td><td>HTL</td><td></td></tr>
<tr><td colspan="6">Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention
MR – Managed Realignment</td></tr>
</table>
</td></tr>
<tr><td>EA - Creating a better place – Our ambition to 2020. (EA, 2018)</td><td>
The Environment Agency have the following overarching objectives: Creating a better place for people and wildlife and to protect the environment and promote sustainable development and will make choices based on:

putting people and wildlife first and create a better place for them
by focusing on the 20% that makes 80% of the difference
by supporting local priorities and recognising every place and community has its own needs.

Culturally, the EA will aim to; think big, act early, be visible, seek partnership and show leadership, focus on outcomes not processes, embrace difference and include everyone.
It may be possible to realise the following sub-objectives, set out in the government's 25-year Environment Plan, on the project: thriving plants and wildlife, using resources from nature more sustainably and efficiently, enhancing beauty, heritage and engagement with the natural environment, mitigating and adapting to climate change, minimising waste.
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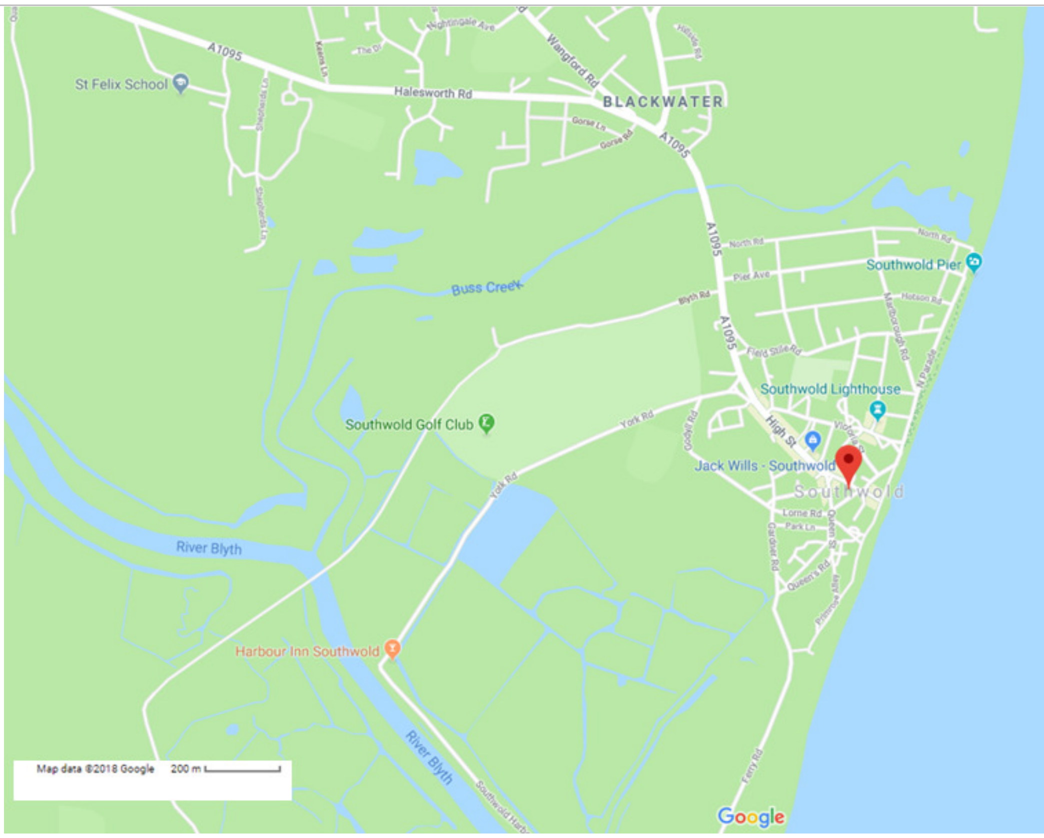
<table>
<tr><td>Suffolk Coastal and Waveney District Strategic Flood Risk Assessment (FRA) (Suffolk Coastal and Waveney District Councils, 2008)</td><td>Appendix A – Waveney District

SFRA to support planning decisions – unlikely to affect works related to improving flood risk</td></tr>
<tr><td>Waveney Local Plan (WDC, 2018)</td><td>Waveney Local Plan is currently in draft (expected adoption winter 2018) and outlines the plan for growth and development and includes consideration of Southwold and the neighbouring Reydon area - relative to this Initial Assessment - as well as the Southwold Harbour area. It also discusses the approach to those unhoused through the effects of coastal erosion.</td></tr>
<tr><td>Economic Drivers</td><td>Summary Description</td></tr>
<tr><td>Southwold Coastal Community Team - Economic Plan (Southwold CCT, 2017)</td><td>A Coastal Community Team (CCT) is a local partnership consisting of the local authority and a range of people and business interests from a coastal community who have an understanding of the issues facing that area and can develop an effective forward strategy for that place.

They have produced an economic plan which highlights flood risk as a key issue for Southwold going forward.</td></tr>
<tr><td>Protect Amenity Value ((Southwold CCT, 2017)</td><td>Southwold is a historic seaside town.

Rough Guides rated it 2nd out of 30 seaside towns in Britain.

Table below illustrates the tourism value to Southwold (Total Population 1,098)
<table>
<tr><td>Total number of trips (day & staying)</td><td>1,393,000</td></tr>
<tr><td>Total staying trips</td><td>34,400</td></tr>
<tr><td>Total day trips</td><td>1,427,400</td></tr>
<tr><td>Total staying nights</td><td>174,000</td></tr>
<tr><td>Total Tourism Value</td><td>£72 million</td></tr>
<tr><td>Total actual tourism related employment</td><td>1,719</td></tr>
</table>
Economic Impact of Tourism Southwold 2015, Destination Research</td></tr>
<tr><td>Social Constraints</td><td>Summary Description</td></tr>
<tr><td>Transport</td><td>There is only one route into Southwold along A1095 which crosses Buss Creek before entering the town. Southwold would become an island if cut off by flooding. There are no alternative routes of transportation (Google Maps, 2018).</td></tr>
</table>

	
Existing Public Space	Promenade atop the seawall is a common walking route, as is access to the cliff frontage off the end of the Easton Marshes seawall. Amusements present at the pier and along North Parade. Beach huts along large stretches of WDC town and Easton Marshes frontage. Carparking and boating lake leeward of WDC Easton March Seawall.
Property	Residential and commercial property along North Parade and fronting Easton Marshes (Southwold and Reydon). Houses on cliffs at Easton Bavents.
Technological Drivers	**Summary Description**
Improved Public Safety	Via reduced flood risk from improved defences. Better control over the realignment of Easton Bavents cliffs could reduce risk to cliff top properties. Opportunity to create improved and safer beach access along the Easton Bavents frontage, by the creation of an access point at the northern end of the Eastern Marshes frontage. Areas likely to be used for amenity due to presence of beach huts (WDC Easton Marshes) and more stable and higher beaches would therefore improve public safety in a frequently used area. Possible realignment of Easton Marshes Seawall would create a significant Health and Safety risk that would need to be managed.
Environmental Constraints	**Summary Description**
Designations (EA, and WDC, 2005b)	Area of Outstanding Natural Beauty. Coastline designated as Heritage Coast. Sites of Special Scientific Interest (SSSI) at Easton Bavents and Town Marshes. PAR listed County Wildlife Sites at Town Marshes, the Denes, Easton Marshes, Reydon Marshes and Buss Creek, but these will need to be confirmed with data request. Areas of cSAC (candidate Special Areas of Conservation) and SPA (Special Protection Areas) in neighbouring areas including SPA and cSAC covering area up to mean high waterline.
Scheduled Monument (EA and WDC, 2005b)	Work undertaken for the 2005 PAR states that English Heritage (now Historic England) confirmed that there were no Scheduled Monuments within the study area as of 2005.

Listed Buildings/Structures (EA and WDC, 2005b)	Two Grade I and five Grade II* Listed Buildings. Several shipwrecks offshore of Southwold (not protected). Several recorded archaeological sites. Southwold conservation area.
Partnership opportunities	**Summary Description**
Government and Councils	Waveney District Council - Lead Local Authority for Southwold Town frontage and leading Initial Assessment works on behalf of EA. Suffolk County Council - Responsible for public highways (excluding trunk roads and private roads) which may be affected by possible flooding.
Local Business	Local business reliant on maintaining transport links in and out of Southwold. Adnams - award-winning UK brewer, hotelier and wine merchant.

Previous studies and review of existing data

The following existing studies inform this Initial Assessment for the Southwold frontage:

- Lowestoft to Thorpeness Coastal Process and Strategy Study (Halcrow, 2001)
- Project Appraisal Report (PAR) – Southwold Coastal Frontage (EA and WDC, 2005)
- The Shoreline Management Plan (SMP) (Suffolk Coastal District Council, 2010a) - and appendices
- Southwold to Benacre Denes Trends report (EA, 2010)
- Waveney District Council - Southwold Beach Analysis Report (ENBE, 2016)
- Cliff recession in the Anglian Coastal monitoring area (EA, 2017)

In addition to the above, a full record of the data obtained for the project is in Appendix A.

2. Problem and objectives

The following sections describe the drivers and processes affecting the Southwold frontage with the purpose of highlighting key issues and subsequently outlining the objectives for any future works.

Coastal processes review

Relevant area

As part of their 2016 study ENBE provided an updated review of the coastal processes influencing the Southwold frontage. The report posits that, to account for the broader scale influences at Southwold, geomorphological change needs to be considered from Benacre Ness in the north, where the coastline begins to rotate away from the southern alignment towards Lowestoft. In the south the influence is not considered to extend beyond Southwold Harbour North Pier (ENBE, 2016).

Benacre Ness is an impermanent coastal promontory formed of sand and shingle ridges that has gradually shifted northwards. South of Benacre Ness is the Benacre Pumping Station which discharges freshwater from the Hundred River.

Further south of Benacre, there are three coastal lagoons known as Broads (Benacre, Covehithe and Easton Broad) which are believed to originate from ancient gravel workings which over time have evolved naturally behind the shingle barriers, reducing in size with coastal erosion (Covehithe Broad has retreated landwards by 300m in 150 years) and now the shingle ridges that separate the lagoons from the sea are often overtopped or breached during storms (ENBE, 2016).

South of Easton Broad are the typically 12-15 m high steep cliffs of Easton Bavents which comprise of sand and shingle layers. The cliffs are subject to ongoing erosion from wave action and weathering (ENBE, 2016). The cliffs transition at their southern extent to the EA Easton Marshes seawall and the Initial Assessment study area.

Local wave climate

Wave action drives the north to south longshore drift along this frontage. Figure 9 shows a wave rose of the wave climate in the vicinity of Southwold and the study area obtained from ABPmer's Data Explorer product (*Note: the website states data is suitable for the initial appraisal of metocean conditions only*) (Data Explorer, 2018). The SMP provided offshore wave roses with the closest to Southwold being from the Minsmere Frontage Coastal Study undertaken by Black and Veatch, 2005 (Suffolk Coastal District Council, 2010b) (see Figure 10) and suggested a predominant North East – South West direction. The inshore modelled data (Figure 9) suggests approximately 60% of the waves are from the North East or the South (almost equally with a slightly greater number from the south) which would predominantly power a longshore sediment transport regime in opposite directions, but significantly, 25% of the waves are shown to be from the East to South East direction, which could result in cross-shore transport. The modelled data also suggests that the East to South East sectors result in the largest waves.

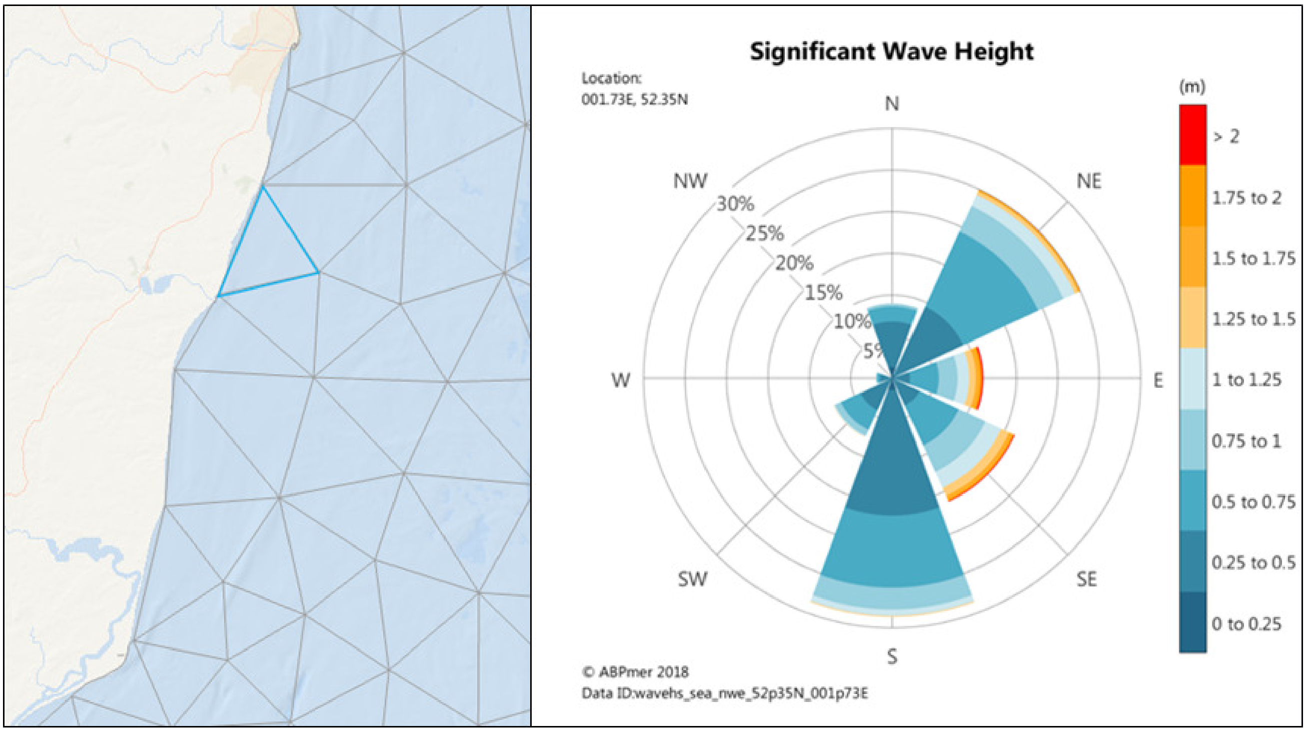


Figure 9 Wave rose Southwold (Data Explorer, 2018)

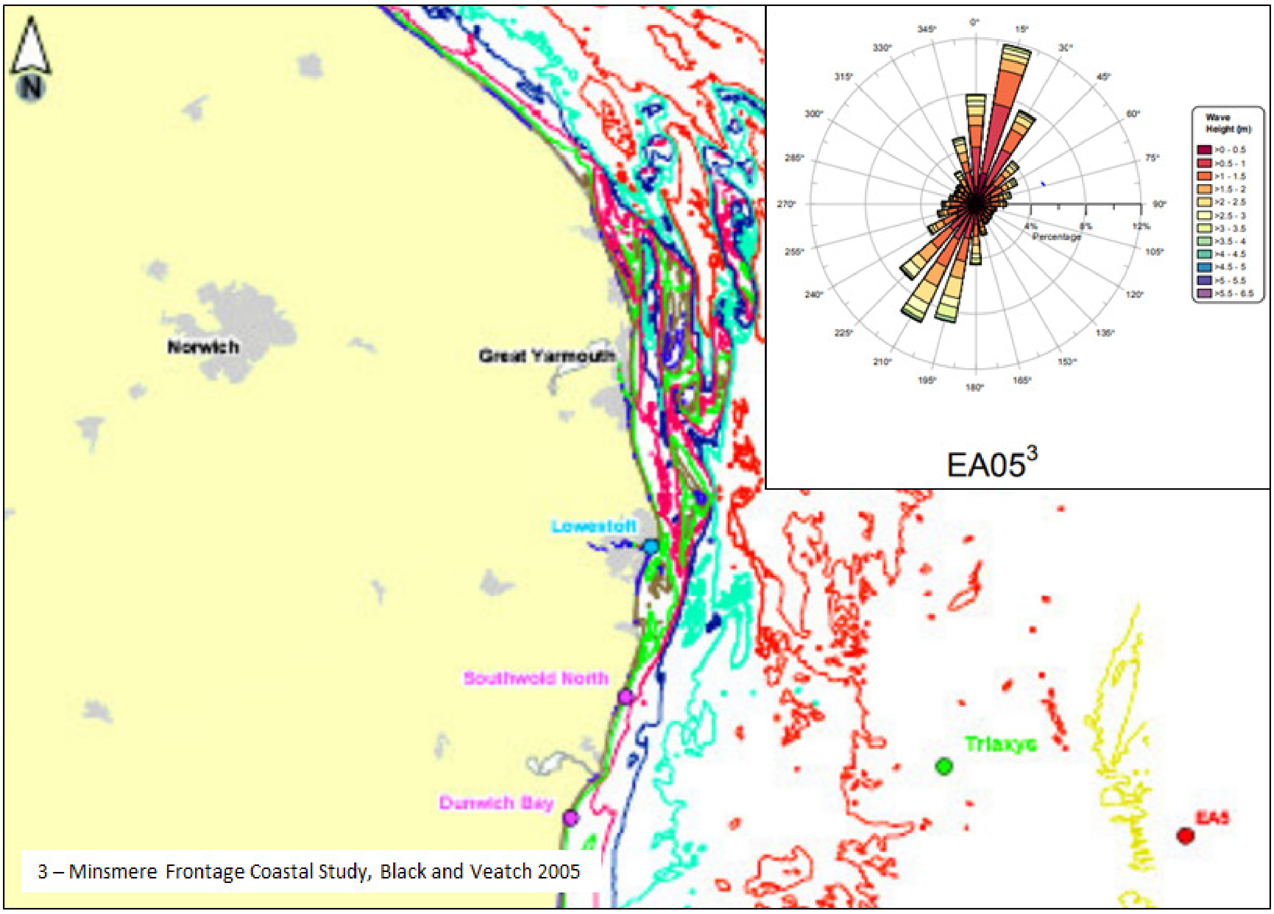


Figure 10 Offshore wave roses (Suffolk Coastal District Council, 2010b)

Tide levels

Tide levels were established using 2012, "Admiralty Tide Tables - United Kingdom and Ireland" issued by The United Kingdom Hydrographic Office (UKHO, 2012) and are detailed in Table 2.

Table 2 Tide levels for Southwold (UKHO, 2012)

Tide	Level (m ODN)
HAT	+1.6
MHWS	+1.1
MHWN	+0.8
MSL	+0.3
MLWN	-0.4
MLWS	-0.8

Extreme water levels

Table 3 details the extreme water levels at Southwold taken as the maximum of a number of points immediately seaward of the Southwold frontage stretching from the town to the Easton Bavents cliffs. The base water levels were obtained from the EA “Coastal flood boundary conditions for UK mainland and islands - Design sea levels” dataset which has a base year of 2008 (EA, 2011). To obtain information for 2018, the base data was adjusted for climate change using UKCP09 data. A medium scenario for climate change was adopted using the 95th percentile value as advised in EA publication ‘Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities’ (EA, 2016).

Table 3 Extreme water levels at Southwold (Taken from EA, 2011)

		Extreme Water Levels (m ODN)					
Return Period	2008 (mOD)	Present day (2018)	Year 10	Year 20	Year 25	Year 50	Year 75
T25	2.87	2.92	2.98	3.04	3.08	3.26	3.46
T50	3.03	3.08	3.14	3.20	3.24	3.42	3.62
T100	3.31	3.36	3.42	3.48	3.52	3.70	3.90
T200	3.50	3.55	3.61	3.67	3.71	3.89	4.09

Sediment supply and transport

Erosion of the cliffs along Easton Bavents, the broads and north towards Benacre provide a mix of material that can feed the Southwold Frontage, with the majority component sand (>70%) (ENBE, 2016), Halcrow, 2001). This can be trapped at Benacre on a south-easterly or moved south along the Southwold frontage on a north-easterly where it can form bars at the mouth of the groyne embayments, then requiring a gentle easterly flow to move this material into the bays. Cross-shore easterly to south-easterly storm conditions can result in the stripping of sediment from bays and the sediment moving seaward, potentially beyond the ends of the existing groynes.

It has been estimated that climate change and rising sea levels will result in an increase in sediment released to the system from the Eastern Bavents cliffs to the North (Brookes et al, 2011 cited in ENBE, 2016), The SMP made similar conclusions that for the period of the SMP (to 2100) and beyond there will be a significant supply of material to the Southwold frontage due to cliff erosion to the north. The SMP noted that the supply from Easton Bavents is modest in relation to that further north and further still, the supply from Easton Bavents would likely reduce as the cliffs to the north continue to erode and the hard defences at Southwold act increasingly as a headland (Suffolk Coastal District Council, 2010a).

We postulate that, over time, as the beach frontage immediately north of the Southwold headland widens as the cliff-line retreats and the sediment supply to the south reduces, this would effectively create a sediment store – which in the future could become a potential source of material for recharging the beaches to the south.

Halcrow (2001) estimated longshore transport rates and relevant locations. Figure 11 graphically represents the envelope of extreme average annual net transport rates along the coastline along with the mean value. Positive represents southerly drift and negative northerly drift. The study area has been indicated with a red arrow and it can be seen that the drift along the Southwold frontage is southerly on average but there can be significant drift reversal. Annual drift values (northerly or southerly) can be order of magnitude greater than the net southerly drift value. The graphic suggests south of Benacre Ness the net drift rates annually are southward and supports the ENBE conclusion that Benacre Ness is the natural end point for the system as beyond this point the drift turns northerly. Figure 12 and Figure 13 provides graphs showing the values of the transport at key locations. The Denes are included and it can be seen that there is a net Southerly drift at this location. Material transporting southerly at the Denes is likely to be captured by the harbour arm of the Blyth Estuary.

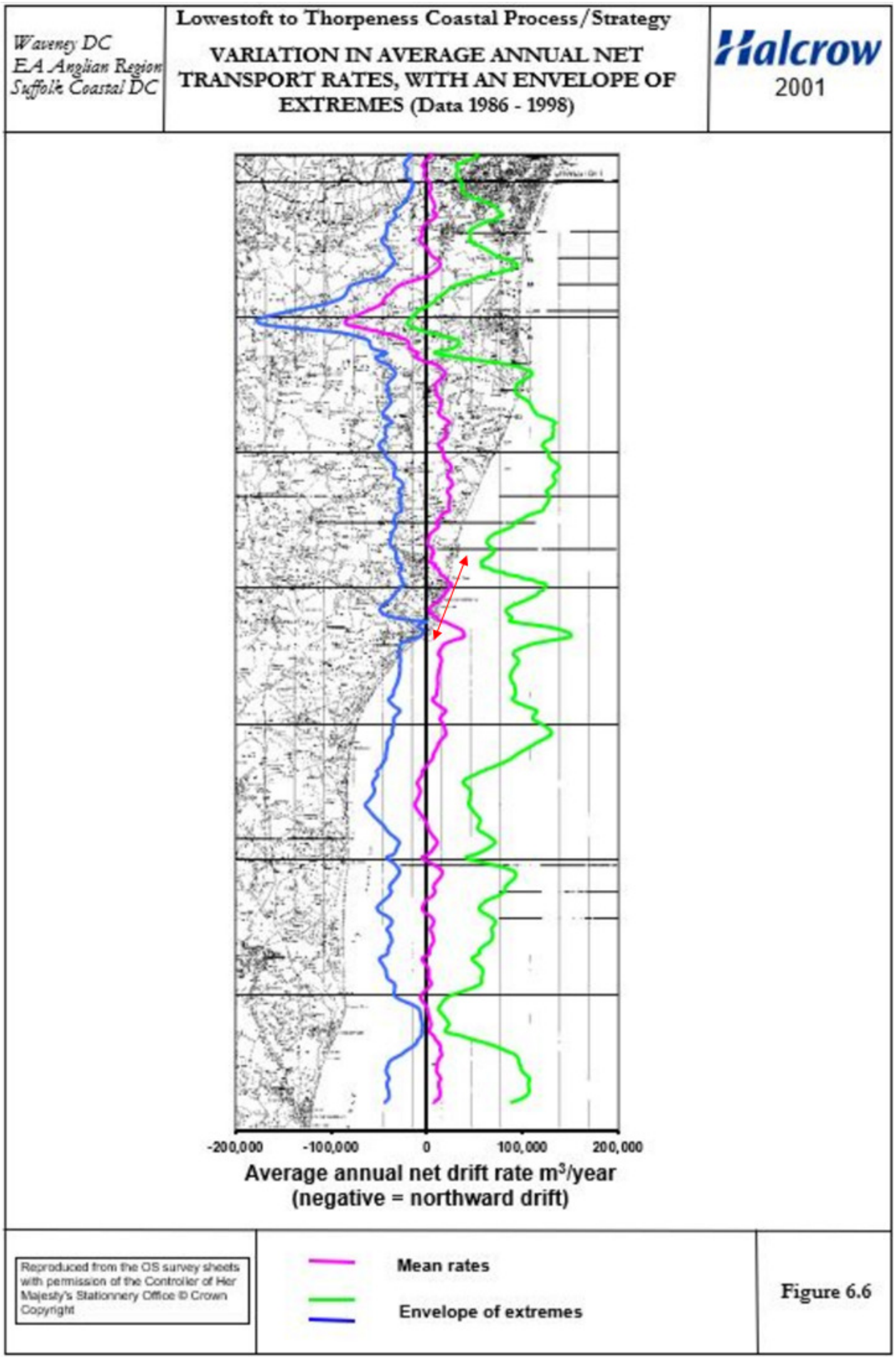
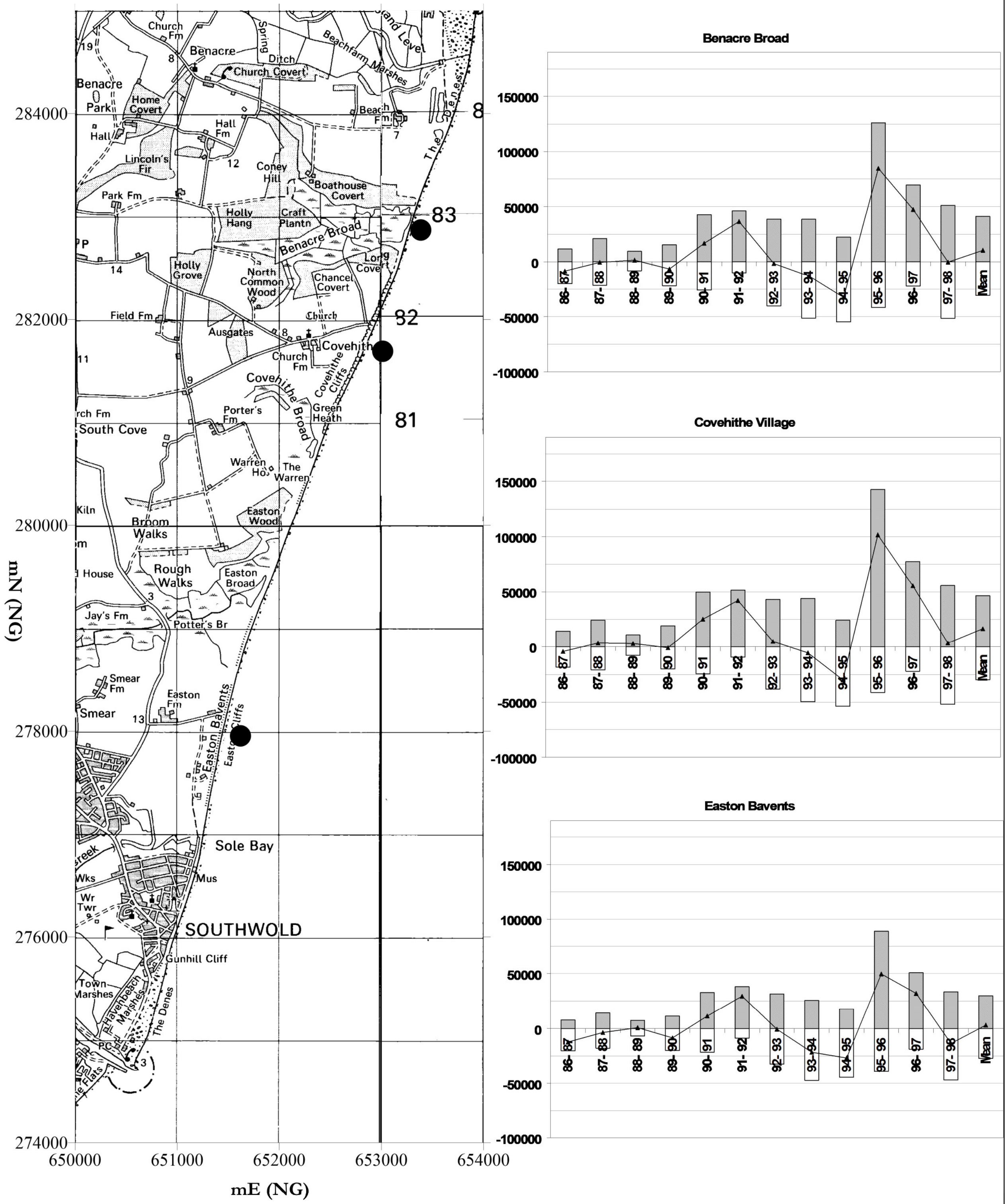


Figure 11 Average annual net drift rate relative to coastline - Red arrow indicates IA study area (Halcrow, 2001)

Waveney DC EA Anglian Region Suffolk Coastal DC	Lowestoft to Thorpeness Coastal Process/Strategy Study **NET ANNUAL DRIFT RATES (m3/year) AT KEY LOCATIONS**	**Halcrow** **2001**



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KEY

Southward drift (m3/year)

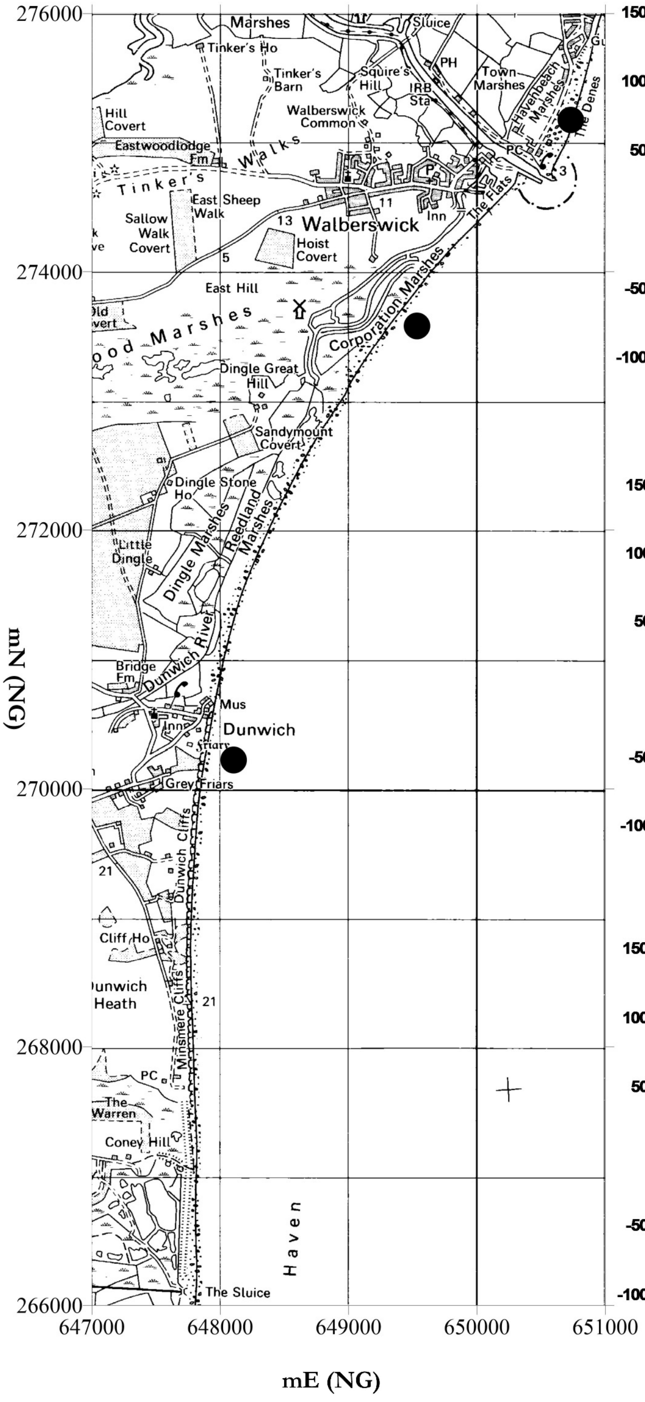
Northward drift (m3/year)

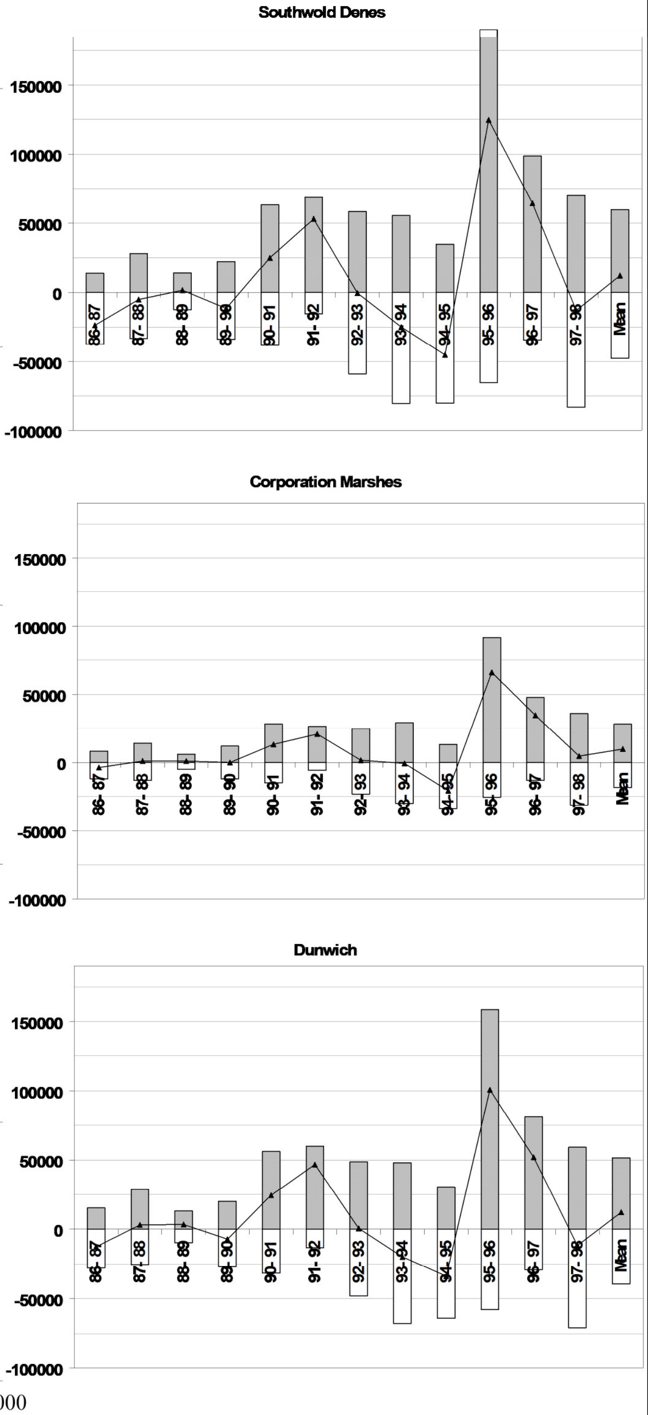
Net drift (m3/year)

Figure 6.7b

Figure 12 Net annual drift at key locations 1of2 (Halcrow, 2001)

Waveney DC *EA Anglian Region* *Suffolk Coastal DC*	Lowestoft to Thorpeness Coastal Process/Strategy Study **NET ANNUAL DRIFT RATES (m3/year) AT KEY LOCATIONS**	**Halcrow** **2001**





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KEY

Southward drift (m3/year)

Northward drift (m3/year)

Net drift (m3/year)

Figure 6.7c

Figure 13 Net annual drift at key locations 2of2 (Halcrow, 2001)

Considering Figure 11 to Figure 13, it can be see that the sediment transport rates in any one direction are large in comparison to the net value, which considered alongside the dominant opposed wave directions (Figure 9 and Figure 10), would contribute to the volatile nature of the Southwold frontage. Sediment transport rates reported are annual net values and therefore any one year may behave differently to another, depending on the predominant wave climate of that year. This could therefore result in a net reversal of drift direction over a shorter period of time. Consequently, any scheme for Southwold would need to allow for the likelihood of such drift reversal.

The potential for sand to move cross-shore is well supported by previous study (Halcrow, 2001), by anecdotal post-storm observation of beach losses correlated to storm wind/wave direction, and by the wave climate analysis which suggests that the largest waves in magnitude, and a third of waves in number, are cross-shore (see Figure 9 and Figure 10).

Performance of existing assets

The position of Southwold relative to the adjacent eroding cliffs to the north and Southwold's hard defences means that, as time passes, Southwold will become more and more a headland. This headland effect influences the orientation of the surrounding coastline and increases the erosion pressure on the Southwold frontage, as these effects will become more pronounced over time. Consideration of the coastal processes and beach behaviour at Southwold reveals the complexity, subtleties and interdependencies of the overall coastal system and processes in this part of the coast, and how, to a large extent, Southwold's continued health is dependent upon a relatively discrete set of hydrodynamic and meteorological conditions which supply the embayments with protective sediment through natural processes. A successful scheme should as far as possible work in harmony with and be adaptable to the predicted future evolution of this shoreline, whilst also capturing and retaining protective beach material where required, without detriment to the needs of adjacent frontages.

The scheme implemented on the findings of the 2005 PAR shortened and rationalised the spacing of the existing irregular spaced groynes to try and stabilise the bays, but also created a dependency on the import of dredged beach material to periodically recharge the bays, increasing in frequency over the scheme life, to ensure beach levels were sustained. The PAR anticipated significant beach recharge in Year 15 (2021). Regular beach recycling to top up groynes bays – with the likely donor site being "The Denes" – was recommended in the Beach Management Plan (BMP) (Halcrow, 2006) although it did note the constraints to this such as the win area being adjacent to the Denes which, at the time of writing, was understood to be a County Wildlife Site (which would need reconfirming). This could impose restrictions on establishing a site for obtaining the necessary material. The BMP also assumed ongoing maintenance to the seawall to ensure the integrity of the structure.

The 2005 PAR scheme allowed the passage of beach material south from Easton Bavents so as not to interrupt adversely the longshore supply of sediment to the Southwold frontage, and sought to smooth and lessen the impact of the abrupt transition between the eroding cliffs to the north and the hard defences to the south. Cliff recession data suggests that that cliff recession immediately north of the scheme has reduced post-scheme (see Section Transition to Easton Bavents Cliffs).

The PAR assessment of annual beach levels at Easton Marshes and geotechnical stability suggested in the Do-Nothing scenario, by Year 1, the beach levels would be too low to support the wall, and it was at risk of failure as a result of undermining even if maintained. The standard of protection for the frontage was well below the indicative standard of protection, and consequently represented an unacceptable risk (EA and WDC, 2005a). As the present beach levels currently approach those at the time of the PAR, this same assessment of risk would apply. At the Southwold Town frontage, the PAR assessment of the remaining design life was between 10 and 30 years with the northern section of the defences at the greatest risk (EA and WDC, 2005a). If beach volatility continues along this frontage then this timeframe would likely be representative of the time to failure in the current day.

The trigger levels adopted from the 2005 PAR, along with other characteristics of the scheme, are detailed in Table 4 (Halcrow, 2006).

Table 4 Design beach parameters for Southwold (Halcrow, 2006)

Frontage	SoP (Years)	Beach Crest Level (m ODN)	Crest Width (m)	Slope	Action trigger level (m ODN)	Emergency trigger level (m ODN)
EA Easton Marsh	1:200	2.0	5.0	1:10 *(except R7-R8 = 1:9)*	1.3 *(dip of 0.2 m from top of sheet pile)*	-2.2 *(dip of 3.7 m from from top of sheet piling)*
WDC Easton Marsh	1:200	2.2	6.5	1:10	1.6 *(dip of 2 m from seawall crest)*	-0.3 *(dip of 0.9 m from top of sheet piling)*
Southwold Town	1:100	2.4	8.0	1:10	1.6 *(dip of 2 m from seawall crest)*	-0.3 *(dip of 0.9 m from top of sheet piling)*

At the EA Easton Marshes seawall and embayments (R5-R8) and the most northerly WDC Easton Marshes embayment (R4-R5), recent observations of the beach show that the sheet pile toe of the seawall continues to be exposed (see Figure 14). This has likely been caused by cross-shore processes stripping the beach and the prevailing conditions not being conducive to moving any longshore accumulations of material back into the bays. The increased exposure of the toe has led to localised exposure and further deterioration of the sheet pile by saltwater corrosion and abrasion from the mechanical action of stone and shingle onto the sheet pile (see Figure 15 to Figure 17), much of which has been in-situ since the 1960s and 1970s (note: to address the imminent risk of failure, the EA are undertaking repairs to 24 m of the worst affected areas of sheet pile seawall toe in the form of steel plating with 60 m^3 of concrete and grout expected to be drilled and injected into the voids behind. WDC has holed piles and damaged concrete wall apron that they plan to investigate and repair by Spring 2019). The exposure of the vertical piling and the resulting wave impacts and reflections are not conducive to sediment deposition at the wall toe, and are likely to be exacerbating foreshore erosion at the toe.

Figure 14 EA Easton Marshes seawall, Left – looking from R8 towards R7 (taken 20 June 2018), Right – lowered level with indications of exposed clay (taken 2 May 2018)

Figure 15 Sheet pile deterioration along EA seawall at location near to access ramp (picture taken 16 April 2018)

Figure 16 Sheet pile deterioration close to access ramp (Left, taken 16 April 2018, Right, taken 6 March 2018)

Figure 17 Sheet pile damage close to groyne R5 (taken 6 March 2018)

Along the WDC Easton Marsh Seawall (R1-R4), concerns have been raised by owners of the beach huts regarding the overtopping spray and algae risk causing slips on the promenade (ENBE, 2016). The beach in this area is not as low as between R4-R8, suggesting the bays are more stable; however, levels still appear lower than the 2006 scheme levels, post beach nourishment (see Figure 18).

Figure 18 Left - Spray at WDC Easton Marshes Seawall (taken 28 September 2018), Right - Variability in bays looking from pier (taken 16 July 2018)

South of the pier, bays for the first 200 m south of the pier (incorporating bays T6-T7 and T7-T8) show signs of volatility; however, the seawall sheet piles are still protected. There are visible signs of wear to the timber groyne boards and piles (see Figure 19). T1-T6 seem to be performing well and the beaches appear to be full and effectively trapping sediment.

Figure 19 Left & Right - Pictures of wear on groyne T8 (taken 11 April 2018)

Beyond groyne T1 (and the study area) is the Denes (see Figure 20) which has been put forward as a possible extraction site for material to be used as recycling along the Southwold town frontage.

ENBE, 2016 suggested a manageable quantity of 5,000m^3 (not to be repeated unless confirmed by further monitoring) may be available, based on an analysis of data since 1997, raising concerns that Denes has been in an erosion phase since 2006 and has only just started to accrete again. They do suggest from viewing historic surveys that there is greater capacity for extraction before the beach profile is at the “worst” recorded survey point (ENBE, 2016). Consideration of photographic evidence suggests the presence of a healthy beach at this location and over the longer term the general trend over the longer period is that of accretion (Figure 21). ENBE have been instructed by WDC to provide an update to the profile analysis at the Denes to try to estimate with more certainty the material that may be available from the Denes for recycling.

Figure 20 Looking towards groyne T1 and beyond to the Denes

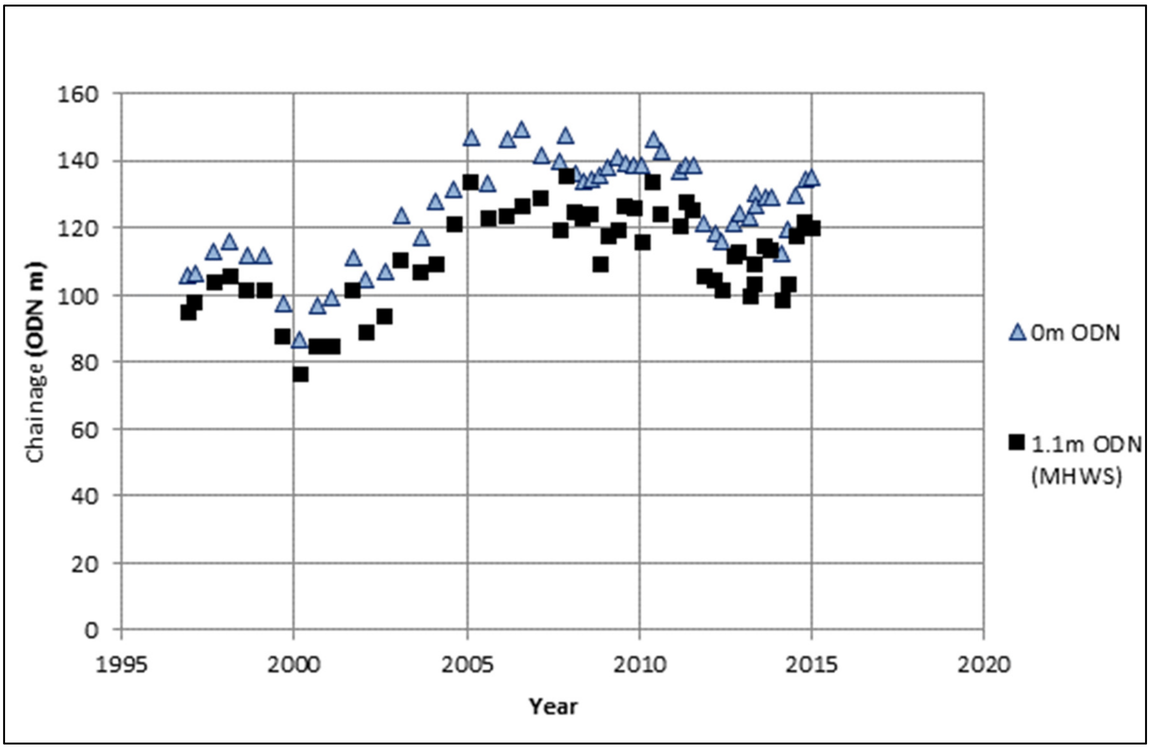

Figure 21 Chainages to the 0mODN and 1.1mODN (MHWS) contours with time for profile SW051, approx. mid way along the Denes frontage (ENBE, 2016)

No significant recharge has taken place post the PAR scheme. The first scheduled recharge designated in the PAR scheme was set for 2021.

Beach volatility

ENBE Beach profile analysis

ENBE (2016) analysed the beach profile information provided by the Anglian Coastal Monitoring Programme where there was a suitable record length. The following profiles were analysed related to the study area, and the locations can be seen in Figure 22

- Easton Marsh (profiles SW018, SW021, SW024 and SW026)
- Southwold Town (profiles SW029, S020, SW035, SW038, SW039 and SW042).

Further analysis of the area north of the study area and south into the Denes was undertaken and can also be seen in ENBE, 2016.

ENBE's analysis summarises the average annual longitudinal movement of the 0 m ODN and 1.1 m ODN contour for before and after the 2006 scheme (Figure 23). The left-hand axis and bar chart shows the annual movement of the contours with positive (>0) showing beach accumulation and growth and negative (<0) showing an overall loss of material. The right-hand axis and line graph shows the R-squared value which relates to the fit of the data to a particular trend. The lower the R-squared value, the greater the variation in the levels of the beach over the record.

Analysis has not been repeated and refer to ENBE, 2016 for further information. A summary of the key findings from the profile analysis follows.

Profile SW18 is the only profile located at the EA Easton Marshes frontage, located within bay R6-R7. It has been monitored post scheme implementation but no comparison to before 2006 exists. Analysis indicated a rapid and significant loss of material with beach levels at or around -1 m ODN levels. The MHWS and sometimes the zero m ODN tide levels will reach the vertical face of the sheet piling, resulting in wave reflection and encouraging beach drawdown. Profiles do indicate an occasional recovery with influx of beach material but typically the high tide level is back at the seawall within a year. The volatility at this profile is supported by a low R-squared value which indicates high volatility.

Profile SW21 is located at the transition between the WDC and EA Easton Marshes seawalls (bay R4-R5). Prior to 2006, the MHWS tide mark had been at or very close to the seawall for almost 10 years. The zero m ODN tide mark was close to the vertical face of the seawall five years before the PAR scheme but the scheme moved this approximately 30 m seawards. 5 years post PAR scheme this had reduced to approximately 10 m and 10 years post scheme was back at the seawall. Beach survey data suggests that the profile is now back at the pre-scheme levels. ENBE put forward that the high erosion rate at this location is due to the change of seawall alignment. The high R-squared value indicated in Figure 23 suggest that there is a strong trend of beach retreat over the period analysed.

Profile SW24 is in bay R2-R3 and no data exists before the PAR scheme. Since the scheme implementation the 0 m ODN tide mark moved 10 m landwards within five years but now appears to have stabilised, being offset from the vertical seawall by around 15 m. Beach levels at the seawall are at around the BMP "action" level. Similarly, at profile SW26 (bay R1-R2) beach levels appear to have fallen rapidly in the first two years post scheme, but the rate of shoreline recession has since slowed down and the MHWS tide mark is offset from the seawall by around 5-15 m (from 25m at point of scheme). Beach levels at the seawall are at or around BMP "action" level.

South of the pier profile SW029 (bay T7-T8) and S020 (bay T6-T7) shows that before the 2006 scheme the area immediately south of the Pier was experiencing erosion and this trend is continuing post scheme, but at a slower rate. Profile S020 has been monitored since 1992 and beach levels were generally stable up until around 2001, but then suffered from rapid retreat and the MHWS tide mark was only 5 m from the wall. This was moved seaward by 20 m by the 2006 scheme but now there is generally a fluctuating trend with MHWS varying by 5-25 m from the seawall. The low R-squared value of the data shown in Figure 23 supports this high level of fluctuation. Both profiles show levels only just above the BMP "action" level.

At profile SW035 (bay T4-T5) the trend is generally of advance with the MHWS mark moving approximately 25m seaward, mostly following 2012. A high R-squared value supports that this is a stable area with high levels of accretion.

At SW038 (approx. T3 bay, T3-T4, since 1997) before the PAR scheme an overall trend of erosion was evident but the MHWS tide marks never reached the seawall. Post the PAR scheme the tide marks were moved seaward by approximately 20 m and although beach levels were low between 2007 and 2012 they have now improved and are at or above the design beach level. SW039 (bay T2-T3, since 2007) has dipped to action level but is now significantly higher. Both profiles have a general trend of accretion in recent years.

Profile SW042 (bay T1-T2) is located towards the end of the promenade and has an overall trend of erosion with intermittent advancement. The close proximity to the Denes, where the coastline is unconstrained and more responsive, may provide some explanation to the trend here (ENBE, 2016).

Figure 22 Beach profile locations – additionally, S012 to S019 are north towards the cliffs, broads and Benacre (ENBE, 2016)

Figure 23 Average annual longitudinal movement (and indication of beach variability of the 0 mODN and 1.1 mODN contours for pre and post 2006 (ENBE, 2016)

ENBE beach dip analysis

Figure 24 presents beach dip analysis undertaken by ENBE, 2016. The shaded envelope represents the full extent of all the dip surveys. Also shown as line data are the surveys for the first and last winter and summer covered by the data providing a snapshot of the dip data following the scheme and at the time of the ENBE study.

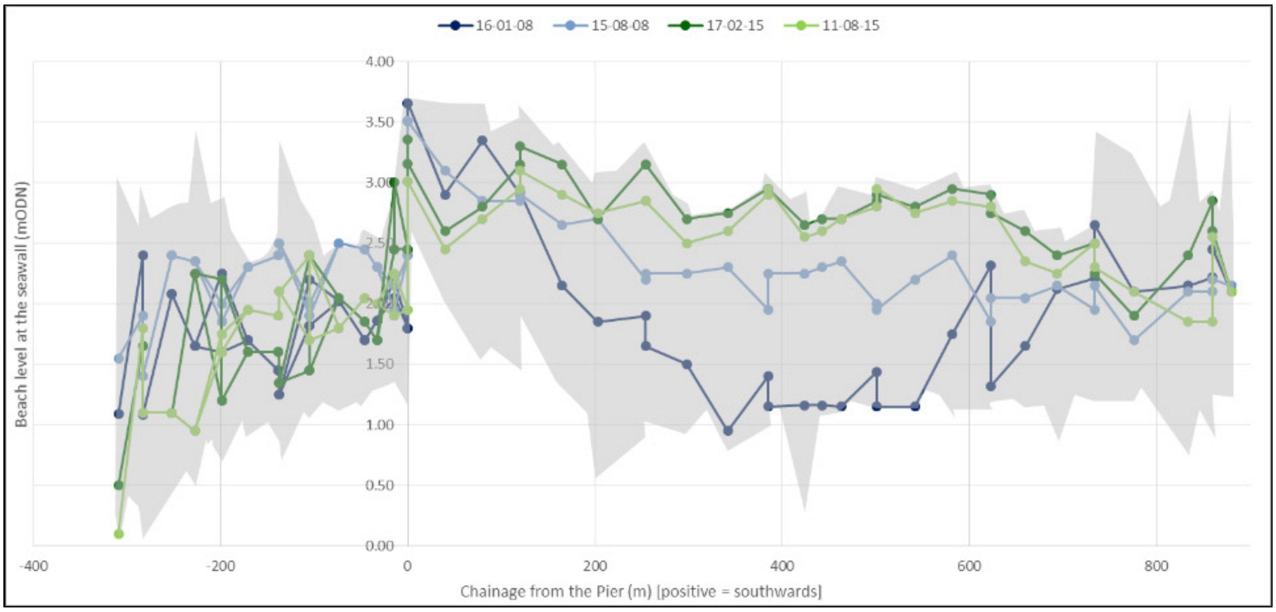

Figure 24 Beach dip information 2008 (Post Scheme) and 2015 (ENBE, 2016)

North of the pier, there is a general trend of reduction in beach level and an increase in variability towards the transition to the EA Easton Marsh section. There seems to be a split at approximately -200m where north of this point 2015 levels are below the 2008 levels. However, south of this point, towards the pier, levels are generally at or above the 2008 levels. Volatility generally increases away from the pier.

Immediately south of the pier (chainage 0-100 m) there is a general trend of reduction in beach level post the 2006 scheme which changes following chainage 100 m where beach levels appear to be healthy and significantly greater than those recorded in 2008 post scheme. At approximately 600 m chainage, beach levels appear to become lower and there is little difference between 2008 and 2015 levels. Variability indicated by the envelope of data points suggest this is an area of high volatility (ENBE, 2016).

2018 Beach dip analysis

Since the start of the Initial Assessment study, WDC have been undertaking beach dip measurements along the EA frontage between groynes R4 and R8, and this data is shown in

Figure 25. The graph includes indications of the level of the clay layer at the frontage based on borehole (B1) and trial pit (P16) investigations undertaken prior to the PAR stage (S.I.C., 2003). The clay layer has historically been felt to be an important defence consideration, since its loss through erosion would expose the more easily erodible strata beneath, potentially accelerating exposure of the sheet piled toe of the defence. The location of the ground investigation data is within bay R4-R5 and may not be representative of the ground levels along the entire Easton Marshes wall, particularly as the boreholes are south of the location of a former estuary. Bays R4-R6 have generally been stable for the 6 months of the survey but the centre of the bays are generally at or below the emergency trigger levels. Bays R6 to R8 have shown significant variability with the bays filling in significantly over the last two months although levels are still below the action trigger levels. The emergency level at the WDC Easton Marshes is -0.3 m ODN and at EA Easton Marshes section is -2.2 m ODN (see Table 4).

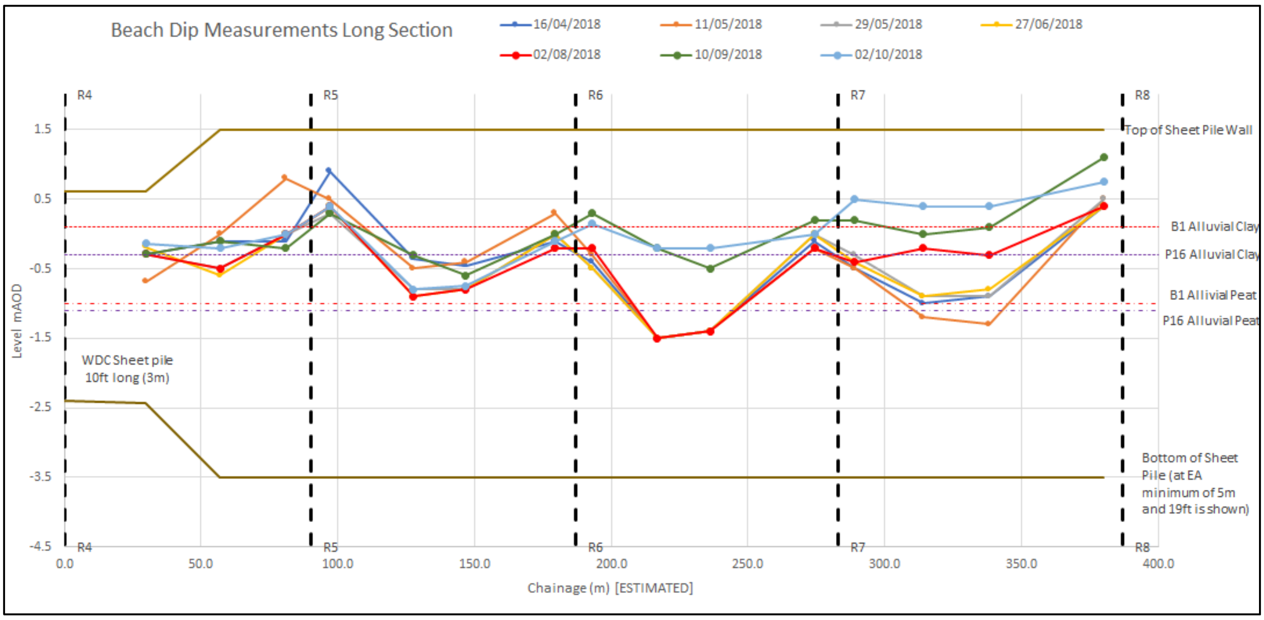

Figure 25 Beach dip analysis R4-R8

The dip data indicates that the greatest degree of pile exposure has been between R6 and R8,and illustrates a general recovery of levels over the 2018 summer, likely in response to the prevalence of mild northerly conditions creating southerly drift of material from the north being carried across the Easton Marshes frontage. The southerly passage of material was evidenced by the creation of a 'spit' of beach extending across the seaward ends of the groynes (see Figure 26 below). Although the conditions brought about a modest increase in beach levels at the toe, as of September 2018, conditions have not been conducive to promote significant onshore movement of this material and a more substantial recovery of the beaches within the bays.

Figure 26 Showing result of prolonged southerly drift across seaward ends of Easton Marsh groynes (photo taken 16 July 2018)

Summary of beach analysis

Table 5 summarises the beach analysis for the study area frontages.

Table 5 Summary of beach analysis

Location	General	Considerations for IA
Easton Marshes	General trend of erosion in the northern bays shown in profile analysis with levels below the action levels and approaching emergency levels. Tide marks are at the wall. Emergency levels at EA Easton Marshes are lower than at WDC Easton Marshes likely due to differences in pile length. 2018 beach dip data over 6 months indicates that significant variability in levels is possible over a short timeframe but even with beach infilling action levels have been exceeded at the EA wall and emergency levels (in bay R4-R5) at the WDC wall. ENBE 2016 analysis shows beach levels more stable in two bays north of pier, following initial erosion trend but action levels have been exceeded.	Beach levels at EA Easton Marshes are significantly lower than 2006 PAR scheme levels and the speed at which this has occurred suggest that the frontage is not conducive to holding a beach without more frequent recharge. Consider protecting the exposed seawall in any works. No profile data exists or recent dip data examined for the most northern bay of WDC Easton Marshes but the behaviour is likely between the transition bay (R4-R5), where the 0 contour is back at the seawall, and bay R2-R3 where, although at action level, some beach crest remains. It is likely that improvements can be made to beach retention at this point, although pressure will likely increase in the future.
Southwold Town	The general trend of erosion in the two bays south of the pier (T6-T8) has slowed from pre-scheme. The bays are showing levels of fluctuation and are only just above the BMP action level. Bays between T2 and T5, the general trend is for accretion, particularly towards the end of the ENBE study time frame. Bay T1-T2 has an overall trend of erosion with intermittent spells of accretion. This is supported by the ENBE beach dip data.	Suggests works required in bays immediately south of pier. Works between T2 and T5 are not required. Fluctuation noticed in bay T1-T2 but at this location redistribution of material from the Denes, as required, is likely sufficient.

Evaluation of residual life

A reappraisal of the residual life provided in ENBE 2016 was undertaken based on a qualitive assessment of the condition of the defences up to 2018.

The Do-Nothing assessment of residual life is as follows:

- WDC Town = 18 years (increasing southward towards the Denes)
- WDC Easton Marshes < 5 years* (based on the section of wall north of R4)
- EA Easton Marshes < 5 years

Repair works at the EA section of the Easton Marshes Seawall are being undertaken and investigations and works at the WDC Easton Marshes Seawall are anticipated in Spring 2019. Residual life at the Easton Marshes seawall has therefore been extended from 1 year to account for these repairs. Given the poor condition of the remaining toe piling, a residual life estimate of less than 5 years is considered appropriate.

*If the WDC repair works don't go ahead as planned in Spring 2019, then a residual life estimate of 1 year for their portion of the Easton Marshes wall could be considered appropriate.

Existing beach access

The beach access ramp is located immediately to the north of groyne R4 (Figure 28) and marks the transition between the WDC and EA frontage. At this location the beach is significantly lower than the seaward end of the ramp (Figure 27 and Figure 29) making plant access to the beach very difficult. The sheet pile is exposed and showing visible signs of significant deterioration (see Figure 15 and Figure 16). Beach Profile SW21 is located closest to this location and the survey data suggests that the profile is now at the levels shown before the PAR scheme (see beach volatility analysis). This profile also shows the greatest erosion rate likely due to its location at the change of alignment of the seawall at the location of the ramp (ENBE, 2016).

Figure 27 View towards ramp from WDC frontage, geotextile in foreground from previous revetment works, change of section noticeable (picture taken 6 March 2018)

Figure 28 View from EA seawall towards access ramp (taken 16 July 2018)

Figure 29 Front view of ramp (pictures taken 16 July 2018)

Transition to Easton Bavents Cliffs

Where the EA seawall at Easton Marshes transitions to the Easton Bavents cliffs (Figure 30) a risk of outflanking exists as the cliffs continue to erode due to the ongoing action of the waves. As this process continues, the hard defences at Southwold will increasingly cause it to behave as a headland. The seawall terminates with a sheet pile installed perpendicular to the defence line (Figure 31). The sheet pile return is protected by a number of tripod concrete armour units formed as a revetment along the transition point and the remains of material deposited there between 2002 and 2005 (Figure 32) although the sheet pile does show indications of weathering (Figure 34) there are currently no visible signs of this defence being outflanked (Figure 35 and Figure 36). Either the sheet pile failing or outflanking would cause the seawall to lose stability resulting in failure. The cliff/EA sea wall transition will also become more of a trap to southerly sediment flows in the future, potentially reducing the supply available to Southwold frontage, as the cliffs continue to erode back relative to the fixed end of the seawall and the beach widens. If the area immediately north of the EA wall becomes a sediment store, then it could also become a potential source of sediment to feed the beaches to the south, although the logistics of moving material from this location would need consideration.

Data from the EA's report of Cliff Recession in the Anglian coastal monitoring area (RP047/A/2017, August 2017) indicates that recession between the end of the EA seawall to 500m north have reduced from 1.4 - 3.3m/year pre-scheme (1992-2005), to 0.2 - 0.7m/year post-scheme (2005-2015).

Concerns have been raised regarding public safety – the beach in front of Eastern Bavents cliffs is popular with walkers and there is currently no safe access off the end of the seawall. There is currently only an ad hoc arrangement (see Figure 32 and Figure 33). If scheme proposals involve works in this location, then this will provide an opportunity to create safer public access onto the beach at the northern end of the scheme. As discussed in the previous section, the only current beach access for maintenance is the existing ramp at the transition with the WDC frontage which is a considerable distance from this location and is also vulnerable to beach level fluctuation. If a scheme were to incorporate improved public and plant access at its northern end, this would greatly improve the ability and reliability of beach access for maintenance, particularly over the EA section and on to Easton Bavents.

A new access point could be provided in the form of a plant ramp or public access steps attached to the end of the seawall on to the beach at the transition point. An alternative could be formed by excavating into the material deposited behind the tripod units, close to the cliff face. Creating a 'soft' access ramp excavated into the existing material in this way has the advantage of being more flexible and easily maintained in the light on anticipated future changes in beach level and orientation of the cliff line. Any access (plant or public) would be subject to discussions with landowners.

Figure 30 Looking from Easton Bavents towards termination of Easton Marshes seawall (picture taken 20 June 2018)

Figure 31 Termination of Easton Marshes seawall protected by Tripod concrete armour units (picture taken 12 December 2017)

Figure 32 Extent of Tripod armour units (picture taken 20 June 2018)

Figure 33 Ad hoc beach access arrangement at termination of Easton Bavents seawall (picture taken 12 December 2017)

Figure 34 Condition of sheet pile at termination of Easton Marshes seawall and ad-hoc beach access (picture taken 12 April 2018)

Figure 35 Easton Bavents cliffs and promontory formed from remains of material deposited in 2002-2005 (picture taken 20 June 2018)

Figure 36 Looking from atop promontory, to the north along Easton Bavents Cliffs (picture taken 20 June 2018)

Table 6 summarises the issues experienced within the study area and identifies the objectives that possible options must satisfy:

Table 6 Summary of problems and objectives at frontages

Location	Problems	Objectives
EA Easton Marshes	Lowered foreshore levels. Increased overtopping. Exposed and deteriorating toe piles. Heightened risk of seawall instability from pile deterioration and undermining. Non-retention of protective beach. Outflanking risk. No maintenance plant access or safe access for public.	Ensure integrity and stability of seawall. Reduce overtopping. Allow passage of material feeding beaches to the south. Provide safe public access to beach. Reduce outflanking risk.
WDC Easton Marshes	Lowered foreshore levels. Beach volatility. Increased overtopping. Exposed and deteriorating toe piles. Heightened risk of seawall instability from pile deterioration and undermining. Lowered beach levels in front of existing ramp preventing easy access to beach for maintenance plant.	Ensure integrity and stability of seawall. Reduce overtopping. Retain beach material for amenity value. Allow passage of material feeding beaches to the south. Improve beach access for maintenance plant from existing ramp.
Southwold Town	Beach level volatility. Reduction in beach width. Increased overtopping.	Less beach volatility and overtopping. Improved beach width.

3. Options assessment

Following an initial appraisal of the Southwold frontage including review of previous work and studies, a long-list of options was established which was submitted to EA, WDC and ENBE Ltd. (acting on behalf of WDC) for review which allowed the key partners the opportunity comment upon and be involved in the options development and appraisal process. Following the review, the long-list was updated and a preliminary short-list established. This was again submitted for review before the final short-list was determined.

Long list of options

To aid the consideration of possible solutions at Southwold, the frontage was notionally split into three sections based on the different constraints and drivers affecting coastal protection and/or the lead authority responsible for the frontage, **whilst still being cognisant of the fact that any options developed would ultimately need to recognise the overall frontage's interdependencies and be compatible with the performance of the IA frontage as a whole**. The three frontages identified were:

- Waveney District Council (WDC) town frontage; located south of the pier, a frontage comprising amenity beach and timber beach control structures and a promenade atop a seawall.
- WDC Easton Marshes frontage; located north of the pier, a frontage consisting of amenity beach and rock groyne structures and seawall promenade which extends to an access ramp at the end of the paved car park behind the seawall.
- Environment Agency (EA) Easton Marshes frontage; located north of the pier from the access ramp to the start of the cliffs at Easton Bavents - enclosed embayments contained between rock groynes with a stepped concrete seawall behind.

The full technical appraisal of long-list options can be found in Appendix B.

WDC Town frontage – long-list options assessment

Table 7 details the long-list options at the WDC town frontage.

Table 7 Long-list options identified for WDC Town frontage

Long-list reference ID	Name	Description of works
TF LL DN	Do-Nothing	No repair, maintenance or other works would be carried out other than necessary actions to deal with immediate health and safety risks.
TF LL DM	Do-Minimum	Removal of material from area of beach that is accreting (e.g. The Denes) to feed the groyne bays that have depleted to maintain the trigger levels detailed in the Beach Management Plan.
TF LL PAR	Implement existing PAR	Continue with works to WDC Town frontage from current scheme detailed in the existing PAR.
TF LL 1	Beach recycling	Removal of material from area of beach that is accreting (e.g. The Denes) to feed the groyne bays that have depleted.
TF LL 2	Beach nourishment (existing grading)	Beach nourishment along frontage and periodic replenishment through nourishment or recycling. Requirement likely for Pier-T8 and T8-T7 and T7-T6.
TF LL 3	Beach nourishment (coarser grading)	Beach Nourishment with a coarser shingle material along frontage to provide greater stability due to larger particle size and encourage a steeper beach slope to form between the existing groynes. Would require initial nourishment and periodic replenishment through nourishment or recycling. Requirement likely for bays Pier-T8, T8-T7 and T7-T6.
TF LL 4	Lengthen timber groyne(s) with nourishment	Lengthening the timber groynes at the WDC frontage south of the pier to reduce the amount of material lost from long-shore processes and reduce material escaping the bay under cross-shore conditions. Would require initial nourishment and periodic replenishment through nourishment or recycling. Requirement likely for bays Pier-T8, T8-T7 and T7-T6.
TF LL 5	Reduce timber groyne spacing with nourishment	The introduction of shorter timber groynes at the centre of affected groyne bays to increase the beach width allowing more stable bays to form. Would require initial nourishment and periodic replenishment through nourishment or recycling. Requirement likely for Pier-T8, T8-T7 and T7-T6.
TF LL 6	Modify timber groynes (T-Head) with nourishment	Introduction of T-Head feature to end of existing timber groynes (most likely with rock for resilience/low maintenance reasons although would require permission of WDC planners who are likely to object to use of rock) to reduce effective groyne spacing and provide a sheltering effect landward of the head reducing cross-shore losses. Would require initial nourishment and periodic replenishment through nourishment or recycling. Requirement likely for bays Pier-T8, T8-T7 and T7-T6 which are most volatile.
TF LL 7	Offshore Reefs with nourishment	Construct small offshore reefs (possibly submerged) within existing bay(s) to reduce cross-shore losses and promote creation of crenulate-shape embayments. Would require initial nourishment and periodic replenishment through nourishment or recycling.
TF LL 8	Rock revetment between existing groyne bay(s)	Construction of a rock revetment across the WDC Town frontage between the existing groyne bays. Pile plating or repiling may also be required to safeguard seawall integrity against future low beach levels and pile exposure and corrosion. Would require permission of WDC planners who are likely to object to use of rock.
TF LL 9	Proactive management of timber groyne board height	Reduce/increase height of groynes to better manage and control the quantity of material moving to the north and the south, as required.
TF LL 10	Steel plating	Where sheet pile at seawall toe has been exposed use steel plating to patch and repair existing sheet piles as they near end of life. Following plating drill down and inject concrete into voids.

Table 8 details the long-list options at the WDC town frontage rejected at appraisal stage along with the reason for rejection.

Table 8 Long-list options for WDC town frontage rejected at Initial Assessment appraisal stage

Long-list reference ID	Option	Reason for rejection
TF.LL 1	Beach Recycling	Insufficient material available from the Denes to renourish entire frontage. Should be considered as part of a more comprehensive option.
TF LL 3	Beach Nourishment (coarser grading)	Diminished amenity of the bays. Larger material more likely to damage timber groynes.
TF LL 7	Offshore Reefs	Change to seaward vista and general feel of Southwold frontage. Technically challenging requiring modelling to get position of reefs correct and also marine construction. Cost in comparison to timber options likely prohibitive. May negatively impact longshore movement.
TF LL 8	Rock revetment between existing groyne bay(s)	Current beach levels are sufficiently high to protect the seawall, so the expense of rock revetment at this location is difficult to justify. Would have amenity impacts.
TF LL 9	Proactive management of timber groyne board height	Would require frequent monitoring, close management and flexible manpower resourcing. Technically would be difficult to predict and therefore unlikely to meet project objectives.
TF LL 10	Steel Plating	Current beach levels are sufficiently high to protect the seawall. If Seawall is exposed and plating required, then stability would be an issue.

WDC Easton Marshes frontage – long-list options assessment

Table 9 details the long-list options at the WDC Easton Marshes frontage.

Table 9 Long-list options identified for WDC Easton Marshes frontage

Long-list reference ID	Name	Description of works
WEM BL DN	Do-Nothing	No repair, maintenance or other works would be carried out other than necessary actions to deal with immediate health and safety risks.
WEM BL DM	Do-Minimum	Patch and repair existing seawall. Use rock from existing structures to provide stability to wall when critical beach levels are exceeded.
WEM LL PAR	Implement existing PAR	Continue with works to Easton Marshes frontage from current scheme detailed in the existing PAR.
WEM LL 1	Beach recycling	Removal of material from area of beach that is accreting (e.g. The Denes) to feed the groyne bays that have depleted. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion.
WEM LL 2	Beach nourishment (existing grading)	Beach nourishment along frontage. Retain existing groynes unmodified. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion.
WEM LL 3	Beach nourishment (coarser grading)	Nourishing the WDC EM groyne bays with a coarser shingle material would provide greater stability due to larger particle size and encourage a steeper beach slope to form between the existing groynes. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion.
WEM LL 4	Modification of existing groyne length with nourishment	Groynes at WDC EM could be lengthened to better hold material under long-shore conditions, and reduce material escaping the bay under cross-shore conditions. Would require nourishment. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Two approaches are possible depending on the approach at EA EM; remove R4 and undertake works to bays R1-R2 and R2-R3 or leave R4 in place and undertake works to R1-R2, R2-R3 and R3-R4.
WEM LL 5	Modification of existing groyne	Construction of new groynes (timber) between existing rock groynes at WDC EM to create a more compressed beach plan shape. Would require nourishment. Pile plating or repiling and repairs to the concrete wall may

Long-list reference ID	Name	Description of works
	spacing with nourishment	also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Two approaches are possible depending on the approach at EA EM; remove R4 and undertake works to bays R1-R2 and R2-R3 or leave R4 in place and undertake works to R1-R2, R2-R3 and R3-R4.
WEM LL 6	Modification of existing groyne shape/type with nourishment	Modify the seaward extent of WDC EM groynes to create 'T' head or 'Y' shape groynes. Would require nourishment. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Two approaches are possible depending on the approach at EA EM; remove R4 and undertake works to bays R1-R2 and R2-R3 or leave R4 in place and undertake works to R1-R2, R2-R3 and R3-R4.
WEM LL 7	Create offshore reefs between existing groyne(s) with nourishment	Construct small offshore reefs (possibly submerged) within existing bays to reduce cross-shore losses and promote creation of crenulate-shape, embayments. Would require nourishment. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Two approaches are possible depending on the approach at EA EM; remove R4 and undertake works to bays R1-R2 and R2-R3 or leave R4 in place and undertake works to R1-R2, R2-R3 and R3-R4.
WEM LL 8	Retain existing groynes and construct additional rock revetment	Install rock revetment between groyne bay(s) to provide support to the seawall and scour protection to the toe of the structure. The toe of the revetment should be designed to be installed at a level below future predicted beach levels. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion.
WEM LL 9	Dismantle groyne(s) to create rock revetment	Dismantle existing rock groyne(s) and use the rock as part of the construction of a rock revetment across the WDC EM frontage. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion abrasion.
WEM LL 10	Steel plating	Where sheet pile at seawall toe has been exposed use steel plating to patch and repair existing sheet piles as they near end of life. Following plating drill down and inject concrete into voids.
WEM LL 11	Managed Realignment	Creation of setback embankment behind existing WDC EM defence. Remove existing seawall and groynes. Provide erosion protection to promontory created north of Pier. Remove areas of seawall that have been abandoned due to realignment. Improve existing/ create suitable beach access ramp to ensure access to foreshore following the realignment.

Table 10 details the long-list options at the WDC Easton Marshes frontage rejected at appraisal stage along with the reason for rejection.

Table 10 Long-list options at WDC Easton Marshes frontage rejected at Initial Assessment appraisal stage

Long-list reference ID	Option	Reason for rejection
WEM LL 1	Beach recycling	Insufficient material available from the Denes to renourish entire frontage. Transport to area north of the pier likely problematic.
WEM LL 2	Beach Nourishment (existing grading)	Increasing pressure along this frontage means holding a beach will become more difficult with the period of recharge increasing with time and therefore recharge is likely to be prohibitively expensive.
WEM LL 3	Beach nourishment (coarser grading)	Diminished amenity of the bays. To ensure material remains within extents of groyne then a significantly large material is likely required.

WEM LL 7	Create offshore reefs between existing groynes	Change to seaward vista and general feel of Southwold frontage. Technically challenging requiring modelling to get position of reefs correct and also marine construction would be required. May negatively impact longshore movement.
WEM LL 8	Retain existing groynes and construct additional rock revetment	Current beach levels are sufficiently high in bays R1-R3 to protect the seawall and issues can be likely managed with groyne modification so the expense of rock revetment at this location is difficult to justify. Would have amenity impacts. May be considered in combination with other options as pressure on WDC frontage increases.
WEM LL 9	Dismantle groyne(s) to create rock revetment	Current beach levels are sufficiently high in bays R1-R3 to protect the seawall and issues can be likely managed with groyne modification so the expense of rock revetment at this location is difficult to justify. Would have amenity impacts. May be considered in combination with other options as pressure on WDC frontage increases. Greater exposure of the pier supports could require discrete protection.
WEM LL 10	Steel Plating	As beach levels lower there would be increasing risk of geotechnical instability that would not be counteracted with plating alone.
WEM LL 11	Managed Realignment	Not necessary or appropriate at this stage. Current issues can be addressed by more cost-effective options. Could be more appropriate in the future as erosion pressure increases along the EM frontage as the cliffs continue to erode.

EA Easton Marshes frontage – long-list options assessment

Table 11 details the long-list options at the EA Easton Marshes frontage.

Table 11 Long-list options identified for EA Easton Marshes frontage

Long-list reference ID	Name	Description of works
EAEM BL DN	Do-Nothing	No repair, maintenance or other works would be carried out other than necessary actions to deal with immediate health and safety risks.
EAEM BL DM	Do-Minimum	Patch and repair existing seawall. Use rock from existing structures to provide stability to wall when critical beach levels are exceeded.
EAEM PAR	Implement existing PAR	Continue with works to Easton Marshes frontage from current scheme detailed in the existing PAR.
EAEM LL 1	Beach recycling	Removal of material from area of beach that is accreting (e.g. The Denes) to feed the groyne bays that have depleted. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion.
EAEM LL 2	Beach nourishment (existing grading)	Beach Nourishment along EA EM frontage. Retain existing groynes unmodified. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Create access through modification of existing cliff face allowing beach access at the northern extent of scheme.
EAEM LL 3	Beach nourishment (coarser grading)	Nourishing the EA EM groyne bays with a coarser shingle material to provide greater stability due to larger particle size and encourage a steeper beach slope to form between the existing groynes. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Create access through modification of existing cliff face allowing beach access at the northern extent of scheme.
EAEM LL 4	Modification of existing groyne length with nourishment	Lengthen existing rock groyne(s) over EA EM frontage to better hold material under long-shore conditions, and reduce material escaping the bay under cross-shore conditions. Would require nourishment. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Would also require a robust solution to deal with the outflanking risk at the northern end of the wall. Create

Long-list reference ID	Name	Description of works
		access through modification of existing cliff face allowing beach access at the northern extent of scheme.
EAEM LL 5	Modification of existing groyne spacing with nourishment	Construction of new rock groyne(s) between existing rock groynes at EA EM frontage to create a more compressed beach plan shape. Would require nourishment. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Would also require a robust solution to deal with the outflanking risk at the northern end of the wall. Create access through modification of existing cliff face allowing beach access at the northern extent of scheme.
EAEM LL 6	Modification of existing groyne shape/type with nourishment	Modify the seaward extent of EA EM groyne(s) to create 'T' head or 'Y' shape groynes. Would require nourishment. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Would also require a robust solution to deal with the outflanking risk at the northern end of the wall. Create access through modification of existing cliff face allowing beach access at the northern extent of scheme.
EAEM LL 7	Create offshore reefs between existing groyne(s) with nourishment	Construct small offshore reefs (possibly submerged) within existing bay(s) to reduce cross-shore losses and promote creation of crenulate-shape, embayments. Would require nourishment. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion. Would also require a robust solution to deal with the outflanking risk at the northern end of the wall.
EAEM LL 8	Retain existing groynes, create new rock revetment and construct new northern control structure	Install modified/J-shape groyne at northern extent of EA EM wall to promote formation of a stable embayment within the cliff frontage to the north and facilitate maintenance access. Extend across toe of cliff to reduce EA EM wall outflanking risk. Install rock revetment between groyne bay(s) affected by beach drawdown to provide support to the seawall and scour protection to the toe of the structure. The toe of the revetment should be designed to be installed at a level below future predicted beach levels. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion.
EAEM LL 9	Dismantle existing groynes, create new rock revetment and construct new northern control structure	Install modified/J-shape groyne at northern extent of EA EM wall to promote formation of a stable embayment within the cliff frontage to the north and facilitate maintenance access through modification of existing cliff face. Extend across toe of cliff to reduce EA EM wall outflanking risk. Dismantle existing rock groynes and use the rock to construct a rock revetment across the EA EM frontage to provide support to the seawall and scour protection to the toe of the structure. The toe of the revetment should be designed to be installed at a level below future predicted beach levels. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion.
EAEM LL 10	Retain existing groynes. New detached reef control structure and additional rock revetment	Create offshore structure at northern extent of EA EM frontage to allow long-shore moving material to bypass structure whilst reducing net erosion at the southern end of the cliffs. Structure would be positioned to allow salient to form in the lee protecting cliffs and encouraging stable bay formation, whilst still allowing material to move long-shore. Would require rock revetment at northern end to provide additional erosion protection. Install rock revetment between groyne bays affected by beach drawdown to provide support to the seawall and scour protection to the toe of the structure. The toe of the revetment should be designed to be installed at a level below future beach levels. Create access through modification of existing cliff face allowing beach access at the northern extent of scheme. Pile plating or repiling and repairs to the concrete wall may also be required to safeguard seawall integrity against low beach levels, pile exposure and continued corrosion and abrasion.

Table 12 details the long-list options at the EA Easton Marshes frontage rejected at appraisal stage along with the reason for rejection.

Table 12 Long-list options at WDC Easton Marshes frontage rejected at Initial Assessment appraisal stage

Long-list reference ID	Option	Reason for rejection
EAEM LL 1	Beach Recycling	Insufficient material available from the Denes to renourish entire frontage. Transport to area north of the pier likely problematic.
EAEM LL 2	Beach nourishment (existing grading)	Increasing pressure along this frontage means holding a beach will become more difficult. Does not have the same amenity implications as WDC frontage as beach is closed to public.
EAEM LL 3	Beach nourishment (coarser grading)	Increasing pressure along this frontage means holding a beach will become more difficult. Does not have the same amenity implications as WDC frontage as beach is closed to public.
EAEM LL 4	Modification of existing groyne length	Historically groynes along this frontage shorter than WDC groynes. Longer groynes could starve beaches to the south and accelerate erosion of the cliffs and increase the outflanking risk to the north. Increasing pressure along this frontage means holding a beach will become increasingly difficult and threaten beach levels at toe of seawall. Does not have the same amenity implications as WDC frontage as beach is closed to public.
EAEM LL 5	Modification of existing groyne spacing	Increasing pressure along this frontage means holding a beach will become increasingly difficult and threaten beach levels at toe of seawall. Does not have the same amenity implications as WDC frontage as beach is closed to public.
EAEM LL 6	Modification of existing groyne shape/type	Increasing pressure along this frontage means holding a beach will become increasingly difficult and threaten beach levels at toe of seawall. Does not have the same amenity implications as WDC frontage as beach is closed to public.
EAEM LL 7	Create offshore reefs between existing groyne(s)	Technically challenging requiring modelling to get position of reefs correct and also marine construction would be required. May negatively impact longshore movement.
EAEM LL 10	Retain existing groynes. New detached reef control structure and additional rock revetment	Likely costly and technically challenging and would require significant analysis and modelling during design with the risk of it still not providing suitable solution at extent of frontage to reduce outflanking risk. Would require marine plant to construct.
EAEM LL 11	Dismantle existing groynes. New rock revetment with new detached reef control structure.	Likely costly and technically challenging and would require significant analysis and modelling during design with the risk of it still not providing suitable solution at extent of frontage to reduce outflanking risk. Would require marine plant to construct.
EAEM LL 12	Steel Plating	As beach levels lower there would be increasing risk of geotechnical instability that would not be counteracted with plating alone.
EAEM LL 13	Managed realignment	Not necessary or appropriate at this stage. Issues can be addressed by more cost-effective options. Could be more appropriate in the future as erosion pressure increases along the EM frontage as the cliffs continue to erode.

Shortlisted options description

As with the long-list options, the short-list options have been grouped by frontage. All short-list options have been qualitatively appraised in respect of their technical characteristics as possible solutions to the problems identified within this Initial Assessment.

Table 13 details the options short-listed at the WDC town frontage.

Table 13 Options short-listed for WDC town frontage at Initial Assessment appraisal stage

Long-list Ref ID	Option	Reason for adoption	Short-list Ref ID
TF DN	Do-Nothing (No repair)	Used in appraisal to act as a baseline against which all other options are tested.	TF BL 1
TF DM	Do-Minimum (Patch and repair)	Used in appraisal to act as a baseline against which all other options are tested.	TF BL 2
TF PAR	Implement PAR	Implement the programme of works outlined in the existing PAR. Options should be appraised against implementing existing PAR.	TF PAR
TF LL 2	Beach Nourishment (existing grading)	Possible to protect wall through management of beach levels through ongoing programme of nourishment with increasing frequency over the life of scheme.	TF SL 1
TF LL 4	Lengthen timber groyne(s)	Increasing length of groyne should retain more sand within embayments.	TF SL 2
TF LL 5	Reduce timber groyne spacing	Reducing spacing of groynes should allow for a more compact and stable beach plan to develop.	TF SL 3
TF LL 6	Modify timber groynes (T-Head)	Reducing the effective spacing of groynes will allow for a more compact beach plan shape. This option would provide the greatest protection from cross shore conditions although would likely face objections from WDC planners.	TF SL 4

Table 14 details the options short-listed at the WDC Easton Marshes frontage.

Table 14 Options short-listed for WDC Easton Marshes frontage at Initial Assessment appraisal stage

Long-list Ref ID	Option	Reason for adoption	Short-list ID
WEM DN	Do-Nothing (No repair)	Used in appraisal to act as a baseline against which all other options are tested.	WEM BL 1
WEM DM	Do-Minimum (Patch and repair)	Used in appraisal to act as a baseline against which all other options are tested.	WEM BL 2
WEM PAR	Implement PAR	Implement the programme of works outlined in the existing PAR. Options should be appraised against implementing existing PAR.	WEM PAR
WEM LL 4	Modification of existing groyne length	Increasing length of groyne should retain more sand within embayments.	WEM SL 1
WEM LL 5	Modification of existing groyne spacing	Reducing spacing of groynes should allow for a more compact and stable beach plan to develop.	WEM SL 2
WEM LL 6	Modification of existing groyne shape/type	T- Head likely preferred arrangement. Reducing the effective spacing of groynes will allow for a more compact beach plan shape. This option would provide the greatest protection from cross shore conditions.	WEM SL 3

Table 15 details the options short-listed at the EA Easton Marshes frontage.

Table 15 Options short-listed for the EA Easton Marshes frontage at Initial Assessment appraisal stage

Long-list Ref ID	Option	Reason for adoption	Short-list ID
EAEM DN	Do-Nothing (No repair)	Used in appraisal to act as a baseline against which all other options are tested.	EAEM BL 1
EAEM DM	Do-Minimum (Patch and repair)	Used in appraisal to act as a baseline against which all other options are tested.	EAEM BL 2
EAEM PAR	Implement PAR	Implement the programme of works outlined in the existing PAR. Options should be appraised against implementing existing PAR.	EA PAR
EAEM LL 8	Retain existing groynes, create new rock revetment and construct new northern control structure (J Groyne)	Rock revetment would provide increased stability to seawall to combat lowering beach levels. Revetment should reduce overtopping and reduce scour in front of the wall. Retaining existing groynes should act to keep beach levels more stable compared to if they are removed and reduce pressure on WDC Easton Marshes frontage. J Groyne structure would create a fixed point and reduce risk of erosion and outflanking at northern extent of Easton Marshes wall by encouraging accumulation of material in its lee also providing an area suitable for beach access.	EAEM SL 1
EAEM LL 9	Dismantle existing groynes, create new rock revetment ad construct new northern control structure (J Groyne)	Rock revetment would provide increased stability to seawall to combat lowering beach levels. Revetment should reduce overtopping and reduce scour in front of the wall. J Groyne structure would create a fixed point and reduce risk of erosion and outflanking at northern extent of Easton Marshes wall by encouraging accumulation of material in its lee also providing an area suitable for beach access.	EAEM SL 2

Interaction between frontages

Before selecting a preferred option, the interaction between the separate frontages was considered to enable a consistent approach to be adopted along the whole study area that would not impact adversely on neighbouring frontages. This also allowed sub-options to be developed for the transition between the WDC and EA sections at Easton Marshes; with options ranging from leaving the groynes at the EA EM frontage intact, to removing groynes at the EA frontage and extending the proposed revetment in to the WDC EM frontage.

The sub-options which have been labelled as sensitivities are described in Table 16 below (note: WDC Easton Marshes sensitivities b, d and f are not reported).

Table 16 Option sensitivities

Frontage	Sensitivity	Compatibility
WDC Town frontage	No sensitivities – it is assumed all town frontage options south of the pier are compatible with options north of the pier.	All options
WDC Easton Marshes	Sensitivity a – assumes that groynes remain to EA EM frontage and therefore options are based on pressure being delayed on the WDC EM frontage. As this option delays the pressure reaching the WDC EM frontage deferring costs to the Waveney frontages to later in the appraisal period would be justifiable.	Compatible with EAEM SL1
	Sensitivity c – assumes that groynes are removed along EA EM frontage with rock revetment installed and pressure point is the northern extent of WDC EM.	Compatible with EAEM SL2 a
	Sensitivity e – assumes that groynes are removed along EA frontage and also the most northerly groyne in the WDC EM frontage with the rock revetment extended south. Option moves pressure point in to WDC EM frontage.	Compatible with EAEM SL2b

Frontage	Sensitivity	Compatibility
EA Easton Marshes	Sensitivity a – assumes that the revetment only extends to the most northern groyne in the WDC EM frontage.	Compatible with WEM SL # c
	Sensitivity b – assumes that revetment extends into the WDC EM frontage.	Compatible with WEM SL # e

Cost of Options

Each shortlist option has been costed and is detailed in Appendix C - Economic Technical Appendix.

Combination Options

To ensure a suitable technical solution is developed for the entire study area the options identified within the options appraisal need to be considered in combination. Table 17 describes the combination options considered in this Initial Assessment. Further options are included in Appendix C.

Table 17 Combination option descriptions

Combination	Description	Option references
Combination 1	Do-Minimum - All frontages (Note 23 years residual life at WDC Town and 10 years residual life along Easton Marshes)	TF BL 2, WEM BL 2, EAEM BL 2
Combination 2	Cheapest Technical Option - Reduce groyne spacing WDC Town, Reduce groyne spacing and Revetment from R3-Easton Bavents including transition structure at R4 and reduced WDC EM scheme (R1-R3).	TF SL 4, WEM SL 2 e, EAEM SL 2 b
Combination 3	Preferred Technical Option - Reduce spacing at town frontage, rock T-Heads at WDC EM frontage and revetment at EA EM frontage with groynes remaining intact.	TF SL 3, WEM SL 3 a, EAEM SL 1
Combination 8	Preferred Technical Option with deferred cost at WDC Frontage.	TF SL 3 DEF, WEM SL 3 a DEF, EAEM SL 1

Costs for all combinations considered can be found in Appendix C. Development of the combination options involved a qualitative assessment of what is likely to be technically preferable whilst also considering the costs for the individual options. Options that included lengthening the existing groynes have been discarded at this stage since, of all the options considered, they would likely affect the long-shore transport of material to the greatest degree yet offer no significant cost benefit when compared to other considered options. Initial discussions with planners at Waveney District Council also suggested that the introduction of rock T-Heads along the town frontage would be considered less favourable than preserving the character of Southwold Town frontage created by the timber groyne field. This option is also considerably more expensive with PV costs (before the addition of Optimism Bias) in excess of £6.5 million, and it therefore has not been considered further. Table 19 details the costs of the four combination options that will be considered for the determination of the preferred option.

Construction cost estimates have been determined for all short-listed options from a review of similar schemes. Professional fees and additional costs have been derived by the project team and benchmarked against similar projects.

Table 18 describes the method for determining costs for the significant items. Generally, quantities were considered on a per linear metre basis but the table details where greater detail was considered.

Table 18 Method of determining quantity by item

Cost	Method of determining costs	Future considerations to improve costs
Beach Nourishment	Based on ENBE calculations of losses and PAR nourishment volumes.	Undertake full beach profile analysis along frontage to present day to have greater certainty in losses. Modelling of beach development.
Timber groyne works	Per linear metre determination.	Modelling/analysis to fine tune characteristics of control structures.
Rock groyne works	Per linear metre determination.	Estimation of section from consideration of bed and water levels. Modelling/analysis to fine tune characteristics of control structures.
Rock revetment works	Based on approximation of section from consideration of recent beach dip analysis and per volume rates.	Confirm section with longer term analysis of beach levels at wall.
Seawall plating	Per linear metre determination.	Increase understanding of the condition of seawall.

The total PV cost over the life of the scheme was then subject to an Optimism Bias (OB) adjustment. An OB of 60% has been assumed for the IA.

Table 19 Combination costs for 50 year appraisal period

Option number	Combination 1 Do-Minimum	Combination 2 Cheapest Technical Option	Combination 3 Preferred Technical Option	Combination 8 Preferred Technical Option - Deferred
Cash capital costs				
WDC Town	0	2,411,532	2,411,532	1,626,532
WDC Easton Marshes	0	2,189,350	1,997,650	1,430,600
EA Easton Marshes	0	2,015,300	2,149,700	2,149,700
Cash capital costs	**0**	**6,616,182**	**6,558,882**	**5,206,832**
Cash operation and maintenance costs				
WDC Town	840,000	1,094,210	1,094,210	919,234
WDC Easton Marshes	98,820	613,290	380,640	331,290
EA Easton Marshes	105,480	504,960	504,960	504,960
Cash operation and maintenance costs	**1,044,300**	**2,212,460**	**1,979,810**	**1,755,484**
Cash other costs				
WDC Town	0	100,000	100,000	100,000
WDC Easton Marshes	0	100,000	125,000	125,000
EA Easton Marshes	0	125,000	125,000	125,000
Cash Other Costs (Detailed design fees, Surveys etc.)	**0**	**325,000**	**350,000**	**350,000**
Cash totals				
TOTAL CASH COSTS Excluding OB	**1,044,300**	**9,153,642**	**8,888,692**	**7,312,316**

Option number	Combination 1 Do-Minimum	Combination 2 Cheapest Technical Option	Combination 3 Preferred Technical Option	Combination 8 Preferred Technical Option - Deferred
OPTIMISM BIAS (OB) (60%)	626,580	5,492,185	5,333,215	4,387,390
TOTAL CASH COSTS. Including OB	**1,670,880**	**14,645,828**	**14,221,908**	**11,699,706**
PV capital costs				
WDC Town	0	1,147,394	1,147,394	629,406
WDC Easton Marshes	0	1,300,107	1,417,355	813,805
EA Easton Marshes	0	1,745,603	1,958,095	1,958,095
PV capital costs	**0**	**4,193,104**	**4,522,844**	**3,401,306**
PV operation and maintenance costs				
WDC Town	489,910	500,663	500,663	399,657
WDC Easton Marshes	80,676	261,361	169,437	141,228
EA Easton Marshes	86,113	229,261	229,261	229,261
PV operation and maintenance costs	**656,699**	**991,285**	**899,361**	**770,146**
PV other costs				
WDC Town	0	96,618	96,618	96,618
WDC Easton Marshes	0	96,618	120,773	120,773
EA Easton Marshes	0	120,773	120,773	120,773
PV other (Detailed design fees, Surveys etc.)	**0**	**314,010**	**338,164**	**338,164**
PV Totals				
TOTAL PV COSTS. Excluding OB	**656,699**	**5,498,398**	**5,760,370**	**4,509,616**
OPTIMISM BIAS (OB) (60%)	394,019	3,299,039	3,456,222	2,705,770
TOTAL PV COSTS. Including OB	**1,050,718**	**8,797,437**	**9,216,591**	**7,215,386**
Cash Construction costs (yr 2)	0	3,143,950	3,857,200	2,209,700

The present value costs for both the cheapest and preferred technical option are relatively close (less than 500k in PV costs, less whole life cash costs). Adopting the preferred technical option of leaving the groynes along the EA frontage would also justify the delay of implementation of the preferred scheme to the Waveney frontages because the erosion pressure would be delayed in comparison with options which remove the groynes along the EA EM frontage.

Table 20 provides a whole life cash breakdown of the options including optimism bias of 60%.

Table 20 Whole life cash cost breakdown of combination options for 50 year appraisal period including Optimism Bias

	Combination 1 Do-Minimum	**Combination 2** Cheapest Technical Option	**Combination 3** Preferred Technical Option	**Combination 8** Preferred Technical Option - Deferred
Beach nourishment and recycling	0	2,242,452	2,902,452	2,262,452
Timber groyne works	0	2,784,000	2,496,000	1,440,000
Rock groyne works and modifications	0	764,800	1,368,800	1,368,800
Rock revetment works	0	3,757,440	2,866,560	2,460,480
Seawall plating	0	1,013,200	836,400	775,200
Access works	0	24,000	24,000	24,000
Capital TOTAL (£)	**0**	**10,585,892**	**10,494,212**	**8,330,932**
Rock structures maintenance	326,880	1,296,512	1,214,208	1,135,248
Timber groynes maintenance and refurbishment	0	1,754,976	1,465,040	1,286,262
Seawall maintenance	0	488,448	488,448	387,264
Beach recycling	1,344,000	0	0	0
MAINTENANCE TOTAL (£)	**1,670,880**	**3,539,936**	**3,167,696**	**2,808,775**
Design & Survey (£)	0	520,000	560,000	560,000
TOTAL (£)	**1,670,880**	**14,645,828**	**14,221,908**	**11,699,706**

Existing (2005 PAR) scheme description

Southwold is currently subject to the scheme designated in the 2005 PAR (Project Appraisal Report) (EA and WDC, 2005a) which resulted in the implementation of a coastal defence scheme in 2006 with a scheme life of 100-years along the Southwold frontage. Works included an embankment at Botany Marshes which in effect split the flood cell into two separate areas.

Table 21 details the items in the PAR due to be implemented within the IA appraisal period. Items that are not comparable to the IA study have been removed (e.g. works outside the IA study area, periodic PAR reviews etc.) so that a rudimental comparison can be made with the costs developed in the IA. Costs have been updated for inflation and future works discounted. PAR costs are based upon contractor involvement with costs established in 2005 and influences beyond inflation, specifically related to coastal construction works may not be adequately represented. Year 0 for the PAR is 2006.

Table 21 Spend profile for PAR option IA appraisal period – adjusted to present day (EA and WDC, 2005a)

Description	**PAR** Year	Adj. Year IA	Capital cost - Remove items not related to IA (£k)	PV Cost - Adjusted (£k)
Reconstruct timber groyne field over Southwold Town frontage. Recharge beach to sustain defence standard over Easton Marshes and Town frontages. Extend outflanking works.	15	3	3,062	2,762
Extend Easton Marshes outflanking works.	25	13	65	42
Reconstruct timber groyne field over the Southwold Town frontage and recharge beach to sustain defence standard over Easton Marshes and Town frontages. Repair Promenade.	30	18	3,455	1,860
Review PAR and extend Easton Marshes outflanking works.	35	23	65	30
Reconstruct timber groyne field over the Southwold Town frontage and recharge beach to sustain defence standard over Easton Marshes and Town frontages. Extend outflanking.	45	33	3,172	1,019
Extend Easton Marshes outflanking works.	55	43	65	15
Reconstruct timber groyne field over the Southwold Town frontage and recharge beach to sustain defence standard over Easton Marshes and Town frontages. Repair Promenade.	60	48	3,574	685
Capital Costs			**13,458**	**6,412**
Maintenance costs.			1,116	534
TOTAL			**14,574**	**6,946**
@ Risk 95%tile Value				**933**
TOTAL PV cost of scheme				**7,880**

4. Initial environmental assessment

An environmental checklist was prepared to establish a baseline for environmental factors affecting Southwold and the study area and to inform the optioneering process. A summary of the main identified items follows. The full checklist can be found in Appendix D.

- Multiple local, national and internationally protected nature conservation sites, both terrestrial and marine – permission for works both within and in close proximity to these will need to be agreed along with required mitigation.
- Historic town with a high density of Listed Buildings and a conservation area, and the frontage of Southwold is a heritage coastline – further study will be required on the impact on the seascape and the design of any new structures must be sympathetic to the surroundings.
- Beach frontage of Southwold is a popular tourist destination during summer months designated bathing water of excellent standard. Local economy is reliant on this tourist industry – proposed works should not limit the access to the beach frontage and must not impact on the bathing water quality.
- Suffolk Coastal Path runs parallel with the shoreline within Southwold. Preferred option should not constrain the use of this path.
- Road infrastructure is made up of narrow residential roads with only one major link road connecting Southwold to wider area (A1095) – increase in volume of traffic and movement of HGV and heavy construction plant will likely impact on local traffic during the construction phase of any scheme.
- Site of proposed works is in close proximity to residential areas, a primary school and many small businesses such as cafes, pubs, and restaurants – noise and vibration should be minimised throughout the construction phase of works
- Works are in close proximity to a WFD waterbody that is linked to multiple protected areas – the scheme must not negatively impact the status of this waterbody or the protected area and must not constrain its potential to reach good status.
- Southwold falls into the Suffolk Coasts and Heaths AONB – preferred option should maintain the landscape value of the site
- There may be requirements for temporary closure or diversion of Public Rights of Way during works.

If the project progresses the following consultations are likely to be required:

- Natural England agreement as part of HRA process
- EIA Screening opinion from the Suffolk Coastal District Council
- Engagement with local landowners and business owners regarding access
- NEAS officers, including cultural heritage and landscape specialists.
- English Heritage and Waveney District Council conservation officer
- Suffolk Coast & Heaths AONB regarding works within the AONB and to the Suffolk Coast Path
- Engagement with MMO regarding works on the shoreline

At the Initial Assessment stage no preferred option in relation to the environmental impact is established.

5. Consequences of doing nothing (Damages)

If no action is taken, the continued depletion of beach material is likely to eventually result in the complete removal of the beach within the vulnerable embayments during extreme storm events. This would result in the seawall being further exposed, increasing wave overtopping due to the higher incident water levels and also, the seawall toe would be exposed for longer periods, increasing the risk of structural instability.

If no intervention is made at the Southwold Town and along the Easton Marshes frontage, then the eventual failure of the seawall and subsequent breach from failure and/ or continuing erosion would put property and infrastructure at risk from flooding or from the eroding shoreline.

The primary source of damages to the Southwold frontage are:

- Erosion damages south of the pier
- Flood damages north of the pier

A brief description of the types of damages follow. Full analysis can be found in Appendix C - Economic Technical Appendix.

Erosion risk

The 2005 PAR assessed historic erosion rates for the Southwold frontage. The erosion rate assessment was undertaken by comparing the alignment of the coastline from historic maps at two known dates prior to the construction of the defences. Erosion damages were calculated in blocks of ten years following failure of the defences (see Figure 37).

The historic erosion rates for the study area have been applied to the Southwold Town frontage at the predicted defence failure date. It is predicted that should no work be undertaken to maintain the existing defences over the Southwold Town frontage, then beach levels would steadily drop, and a failure of the defences would occur over Years 18 to 28 (2036 to 2046). It is considered that the northern end would fail first due to its proximity to the critical Easton Marshes section, failure would then progress south as the frontage 'unzips', leading to failure of the southern-most section. For the erosion benefit analysis, failure of the Southwold Town frontage is assumed to occur in Year 18. The SMP also undertook an erosion analysis based on fixed points of 500 m intervals for a range of scenarios but the PAR approach was adopted as it was at a higher level of detail for the Southwold frontage.

Flood risk

The primary risk of flooding is tidal flooding following breaching of the Easton Marshes seawall. Based on the current condition, it is estimated that the defence has a residual life of < 5 years. Therefore, a breach could be expected to occur by year 5 if no action is taken.

For the 2005 PAR, a flood distribution model was used to predict the extent and depth of flooding over a topographic grid as a result of an assumed 100m breach in the seawall (See Figure 38 for Epoch 10, further epoch contained in Appendix C but for Do-Nothing epoch of approximately 2014 is most relevant). The western limit of the flood extent is defined by the embankment at Botany Marshes which was constructed as a recommendation of the 2005 PAR.

The flood extents and depths from the 2004 flood distribution model have been combined with the geo-referenced National Receptor Dataset and checked against Google and Bing maps and local knowledge to determine the assets at risk once breach occurs.

The residual life estimate of < 5 years was based on the assumption that the proposed toe pile plating repair works to the most severely deteriorated portion of the toe pile (which spans across the WDC/EA Easton Marshes seawall transition) will be completed. Were these works not completed, then a residual life of 1 year could be considered more appropriate.

Residential and non-residential Damages

Residential properties in the risk areas were identified from the National Receptor Dataset (NRD). The NRD data was verified using Google and OS maps to confirm the number of residential and non-residential properties.

The market value of the residential properties in Southwold were identified using Land Registry information for the East of England (http://houseprices.landregistry.gov.uk) and updated to 2018 prices using GDP Deflator Inflation Indices to the base date of Q1 2018. These values were used as write off and capping damage values.

Non-Residential Properties were identified from the National Receptor Dataset (NRD). Non-residential properties include properties such as shops, public conveniences and car parks. Market values were estimated from rateable values derived from (https://www.gov.uk/government/statistics/non-domestic-rating-business-floorspace) for the East Region and a yield factor as described in the MCM. The non-residential property market values have been updated using GDP deflator indices to Q1 2018.

Transport damages

Under the Do-Nothing option, a cost of £2,760,469 is included in Year 5 to rebuild the A1095 access road and bridge between Reydon and Southwold. This is based on the cost to build an improved road and bridge in its existing location in Year 5 to resist future flood events.

A cost of £2,324,153 is included in Year 10 for the Do-Minimum option.

Recreational and amenity benefits

For the 2005 PAR, an assessment of recreational and amenity benefits was undertaken in accordance with the MCM.

The analysis applied the perceived benefits from a recreational benefit study undertaken for a scheme at nearby Corton to Southwold visitor numbers provided by WDC.

For this Initial Assessment, the updated monetary gains and losses per adult visit with coastal protection scheme options for the Corton location were obtained from the 2018 MCM (Table 8.3) (FHRC, 2018).

Updated visitor numbers were obtained from the Economic Impact of Tourism Report, Southwold - 2015 produced by Destination Research. This report records that in 2015 there were a total of 1,393,000 day trips to Southwold and 174,000 staying nights. This gives an average of 1.567m visitors each year (Destination Research, 2015).

Other damages

In addition, the following assumptions were made in the economic assessment:

- The human related intangible benefits guidance calculates an economic value for the benefit of avoiding flooding based on the number of households and the standard of flood protection prior to and after implementation of the management option. The benefit is added to Improve schemes to monetise the effects of reduced stress (Defra, 2003). Human related intangible benefits have been valued in monetary terms in the economic damages assessment.
- Risk of injury or loss of life from flooding has been valued in monetary terms in the economic damages assessment. The FCERM-AG Risk to life guidance calculates an economic value for the risk to life in the flood area based on the number of properties at risk, the likely flood water velocity at those properties and the probability of failure of the defence.

Do-Nothing damages assessment

The Do-Nothing damages have been calculated and are detailed in Table 22. See Appendix C - Economic Technical Appendix for detailed explanation of how damages were determined.

Table 22 Do-Nothing damage summary (50 year appraisal period)

	Assets	**PV Damages (£) (50 year appraisal period)**
Erosion	Residential property (write off)	2,494,055.62
	Non-residential property (write off)	2,355,983.24
Total Erosion Damages		**4,850,039**
Flood	Direct Residential Damage incl write-offs	13,029,308
	Direct NRP Damage incl write-offs	3,142,928
	Residential accommodation/evacuation	1,200,293
	NRP Indirect	258,537
	Vehicle Damages	688,329
	Emergency Response and Recovery	2,418,808
	Risk to Life	0
Total Flooding Damages		**20,738,204**
Transport Damages		2,760,049
Recreational and Amenity Damages		28,124,194
Total PV Damages		**56,473,246**

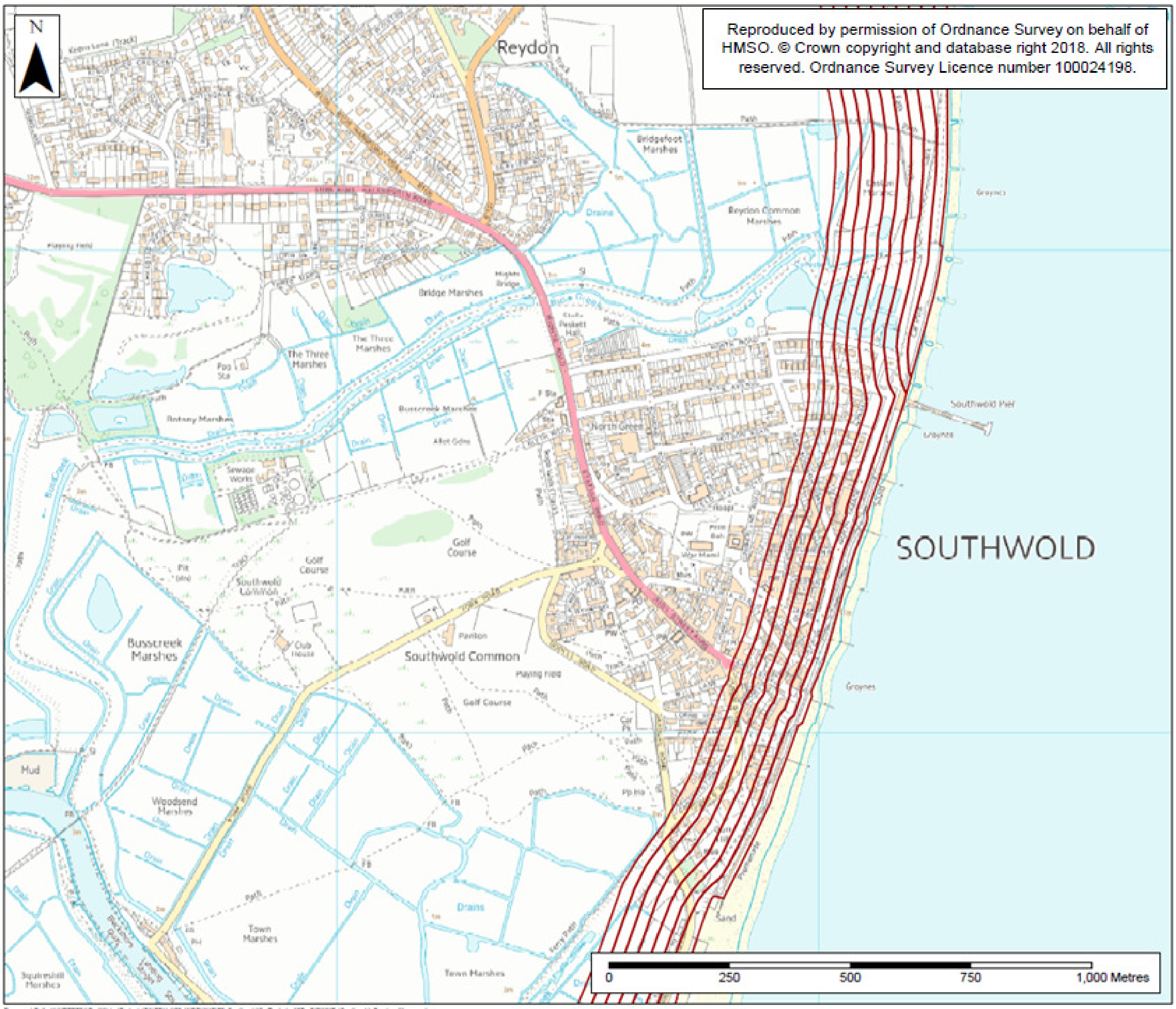

Figure 37 Erosion damage contours in 10 year epochs (EA and WDC, 2005a)

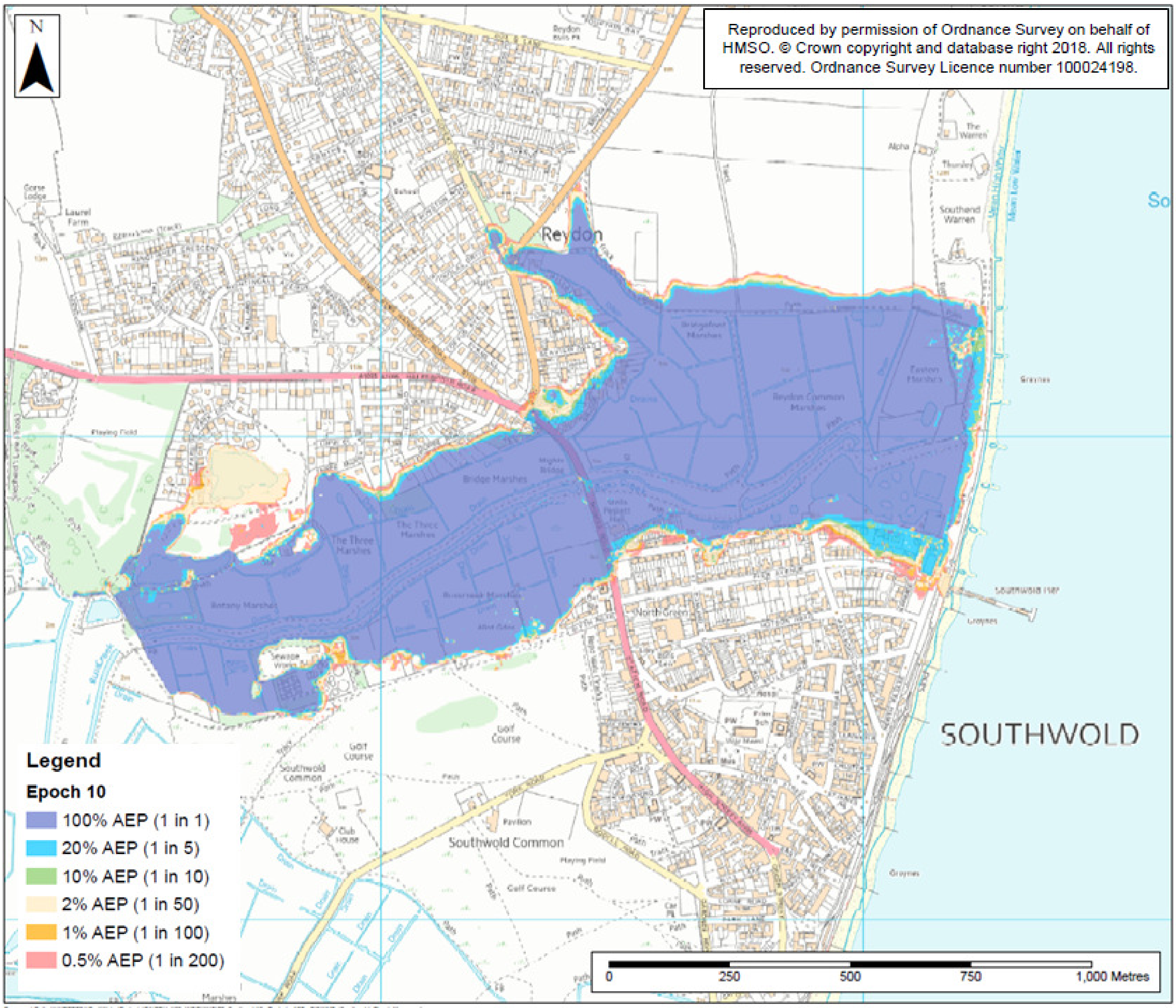

Figure 38 Flood extents epoch 10 (EA and WDC, 2005a)

Benefits

Table 23 details the 'Do-Nothing' damages and 'Do Something' benefits for the combined Easton Marshes and Southwold Town benefit area over the 50-year appraisal period.

Table 23 Summary of short listed option damages and benefits

Damages and Benefits £					
Option Number		**Combination 1**	**Combination 2**	**Combination 3**	**Combination 8**
Option Name	Do-Nothing	Do-Minimum	Cheapest Technical Option - Reduce groyne spacing WDC Town, reduce groyne spacing and Revetment from R3-Easton Bavents including transition structure at R4 and reduced WDC EM scheme	Preferred Technical Option - Reduce spacing at town frontage, rock T-Heads at WDC EM frontage and revetment at EA EM frontage with groynes remaining in tact	Preferred Technical Option with deferred cost at WDC Frontage
	Do-Nothing	Do-Minimum	Maintain	Maintain	Maintain
AEP or SOP (where relevant)	N/A	N/A	N/A	N/A	N/A
Total monetised PV damages	28,348,292	25,588,243	741,999	741,999	741,999
PV recreational damages	28,124,954	28,124,954	-	-	-
Total monetised PV benefits	-	2,270,197	55,731,247	55,731,247	55,731,247
Total monetised & recreational PV benefits		2,270,197	55,731,247	55,731,247	55,731,247

Environmental assets

No gains or losses to environmental assets have been included at this stage.

6. Economic summary and preliminary preferred option

Description of preferred option

Table 24 outlines the anticipated works for the preferred options for Southwold developed in this Initial Assessment. Note - deferring options delays all capital expenditure for a period of 15 years. Maintenance activities are not deferred.

Table 24 Description of works for combination 3 (preferred technical option) and 8 (preferred technical option with deferred costs to WDC frontage)

Appraisal Period	Combination Option 3	Combination Option 8
0-5	Yr 1 Design and Surveys. Yr 2 Install 2 intermediate groynes in bays T6-T7 and T7-T8 including nourishment of those bays. Install Rock T-Heads to groynes R2-R4 including nourishment of bays R1-R4. Install Rock Revetment from R4-R8 including partial seawall plating and also along Easton Bavents transition. Leave existing groynes intact. Construct J Groyne control structure at R8 and beach access structure.	Yr 1 Design and Surveys. Yr 2 Install Rock Revetment from R4-R8 including partial seawall plating and also along Easton Bavents transition. Leave existing groynes intact. Construct J Groyne control structure at R8 and beach access structure.
6-10		
11-15		
16-20	Yr 17 Partial beach recharge to TF including recycling and import. Yr 20 Partial beach recharge to WEM EM frontage.	Yr 17 Install 2 intermediate groynes in bays T6-T7 and T7-T8 including nourishment of those bays. Install Rock T-Heads to groynes R2-R4 including nourishment of bays R1-R4.
21-25	Yr 22 Partial groyne rebuild to timber groynes at TF.	
26-30	Yr 30 Partial beach recharge to T6-R1	
31-35	Yr 32 Partial beach recharge and recycling to T1-T6	Yr 32 Partial beach recharge to TF including recycling and import. Yr 35 Partial beach recharge to WEM EM frontage
36-40	Yr 36 Partial Beach recharge to WEM EM frontage. Yr 37 Move material from EA rock groynes to toe of structure.	Yr 37 Partial groyne rebuild to timber groynes at TF.
41-45	Yr 41 Partial beach recharge to T6-R1 Yr 42 Partial groyne rebuild to timber groynes at TF. Install rock revetment between R3-R4 WDC EM.	Yr 45 Partial beach recharge to T6-R1
46-50	Yr 37 Partial beach recharge and recycling to T1-T6 Yr 50 Partial beach recharge to T6-R1, Beach recharge to WEM EM frontage.	Yr 47 Partial beach recharge and recycling to T1-T6
Maintenance	Annual maintenance to seawall, timber groynes at TF including some refurbishment, rock groynes and T-Heads at WDC EM, Rock Revetment, and J Groyne control structure.	Annual maintenance to seawall, timber groynes at TF including some refurbishment, rock groynes and T-Heads at WDC EM, Rock Revetment, and J Groyne control structure.

Economic summary

The benefit to cost ratios, raw partnership funding scores and partnership contributions required to reach a PF score of 100% are summarised in Table 25. The adjusted score needs to exceed 100% before a project can proceed. Consideration of the 4 combination options considered shows that the highest benefit cost ratio is 7.7 for the preferred technical option with deferred costs over the 50-year project appraisal period.

The Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA) calculation tool was used to establish the raw partnership funding scores for each option assuming no partnership contributions. The full calculation sheets are included within Appendix C - Economic Technical Appendix.

All maintain options provide the same benefits. No external contributions have been identified at this stage.

Combination 8 has therefore been adopted as the preferred option (shaded grey) as this results in the smallest funding gap and is therefore the most likely to be implemented although a PF score of 27% is significantly short of what is required to implement a scheme.

Table 25 Benefit-cost assessment

	Short listed options: prospect of FCRM GiA funding			
Option number	**Combination 1**	**Combination 2**	**Combination 3**	**Combination 8**
Option name	Do-Minimum	Cheapest Technical Option - Reduce groyne spacing WDC Town, reduce groyne spacing and Revetment from R3-Easton Bavents including transition structure at R4 and reduced WDC EM scheme	Preferred Technical Option - Reduce spacing at town frontage, rock T-Heads at WDC EM frontage and revetment at EA EM frontage with groynes remaining in tact	Preferred Technical Option with deferred cost at WDC Frontage
50 year appraisal				
PV Costs	1,050,718	8,797,437	9,216,591	7,215,386
PV Benefits	2,270,197	55,731,247	55,731,247	55,731,247
Av. BCR	2.2	6.3	6.0	7.7
Incr' BCR		6.9	6.5	8.7
15 year appraisal (to 1st capital injection)				
PV Capital costs	0	5,198,273	6,302,243	3,841,509
PV Maintenance costs	591,163	681,382	634,249	484,476
PV Costs	591,163	5,879,655	6,936,492	4,325,985
PV Benefits	2,577,450	19,448,305	19,448,305	19,448,305
Partnership funding calculator				
FCRM Raw Partnership Funding Score	N/A	20%	17%	27%
PV contributions to capital works	0	0	0	0
PV Maintenance contributions (Maintenance to be met by LA)	0	681,382	634,249	484,476
PV Contributions secured to date	N/A	0	0	0
Eligible FCRM GiA	N/A	1,022,387	1,050,663	1,026,893
Partnership Contribution required to achieve an Adjusted Score of 100%	N/A	4,175,886	5,251,580	2,814,616

The PF calculators for these 3 options assuming a benefit period of 15 years are included in Appendix C.

Key delivery risks (economic, social and environmental)

A high-level assessment of risks associated with the promotion of any scheme at Southwold have been considered and are detailed in Table 26.

Table 26 Key delivery risks and mitigation

Risk	Key Mitigation
Lack of adequate funding	Ensure that contributions are secured to fill any shortfall in central funding. Consider if works can be packaged with other coastal scheme to generate material cost savings. Deferring works along the WDC frontages where the risk is less immediate.
Deferring works along the WDC frontages may impact on ability to secure external contributions.	Any final scheme should try and offer amenity benefits to maximise project funding.
Planning consent not awarded	Ensure adequate liaison with local council, residents and other stakeholders.
Unforeseen ground conditions or technical complexities	Ensure sufficient geotechnical and other investigations undertaken, particularly at the northern part of the Easton Marshes wall where there is less information
Costs under-estimated	Ensure that the implications of the outcomes from investigations are adequately costed, that all cost items are identified and that any uncertainties are covered by appropriate levels of risk contingency. Early Contractor Involvement at the next stage would improve accuracy of costs.
Accuracy of outline design	Ensure sufficient topographic and geotechnical surveys undertaken to allow a fully informed design to be undertaken.
Environmental consents	Work borders SSSI and early discussions should be had with Natural England (if a scheme progresses)

7. Conclusions and recommendations

Conclusions

Key Influencing factors

- Net drift across the whole frontage is southerly, but there can be significant drift reversal. Annual drift values (northerly or southerly) can be order of magnitude greater than the net southerly drift value.
- Beach material can be lost cross-shore from the groyne bays under easterly storms and then transported either north or south depending on the persistence of subsequent conditions.
- Persistent northerly conditions create southerly drift that feeds the Easton Marshes frontage but requires suitable cross-shore conditions to push that material into the groyne embayments to significantly benefit beach levels adjacent to the defences.
- Persistent southerly conditions create northerly drift and can push material northward, out of the Easton Marshes frontage.
- The EA groyne bays across the Easton Marshes frontage are depleted with beach levels at or below levels at the time of the 2005 PAR. The already deteriorated sheet piling at the toe of the defence is exposed and the embayments are susceptible to further draw-down and the defence is at risk of failure.
- Beach levels within the first three WDC bays north of the Pier are less depleted than those to the North although do display some volatility. Current beach levels and widths are lower than those post-scheme, but the sheet piled toe of the defence is protected.
- As the Easton Bavents cliffs continue to erode back, the hard defences at Easton Marshes (Southwold as a whole) will act more and more as a headland. Erosion pressure will increase from north to south across the Easton Marshes frontage. Over time, this erosion pressure will be felt further south towards the Pier and beyond.
- The erosion pressure felt across the northern (EA) Easton Marshes frontage means it is not sustainable or economically viable to retain beach material as a form of defence due to the required quantity and frequency of recharge campaigns.
- Beach width and height across the WDC town frontage is susceptible to fluctuation but the beach is holding sufficiently post-scheme to protect the sheet piled toe of the seawall and promenade structure.
- Beach volatility across the WDC town frontage is greatest in the three embayments south of the Pier. This volatility is impacting amenity and recreational value. Over time, as erosion pressure increases from the north, it is anticipated that beach volatility across the town frontage will increase and extend further to the south.

Scheme Requirements

- To maintain the existing flood defences across the northern (EA) Easton Marshes frontage requires protection by means of a rock revetment in combination other works to prevent failure of the defence in the short term.
- Similar protection works are likely to be required across the WDC frontage north of the pier in the medium term as erosion pressure moves further south.
- Opportunities exist in the short to medium term to better manage the transition between the hard frontage and cliff transition at Easton Bavents, manage the outflanking risk to the seawall and to harness the erosion of the cliffs and to maintain and control the supply of sediment across the Easton Marshes frontage to feed the beaches to the south.
- Although it is not considered necessary or cost-effective in the short term or even medium term, the managed realignment of the Easton Marshes defences back to a point more compatible with the alignment of the cliffs to the north will likely be required in the longer

term as the maintenance of the current Easton Marshes defence alignment becomes ever more unsustainable.

- The preferred option presented within this Initial Assessment recognises that holding a protective beach along the EA section of the Easton Marshes seawall is not feasible in the longer term, and that the provision of a hard rock defence in place of a protective beach is an intermediate stage in the evolution of the defences at this location. This would be compatible with the longer term realign management policy stated in the current SMP.

Preferred Technical Option

The preferred technical solution identified by this IA by via a long-list to short-list optioneering exercise identified the preferred technical solution to the problem to be as follows:

- Reduce the spacing of groynes across the town frontage by the introduction of slightly shorter timber groynes within the most volatile embayments.
- Modify the existing groynes across the WDC frontage north of the Pier with rock T-Head additions.
- Construct a rock revetment to protect the seawall toe across the EA Easton Marshes frontage, with the existing rock groynes remaining intact.
- Periodically extend the rock revetment across the WDC frontage north of the Pier to replace the existing beach protection before the end of the appraisal period, in response to anticipated increased erosion pressure.

Option Costs

The whole life PV costs of the preferred technical option is £9,217k (combination 3).

Deferring all capital works along the WDC frontage for 15 years results in whole life PV costs of £7,215k (Combination 8).

For comparison the cheapest feasible technical option (combination 2) resulted in whole life PV costs of £8,797k, within 500k of the preferred technical option.

Options include optimism bias at 60%.

Alternative Options Considered

Options explored using the rock from the existing groynes to reduce the cost of forming a revetment across the EA frontage. However, a considerable amount of rock was required to construct an adequate revetment in addition to the rock contained in the existing groynes. The need for additional rock to construct a revetment cannot therefore be avoided which, combined with the need to dismantle the existing groynes, negates what would otherwise be an advantageous re-use approach. Additionally, the removal of the existing rock groynes would increase the erosion pressure on the WDC Easton Marshes frontage to a greater degree than if the groynes were to remain. This would result in increased whole life costs from a requirement for increased nourishment and the earlier need for a revetment to combat lowering beach levels which would eventually would drop to a point that threatened the stability of the seawall. This increase in whole life costs offsets the saving that can be made from reusing rock from the groynes. The preferred option does assume the eventual removal of the existing rock groynes, but not until later in the appraisal period when the rock can be used to supplement the rock within the revetment.

Alternatives considered in the IA included reverting to the policy of regular and increasing beach recharge from the 2005 PAR. However, as has been shown and explained in this report, erosion pressure across the northern parts of the frontage has increased such that the maintenance of a protective beach as primary defence with regular recharge is no longer considered feasible, sustainable or cost effective. South of the Pier, the frontage has performed better post-scheme and some PAR assumptions have been shown to be conservative e.g. full groyne rebuild every 15 years along with, full recharge to PAR quantities. A rudimental consideration of the cost of implementing the PAR was undertaken which indicated a PV cost of £7,880k for continuing with the PAR management policy. To improve on this comparison the PAR could be re-costed based on similar rates to the IA options.

The benefits identified for a Do Something option at Southwold is £55,731k. In addition to flooding and erosion benefits a significant amount for recreational and amenity benefits were identified, based on tourism to Southwold, amount to £28,124k. An amount of £2,760k has been included for the repairs to the road into Southwold from flood damages, which is the sole access route into the town.

There are significant problems at Southwold, caused by coastal processes that a scheme would help to alleviate; however, **the FCRM Raw Partnership Funding Score of 17% for combination 3 and 27% for combination 8 would not be sufficient to support a viable scheme for Southwold** and significant partnership funding would be required to get the go ahead for such a scheme. Schemes throughout the country also adopt the PF calculator and priority will be given to those schemes that provide the highest scores. Therefore, it is important that potential sources of partnership funding are established if appraisal was to move to the next stage, **otherwise it is difficult to see a viable economic case for progressing to OBC.**

If feasible, works at Southwold could be undertaken in conjunction with another nearby coastal defence scheme to reduce fees and material unit rate costs.

Recommendations for future work

- For any future work, extreme water levels should be established from Environment Agency State of the Nation data sets which include extreme waves and water levels at points around the UK coastline. Water levels were adjusted to account for climate change based on UKPC09 data. UKPC18 data is available from November 2018.
- Ground investigation works were undertaken prior to the 2005 PAR but there is some uncertainty to the ground conditions along the EA Easton Marshes seawall and investigations should be undertaken to improve knowledge of this area and to inform the design of any protective works. Measurement of the existing sheet pile thickness should be taken to allow an accurate determination of residual life and to make certain that plating is sufficient for any repair works.
- No additional analysis of beach profiles was undertaken and ENBE’s 2016 analysis was used for this IA. Future work should continue the analysis to present day to allow a more accurate picture of beach condition, to establish the amount of material that may be available for recycling, and to improve on the calculation of volumes required for future nourishment.
- Undertake Beach Dip analysis along the whole frontage to present day using existing WDC data record.
- An overtopping analysis should be undertaken along the Easton Marshes seawall to establish the discharge and volumes and to ascertain the current standard of flood protection and likely future with the implementation of any rock revetment option at this location.
- Analysis of recent (Spring/Summer 2018) wind data would help to understand the wind regime at Southwold that has driven the recent persistence of southerly drift and to confirm anecdotal evidence of recent beach evolution.
- Deferral scenario considered delays all capital works for 15 years along the Waveney frontage. Revisit deferral scenarios and consider a number of combinations including only deferring work to town frontage and including the possibility of intermediate repairs.

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Appendix A – Available information and data

Appendix B – Options appraisal

Appendix C – Economic Technical Appendix

Appendix D – Environmental checklist and constraints map