Bawdsey Coastal Defence High Level Options Appraisal

October 2015

Environment Agency

Environment Agency

Mott MacDonald

Bawdsey Coastal Defence High Level Options Appraisal

October 2015

Environment Agency

Mott MacDonald, Mott MacDonald House, 8-10 Sydenham Road, Croydon CR0 2EE, United Kingdom
T +44 (0)20 8774 2000 F +44 (0)20 8681 5706 W www.mottmac.com

Mott MacDonald

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
2	23/10/2015	JJW/GW	SC	PP	Final version

Information Class: Standard

Contents

Executive Summary

Following a review of historical and contemporary coastal processes acting along the shoreline between Orford Ness and the Deben Estuary, Mott MacDonald have been tasked with providing a high-level coastal defence options review for East Lane Bawdsey (ELB) and the Bawdsey Manor frontage.

The report presents a high-level assessment of a range of coastal defence options for East Lane Bawdsey and outlines the merits and drawbacks of potential schemes by considering efficacy, impacts and costs. It also provides. up-to-date cost estimates for four defence enhancement options for the Bawdsey Manor frontage.

The options considered in this report were agreed between Bawdsey Coastal Partnership, Environment Agency, Suffolk Coastal District Council, Natural England and Mott MacDonald at a workshop in May 2015.

1 Introduction

Following a review of historical and contemporary coastal processes acting along the shoreline between Orford Ness and the Deben Estuary, Mott MacDonald has been tasked with providing a high-level coastal defence options review for East Lane Bawdsey (ELB) and the Bawdsey Manor frontage.

Section 2 presents a high-level assessment of a range of coastal defence options for East Lane Bawdsey and outlines the merits and drawbacks of potential schemes by considering efficacy, impacts and costs. The options include:

Do Nothing: This baseline case is useful for comparative purposes, but is not a realistic option given the present threats to the frontage north of the most recent works. **This option was dismissed and is not considered further.**

Do Minimum: This approach involves maintaining the existing defences by patch/repair. As above, this is not a realistic option as it does not address the present erosion threat. **This option was dismissed and is not considered further.**

Sustain: This approach involves patch/repair works plus a sediment recharge programme from donor sites to maintain / sustain sacrificial beach cover to resist erosion pressures. This option was judged to be high-risk as there is no guarantee that any recharge will remain in place. **This option was dismissed and is not considered further.**

Option Improve 1: Improve 1 involves extension of the existing revetment (gabions, rock, Pre-Cast Concrete block) along the line of the present flood defences by a distance of approximately 150m. This option follows the works previously undertaken and offers a relatively high level of resilience using a conventional coastal engineering approach. Uncertainty about local coastal processes and future coastal evolution necessitates a degree of over-design to reduce project risk. **This option is further examined in Section 2.**

Option Improve 2: Improve 2 involves Improve 1 (above) plus beach recharge and the installation of groynes to encourage sediment retention and the establishment of a resilient beach fronting the defences. These additional scheme features may improve resilience and perhaps promote more natural beach function in front of the revetment. **This option is further examined in Section 2.**

Option Improve 3: Improve 3 involves the installation of one or more breakwaters (emerged or submerged) to protect the adjacent coast from incident wave attack and to encourage formation of a salient to enlarge the existing beach in alongshore and cross-shore directions. This option may also be combined with Improve 1 and 2. **This option is further examined in Section 2.**

Option 4: Managed Realignment: An option for coastal realignment involving the set-back of existing defence (and beach recharge) has also been considered. In the long-term, this could be considered to be the most sustainable solution as it allows natural coastal adjustments to sea level, sediment supply and wave climate. It is, however, an option that will require further knowledge of coastal processes and the use of a suitable prognostic model to guide the design of a scheme. **This option is further examined in Section 2.**

Section 3 takes what is judged to be the most appropriate defence options for the Bawdsey Manor frontage proposed by Posford Haskoning (2003) and provides outline scheme designs and up-to-date costs for 4 options including: (a) a full height rock armoured sloping revetment in front of the existing Steel Sheet Pile wall; (b) limited rock toe protection; (c) a rock groyne field; and (d) beach recharge.

The options presented in the report are summarised in **Section 4**. At this stage in the process no option is ruled in or out and recommendations are not made.

2 East Lane Bawdsey Coastal Defence Works

The northern termination of the most recent emergency coastal defence works at East Lane, Bawdsey (ELB) remain a concern of the Bawdsey Coastal Partnership (BCP). At this location it appears that the normal supply of beach sediments from the north by alongshore transport has either been greatly reduced or possibly reversed temporally. While this situation remains, erosion has a potential to threaten both the existing defences and the designated habitats to the north. A solution to this issue has been investigated via a high-level options appraisal approach. Options judged to be viable have been costed to provide a guide on the likely financial requirement to implement a given scheme.

Communications with the EA and BCP, together with information available in various reports provided to Mott MacDonald, have enabled identification of potential options for further works along the ELB frontage.

2.1 High-level options appraisal

2.1.1 Option Improve 1.

In this option the existing revetment (gabions, rock, Pre-Cast Concrete block) is extended along the line of the present flood defences by a distance of approximately 150m. Mott MacDonald consider that in engineering terms, the Improve 1 option is a viable, relatively low-cost option for maintaining the integrity of the existing flood defences in the short -term. Consequently, to provide a guide to likely costs, an option based on a typical cross-section detailed in Figure 2.1 (from Posford Haskoning, 2003) has been further investigated at a high-level and costs of a possible 150m northern extension of the recently constructed rock armoured revetment to the north of East Lane Point at Bawdsey are now provided.

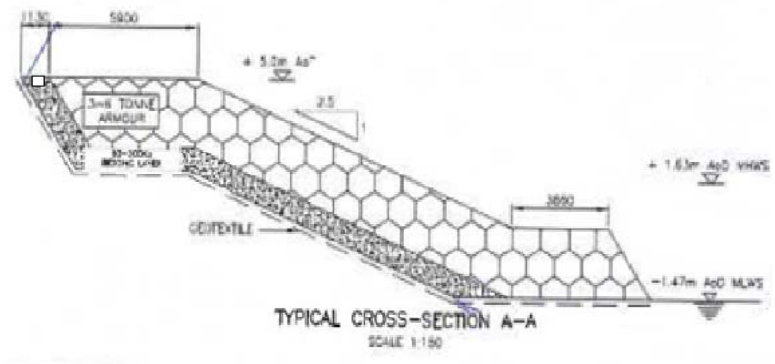
The cost estimate was undertaken based on current prices and includes rock armour (3T-6T standard grading), geotextile, earthworks/excavation and construction costs. With a materials and construction cost of £7,560 per metre run, plus design, supervision and management costs the cost of the scheme would be approximately £1.3M. Please note that the costings have not been checked and are currently being reviewed.

Efficacy – Since 2005 the southern extent of Hollesley Bay has progressed northwards from East Lane Point over a distance of approximately 450m. This suggests an average annual rate of *circa*

50m per year. All reports previous to this study have commented that sediment moves in a north to south pattern but Mott Macdonald (2015) has found that this may have been temporally reversed. Should this continue then this option would need further interventions in the near future.

Impacts – This solution does not attempt to retain sediment transport at ELB and therefore does not exacerbate the current situation regarding any down-drift sediment starvation impacts. However, this solution involves heavy coastal engineering in an area of internationally important designated shingle habitat and saline lagoons. The Habitats Regulations Assessment will determine the viability of this approach.

Figure 2.1: Improve 1 option based on a typical cross-section detailed in Posford Haskoning (2003).



Source: Mott MacDonald, 2015

2.1.2 Option Improve 2.

Option Improve 2 involves Improve 1 plus nourishment and the installation of groynes to encourage sediment retention and the establishment of a resilient beach fronting the defences.

Major coastal schemes of this nature have been implemented at sites near ELB over recent years. These include South Felixstowe in 2008, Central Felixstowe in 2010 and Clacton to Holland-on-Sea in 2015. All of these schemes involved the installation of rock groynes and subsequent beach recharge to supplement the depleted beach levels at the sites.

In the three examples above the works were implemented through majority FDGiA (Flood Defence Grant in Aid) funding. The Felixstowe schemes predate the introduction of Flood and Coastal Resilience Partnership Funding (Defra 2011) and so were wholly funded through FDGiA. The Clacton to Holland-on-Sea scheme was funded through majority FDGiA supplemented with Partnership Funding.

The South Felixstowe scheme protects the coast from The Pier to Landgard Common over a distance of 2.3km. It consisted of 19 'T shape' groynes and 2 straight groynes at the southern end. The beaches where fully nourished with dredged sand and shingle at the end of construction. The scheme cost approximately £9M and was justified by the protection of 1200 properties against coastal erosion and flooding.

The Central Felixstowe Scheme protects the coast from Cobbolds Point to The Pier. Here 20 rock groynes were installed over a 1.6km length of coast with beach nourishment placed to complete the project. A further rock headland was installed at Cobbolds Point to protect the promontory (Figure 2.2). The works cost £10M and were justified by protecting 1400 properties against coastal erosion.

Figure 2.2: Cobbolds Point and Central Felixstowe

Source: Mike Page

Gradual beach erosion in the Clacton area placed significant stress on the existing seawall defences and in response the Clacton-to-Holland coast protection scheme was completed in 2015. Here 23 'fishtail'

groynes were installed over a two year period with beach nourishment to complete the scheme (Figure 2.3).

Figure 2.3: Clacton to Holland on Sea coast protection scheme

Source: Tendring District Council

The scheme covered a 5km stretch of coastline and cost £36M, of which £27M was FDGiA. The project provides protection against coastal erosion to over 3000 properties.

With Cobbolds point not dissimilar to the ELB promontory the case of Felixstowe Central is the most directly comparable situation ELB. Rock reinforcement could be placed against the existing structures and a sequence of rock groynes placed to the north and perhaps the south of ELB which would then be complemented by shingle recharge. The existing rock revetment could be absorbed into the new scheme design and offer some reduction in costs.

Costs – Currently the engineered section of coast at ELB is approximately 900m. If this is redesigned, and new structures are built to the north and south of the Point, a figure of £6-8M total would be appropriate, which includes reuse of the existing material on site. There will also be an ongoing need for recharge of the shingle beaches. At all other sites quoted this is generally factored to occur every ten years or so, informed by beach monitoring. A further allowance of £1.0M to £1.5M, every 10 years, would be an appropriate estimation. If this option is taken forward for further consideration these figures can be much more accurately estimated through detailed design and early contractor involvement.

Efficacy – It is the view of Mott MacDonald that this approach will offer a much greater level of certainty that the scheme will realise the benefits of protection against coastal erosion and flooding providing maintenance through beach recharge is carried out when required. The Felixstowe schemes have been in place for over 5 years and there is general consensus, confirmed by beach monitoring, that the schemes are working well.

Impacts – The addition of sediment into the system will provide additional benefits down-drift of the site through "leakage" of sediment from the scheme area. As with option 1 this will involve extensive and active engineering in an important designated site. Again a Habitats Regulation Assessment would be required to determine what mitigation may be required.

2.1.3 Option Improve 3.

Option improve 3 involves the installation of one or more breakwaters (emerged/submerged) at strategic location(s) offshore from ELB. Such a scheme would require careful investigation, possibly using a physical model. Although used extensively in Europe, there are relatively few examples of offshore breakwaters in the UK. The nearest to ELB are the 8 breakwaters built in the 1990's at Sea Palling, Norfolk and in 2008 at Jaywick, Essex. The general principle is that these structures help to reduce incident wave energy and promote the creation of a wider beach by modifying the local wave conditions to favour sediment accretion. Their design must ensure that they provide the required level of coastal protection without significantly interrupting alongshore sediment transport and thus physical modelling is normally required to refine designs.

Irrespective of the construction material used breakwaters are expensive and will require a detailed study to understand their performance in the context of the local coastal processes and sediment regime. It is clear from Mott MacDonald (2015) that the present understanding of morphodynamics along the Bawdsey frontage is incomplete and data pertaining to alongshore and cross-shore sediment transport rates are presently inadequate for design purposes. While this might be addressed through modelling, it carries with it a risk that an offshore breakwater may not work at this location.

Figure 2.4: Sea Palling Offshore Breakwaters

Source: Mike Page

The breakwaters at Sea Palling (Figure 2.4) were built in two phases in the mid 1990's. The 4 northern breakwaters are higher than the newer 4 southern breakwaters. The difference in sediment retention can be seen in figure 4 where the higher breakwaters create salients almost extending to the structures and the lower breakwater salients are much reduced in size. The implementation costs of the Sea Palling scheme have not been acquired as the project is 20 years old and may no longer be relevant.

It is noted that despite careful design and physical modelling, modifications to the breakwaters post-construction were required to maintain alongshore transport continuity, adding further to costs.

More recently an offshore breakwater was installed at Jaywick, near Clacton (Figure 2.5). The project consisted of one additional breakwater (in the upper centre of the photograph), the extension of the 2 "fishtail" groynes on either side, and beach recharge. In total this scheme cost £9M in 2008 and adds to the portfolio of defence infrastructure that protects 2100 properties from flooding the low lying land.

Figure 2.5: Jaywick Offshore Breakwaters

Source: Mike Page

The design of breakwater structures needs to be carefully assessed in order to achieve a desirable outcome for beach retention. The subtle difference between the two designs at Sea Palling can be seen. This will be a significant issue if alternatives to rock armour are utilised.

Searches reveal a number of alternative solutions to breakwater design that involve unconventional materials. For example, ships have been scuttled close to the shoreline (Brazil) and old barges have been sunk to protect the coast from erosion at Bradwell-on-Sea (Figure 2.6).

Figure 2.6: Beached barges to protect against coast erosion at Bradwell-on-Sea

Source: Various

Regarding the suggested use of recycled materials to construct a reef/breakwater, a brief commentary of “Rigs to Reefs” was undertaken by Royal Haskoning in 2011. They highlighted the three key stages of criteria assessment that all coastal protection schemes need to follow. These being technical feasibility, economic viability and environmental and social acceptability. While there are documented pollution issues associated with some materials (e.g. old tyres) the option of using such recycled materials for breakwater/reef construction is not dismissed outright. However, there needs to be confidence that the materials used and the scheme design can provide the required level of protection, especially in extreme conditions, and over extended periods. Specifically, engineering standards that ensure the safety and performance of unorthodox materials in coastal defence works do not exist and such an approach is judged to carry a high risk.

Costs – A similar project to Jaywick delivering protection to ELB would cost in the order of £10-15M. This could be a combination of Improve option 2 with groynes and offshore reefs added to improve sediment transport across the site. There will be an ongoing need for periodic recharge of the shingle beaches. At all other sites quoted this is generally factored to occur approximately every ten years, and is informed by beach monitoring. A further allowance of £1.0M to £1.5M, every 10 years, would be an appropriate estimation. If this option is taken forward for further consideration these figures can be much more accurately estimated through detailed design and early contractor involvement.

Efficacy – The high costs associated with this type of approach includes the need for detailed appraisal and modelling of structure design. Uncertainties can be mitigated by over design so confidence can be achieved (at a cost). A possible need to modify the built structure cannot be overlooked.

Impacts - A suitable designed rock armour based offshore breakwater coast protection scheme would have a lesser impact upon adjacent beaches than option Improve 2 alone. Under current conditions sediment losses would need to be replaced through beach recharge. Again a Habitats Regulation Assessment would be required to determine what mitigation may be required

2.1.4 Option 4. Managed Realignment.

Climate change is already affecting our lives. Scientific predictions of climate change impacts increasingly influence government policies and in turn affect our society. The ultimate consequence of climate change means that individuals and communities can no longer continue along the same course and must in future work more effectively with nature.

As the environment around us is changing we are all compelled to adapt to the new conditions and become more resilient to change as individuals and communities. Climate change and environmental and financial concerns have in many cases led to a shift from the traditional 'hold-the-line' approach of coastal protection towards more flexible 'soft' engineering options. Managed realignment (MR) is a relatively new soft engineering approach aiming to maximise environmental and socio-economic benefits by creating space for coastal habitats to develop while at the same time maintaining a good standard of coastal protection to individuals and communities. The natural adaptive

capacity of coastal habitats (and the ecosystem services they provide) underpins the concept of managed realignment whereby coastal areas are allowed to function more naturally and again re-establish a natural level of coastal protection that may have been lost due to 'hard' engineering interventions in the past.

Therefore, with this in mind, an alternative to holding the line at ELB is managed realignment (MR). This would involve setting-back the existing flood defence to a new location and allowing sea flooding to occur by breaching the existing defences in a controlled way. As with all coast protection solutions MR schemes require careful design to ensure hydrology and coastal processes continue to operate in a semi-natural fashion to reduce the need for extensive engineering.

There have been over 50 MR projects in the UK in the past three decades delivered by a variety of organisations. While a MR scheme at ELB would result in the loss of features presently located in the land behind the defences, new features, such as important natural habitats would be expected to emerge in time and MR scheme designs aim to produce a wide diversity of ecosystem services. There are now numerous examples in the UK where the natural environment is fundamental to the health of the local economy e.g. Minsmere and the north Norfolk coast.

Figure 2.7: Part of Medmerry MR, July, 2014 showing diversity of coastal habitats.

Source: Channel Coastal Observatory

Costs – costs of managed realignment schemes are massively variable because of the bespoke requirements of individual situations (i.e. the nature of the breach, its location, the extent of secondary defence and any land raising required). The recent scheme at Fingringhoe, Essex cost less that £0.5M, whilst the combined habitat creation and community protection scheme at Medmerry (Figure 2.7) cost £36M. The funding of MR schemes can be supported by numerous grant opportunities. The most significant of these is the LIFE which is the European Union's financial instrument which support projects that tackle the impact of climate change, benefit nature conservation and involves local communities. Since 1992 LIFE has co-financed some 4171 projects, contributing approximately €3.4b to the protection of the environment and climate. Other smaller grants such as WREN and Big Lottery Fund may also provide grant support. FDGiA may offer some funding opportunity but only in relation to the benefits, in terms of properties protected, offered by the scheme.

Efficacy – A properly designed and implemented managed realignment scheme will negate the need for future capital investments in further sea defence infrastructure in the longer term. The scheme would also be designed to be resilient to future sea level rise and through the restoration of natural coastal processes it will provide longer-term benefits to wider coastal area.

Impacts – There would be major impacts initially and there would need to be a great deal of preparation prior to any change in defence management. A project such as this will have wide, far-reaching and significant impacts throughout the floodable area. As with all the options this is likely to have a significant impact of the designated shingle habitat and saline lagoons on the seaward side of the defences along Hollesley Bay. However, it is considered that any habitat losses would be more than compensated for by the gains in both habitat diversity and extent. As with the other options a Habitats Regulation Assessment would be required to inform this and determine what mitigation may be required.

3 Bawdsey Manor Frontage

The 310 m Bawdsey Manor frontage is defended by a Frodingham steel sheet pile wall 3 m from the toe of the cliff (Figure 3.1) and an older timber groyne field seaward of the piles, which is in a poor state of repair. The beach at present is depleted of sediments. To the south of Bawdsey Manor there is a 325 m length of shingle beach with steel sheet pile walls at the crest. The parts of these walls not covered by sediment are in very poor condition and have, in many locations, completely corroded. The north bank of the Deben Estuary is characterised by a large accumulation of shingle.

Figure 3.1: Frodingham steel sheet pile wall defending Bawdsey Manor.

Source: Mott MacDonald, 2015

Mott MacDonald has reviewed various sea defence improvement options for the frontage using the Posford Haskoning (2003) report for Bawdsey Manor Frontage as a guide. Following a high-level review of the various sea defence improvement options and costs the following options were selected for the development of a concept design and updated budget costings of the proposed works using the current prices (2015) obtained from recent similar works along the East coast of England. Using the Posford Haskoning terminology for the different options, Mott MacDonald has reconsidered:

- Limited rock toe protection to SSP sea defence wall – **Option 5 – Hold the Line – Threshold Driven.**
- Full height rock armoured sloping revetment in front of the existing Steel Sheet Pile wall (SSP) sea defence wall – **Option 6 - Hold the Line – Maximum Delay.**
- Rock Groyne Field – **Option 8 - Beach Build Up.**
- Shingle Re-charge of Upper Beach – **Option 9 – Local Advance.**

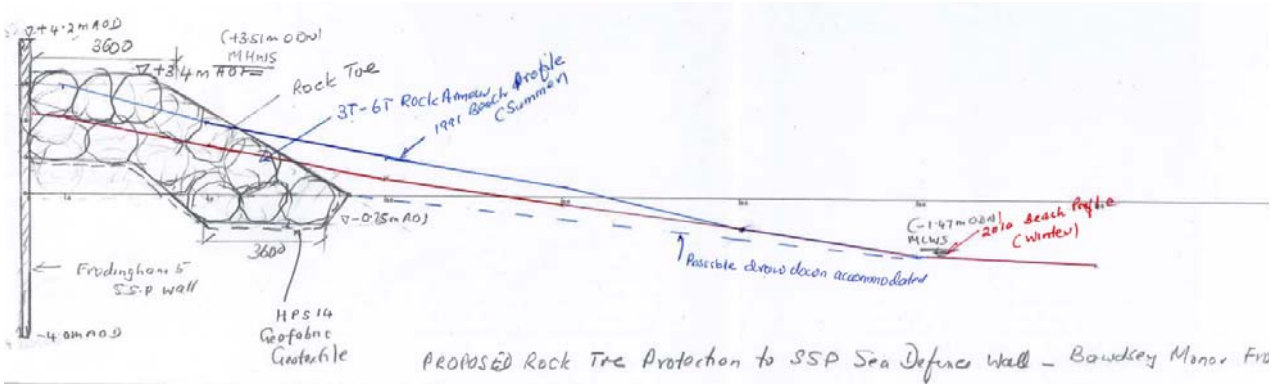
Concept drawings of each option are provided in Figure 3.3, Figure 3.2, Figure 3.4 and Figure 3.5. The cost of each option including rock armour (3T- 6T standard grading), geotextile, earthworks/excavation, construction costs and the design, supervision and management costs is summarised in Table 3.1. Please note that the costings have not been checked and are currently being reviewed.

Table 3.1: Revised Posford Haskoning costs and Mott MacDonald concept design cost for defence options for the Bawdsey manor frontage.

	Posford Haskoning (2003) costs			Mott MacDonald (2015) concept design cost		
Scheme	Construction	Design, Supervision and Management	Capital	Construction	Design, Supervision and Management	Capital
Option 5 – Hold the Line – Threshold Driven	589,225	88,384	677,609	1,029,438	154,416	1,183,853
Option 6 - Hold the Line – Maximum Delay	1,334,970	200,246	1,535,216	2,104,375	315,656	2,420,031
Option 8 - Beach Build Up (rock groynes)	N/A	N/A	N/A	492,391	73,859	566,250
Option 9 – Local Advance (recharge)	168,000	25,200	193,200	226,800	34,020	260,820

3.1 Option 5 – Hold the Line – Threshold Driven.

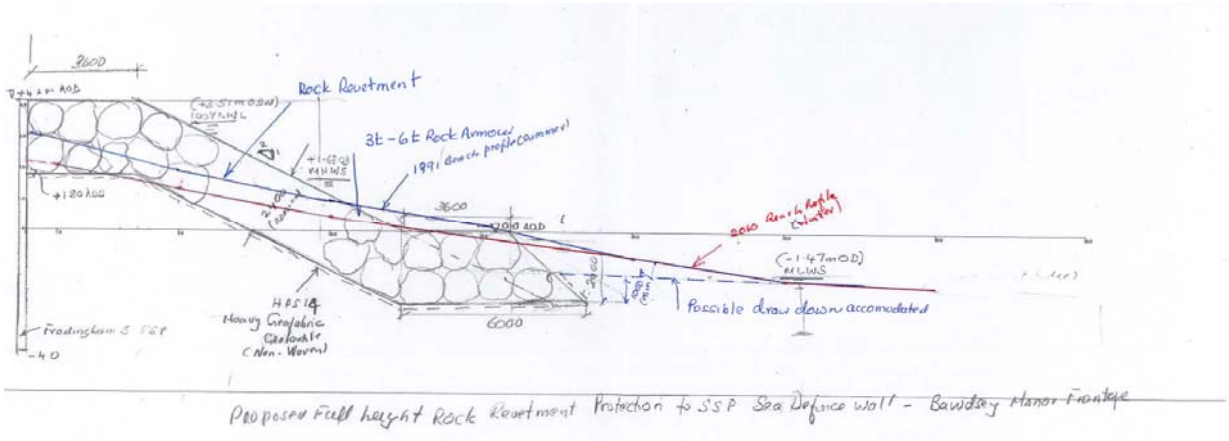
Figure 3.2: Limited rock toe protection to SSP sea defence wall – Option 5 – Hold the Line – Threshold Driven



Source: Mott MacDonald

3.2 Option 6- Hold the Line – Maximum Delay.

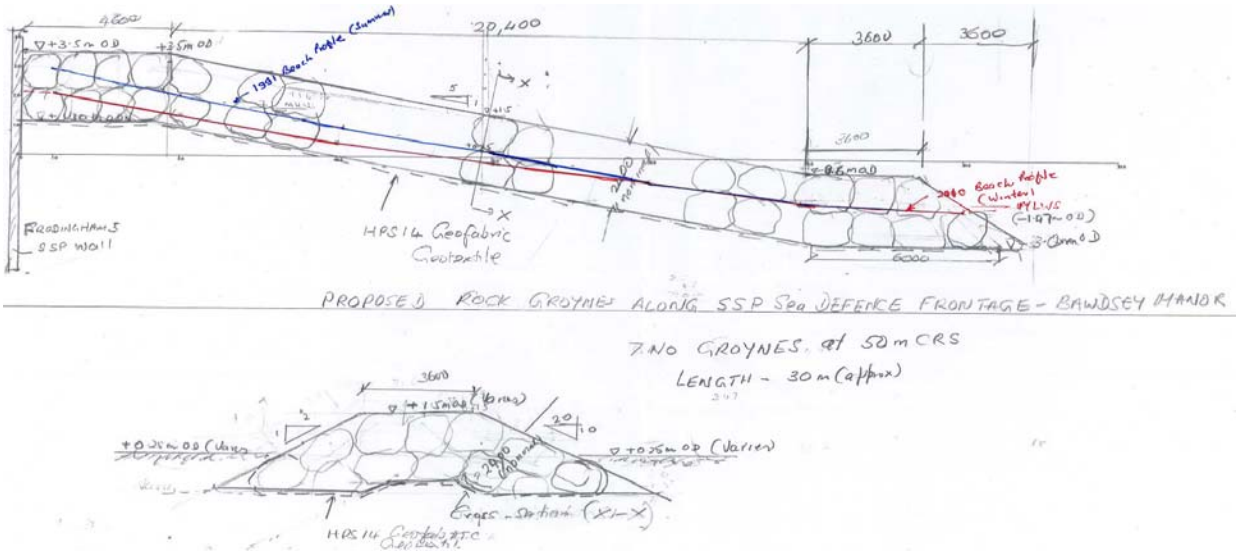
Figure 3.3: Full height rock armoured sloping revetment in front of the existing Steel Sheet Pile wall (SSP) sea defence wall – Option 6 - Hold the Line – Maximum Delay



Source: Mott MacDonald

3.3 Option 8 - Beach Build Up.

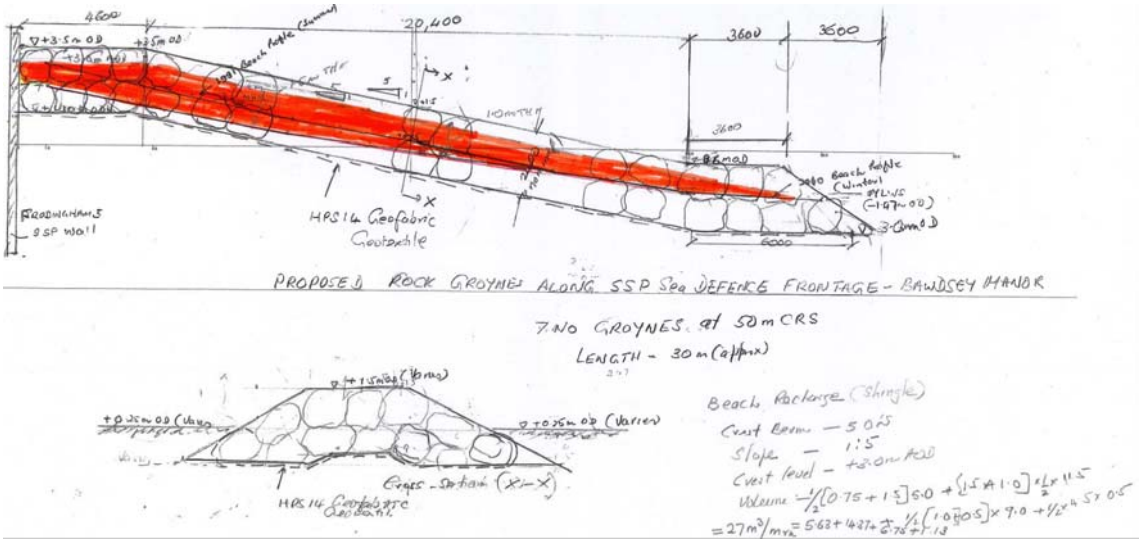
Figure 3.4: Rock Groyne Field – Option 8 - Beach Build Up



Source: Mott MacDonald

3.4 Option 9 – Local Advance.

Figure 3.5: Shingle Re-charge of Upper Beach – Option 9 – Local Advance



Source: Mott MacDonald

4 Summary of Options

4.1 East Lane Bawdsey

The report has considered a number of different approaches to managing the coastal frontage. However, as agreed, no preferred option is concluded.

Whilst option 1 (Improve 1- Extend the existing revetment) provides the lowest cost approach to the immediate problems at ELB it does carry significant risks regarding need for further intervention in the short term.

Option 2, (Improve 1 plus nourishment and the installation of groynes) is a scheme similar to Felixstowe and Clacton. It is likely that this would be the preferred option if there were similar benefits in terms of risk to properties. It provides the lowest cost solution offering longer-term flood risk reduction while also minimising the likely need for further interventions, with the exception of recharge on a decadal basis.

Option 3 (Improve 3 -Installation of breakwaters) whilst providing benefits similar to option 2, is likely to be much more expensive. Generally, offshore breakwaters are utilised in situations where ongoing sediment transport are essential for maintaining the integrity of the adjacent shorelines. It is not likely, under current conditions, that the shoreline at ELB can be advanced to the point where natural sediment transport occurs past the site unhindered. Regular, repeated beach recharge is likely to be required to rectify the deficit.

Option 4 (managed realignment) is an option that could be implemented but may not be a low cost option. It can offer a sustainable long-term management option by reducing the pressures on flood defences and compensating for habitat lost due to developments or coastal squeeze. Significant design and adaptation of the hinterland would be required. If, however, the numerous issues constraining this option could be overcome, the result would be a more sustainable outcome with the creation of a potentially rich conservation area which could bring long-term benefits to this part of Suffolk. This option would negate the need for continuing ongoing investment in engineering as sea levels rise in the latter part of this century. Whilst option 2 and 3 provide defence assurance (with ongoing re-investment) for a period of *circa* 50 years, the realignment option would be able to adapt to increasing sea levels with minimum further investment far beyond the 50 year timeframe.

4.2 Bawdsey Manor

Four options have been costed at 2015 prices. All will provide varying degrees of improvement to the existing coastal defences and the selection will depend on resources available to fund a particular scheme.

5 References

Mott MacDonald, 2015. Coastal Processes Study: East Lane, Bawdsey, Suffolk, Final Report, 125pp.

Posford Haskoning, 2003. Bawdsey Manor Implementation Report, Final Report, SCDC, 127pp.

Defra, 2011. Flood and coastal resilience partnership funding, 11pp. https://www.gov.uk/government/publications/flood-and-coastal-resilience-partnership-funding