Coastal Management Plan

Hunstanton Coastal Management Plan

60552153

October 2019

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Quality information

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Revision History

Revision	Revision date	Details	Authorized	Name	Position
0	Dec 2018	Draft for Comment	DG	Daniel Glasson	Associate Director
1	April 2019	Final	PN	Paul Norton	Director
2	Oct 2019	With Addendum	PN	Paul Norton	Director

Distribution List

Issue	Association / Company Name
0	Borough Council of King's Lynn & West Norfolk
1	Borough Council of King's Lynn & West Norfolk
2	Borough Council of King's Lynn & West Norfolk

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Table of Contents

Appendices

1. Introduction

1.1 Project background

AECOM Infrastructure and Environment UK Limited has been appointed by the Borough Council of King's Lynn and West Norfolk (BCKLWN) to develop a Coastal Management Plan (CMP) to implement the 2010 Shoreline Management Plan's (SMP2) preferred management policy for the Hunstanton frontage.

1.2 The location

Hunstanton is a seaside town positioned on the west facing coast of the Wash in Norfolk, approximately 21km north east of the town of King's Lynn as shown in Figure 1-1. The study area comprises approximately 1.3km of undefended cliffs (Unit A, Photograph 1-1) and to the south approximately 1.5km of defended coastline (Unit B, Photograph 1-2) where the existing defences typically consist of seawalls, a raised promenade, floodwalls and beach management groynes. The entire coastline is fronted by a sandy/shingle beach of varying levels.

Figure 1-1: Location of study area (imagery ©2017 Google)

Hunstanton is a popular tourist area, particularly in the summer months. The promenade is a prominent amenity area with an array of attractions that are well trafficked by the public. There are numerous seasonal kiosks located along the promenade with an amusement park, a leisure centre, an aquarium and several caravan parks located just behind the floodwall.

Photograph 1-1: Hunstanton Cliff located in Unit A

Photograph 1-2: Example of existing defences located in Unit B

1.3 Purpose and structure of this document

The Coastal Management Plan identifies and recommends the preferred approach for managing coastal flood and erosion risk along the Hunstanton frontage. Sections 2 - 4 of this document summarises the steps taken during the development of the Plan to arrive at the preferred approach (please note that more detailed information on the development of the Plan can be found in the Appendices). Section 5 provides details of the plan as agreed with BCKLWN (which can be readily removed and used as a standalone document), and Section 6 provides some information for implementing the plan.

2. Risks - What is at risk if we do nothing?

Gaining an understanding of the flood and erosion risk along the Hunstanton frontage is imperative in order to define a baseline for developing the Coastal Mangement Plan. The baseline was established by considering a 'Do Nothing' scenario. This extreme scenario assumes that no action will be taken to maintain or repair the existing defences (where present) which will result in them deteriorating over time until their eventual failure, this represents the 'worst case' in terms of damage.

In order to compare different management scenarios, the potential damages and benefits of different options were expressed in a directly comparable unit of measurement; i.e. monetary terms. This economic assessment was undertaken in line with the framework of the HM Treasury and Defra's Flood and coastal erosion risk management (FCERM) appraisal guidance. Details of how the economic assessment was undertaken can be found in the Economics Report in Appendix C.

The appraisal period considered for the Coastal Mangement Plan is 100 years. All potential options were appraised over three time periods (also known as epochs) within the 100-year period:

- Short term: 2018-2030
- Medium term: 2030-2060
- Long term: 2060-2118

Dividing the economic assessment into these broad time periods allowed the present and future flood and erosion risks to be identified and quantified. In addition, the assessment also considers the potential consequences of climate change, where the continued warming of the global oceans is expected to increase sea levels in the future and therefore increase the expected flood and erosion risk across the frontage over the next 100 years.

2.1 'Do nothing' damages

The types of economic damages can be split into three categories: erosion damages, flooding damages and additional damages. Additional damages capture economic losses that are not directly attributed to flooding or erosion damages to properties, for example loss of visitors to an area or erosion of infrastructure such as roads.

The results of the baseline erosion damage assessment are shown in Table 2-1. The point at which the erosion of properties will occur was determined by using erosion prediction rates that were established in the SCAPE (Soft Cliff and Platform Erosion) model that was constructed as part of the development of the Strategy (Wash East Coastal Management Strategy, 2015).

The results showed that there was no short term (up to 2030) erosion of properties predicted along the frontage under a scenario of not maintaining the existing defences and allowing them to deteriorate and fail. However, the analysis found that in the medium and long-term periods (2030+) there are a number of properties that are predicted to erode. The vast majority of these properties are located in Unit B. A summary of the properties predicted to erode in the next 100 years are shown in Table 2-1 and their locations presented in Figure 2-1 and Figure 2-2.

Table 2-1: Properties at erosion risk in the next 100 years (assuming 10m property buffer)

Epoch	Residential Properties		Commercial Properties		Total	
	Unit A	Unit B	Unit A	Unit B	Unit A	Unit B
Short (2017-2030)	0	0	0	0	0	0
Medium (2030-2060)	0	14	2	24	2	38
Long (2060-2117)	0	23	2	9	2	32
All	0	37	4	33	4	70

Figure 2-1: Map showing properties in Unit A at risk of erosion in the next 100 years

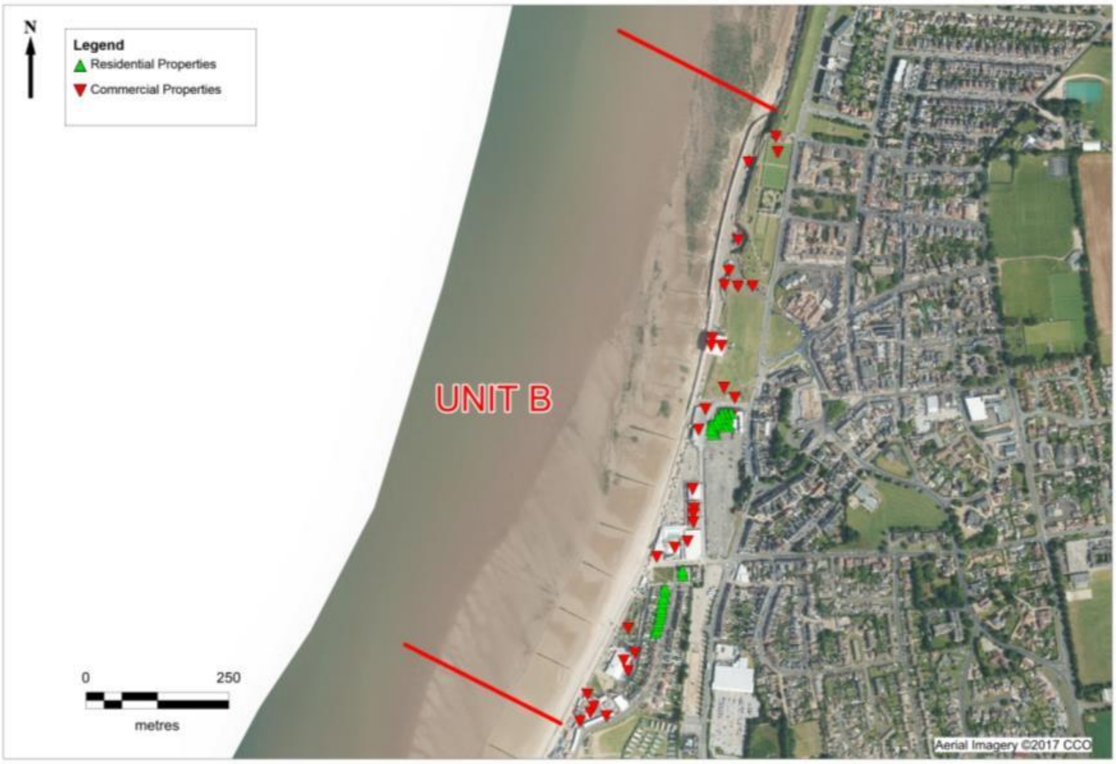

Figure 2-2: Map showing properties in Unit B at risk of erosion in the next 100 years

As well as considering erosion damages, the flooding of properties has also been considered. Properties in Unit A are not affected by flooding due to their cliff top location. In order to identify the properties at risk of flooding in Unit B the Environment Agency's Flood Map for Planning Risk has been used. Although there is a floodwall with flood gates along the rear of the promenade, following FCERM guidance the 'Do Nothing' scenario assumes that the flood gates would not be closed in a flood event, as the 'Do Nothing' scenario represents a 'worst case' scenario. Using this approach has enabled an estimate of the damages from flooding to be developed; however, this economic damage was found to be small in relation to the estimated erosion damages. The locations of the properties at risk of flooding in Unit B are shown in Figure 2-3 below.

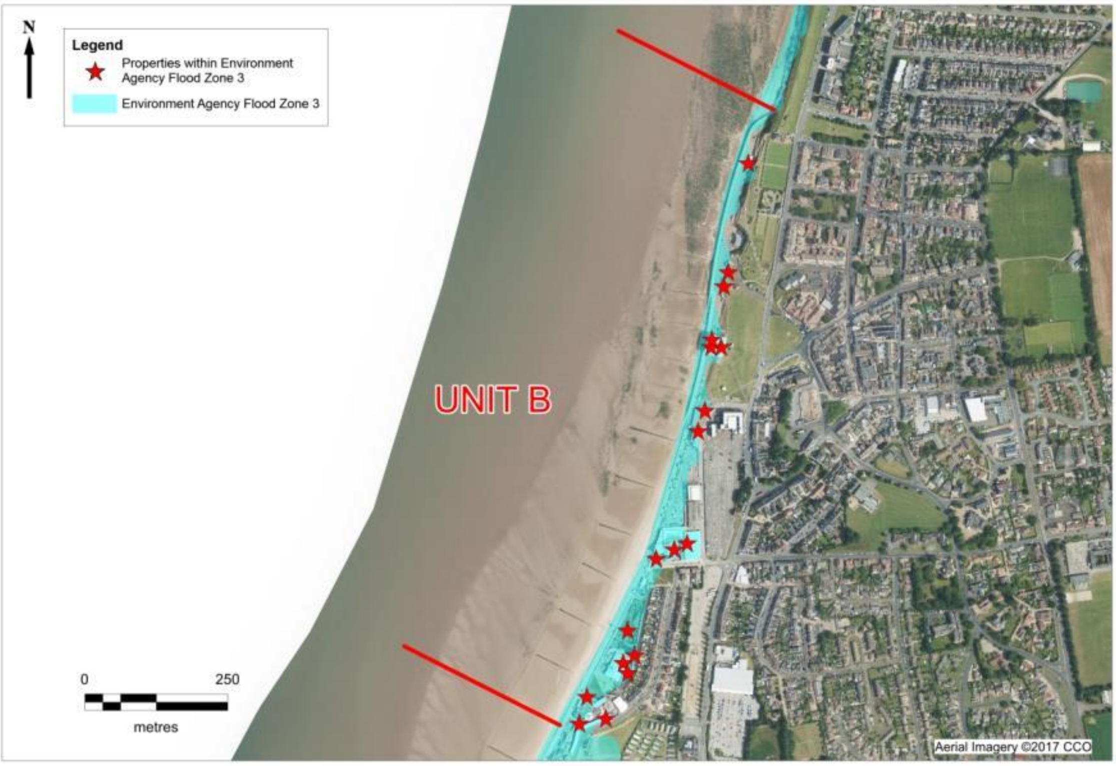

Figure 2-3: Map showing properties in Unit B at risk of flooding from up to a present day 1 in 200-year flood event (all commercial)

In addition, to flood and erosion damages to properties, non-property (or additional) damages have also been estimated within the economic assessment. The potential 'additional' damages that have been considered include: 'risk to life', loss of visitors, damages to local roads and impacts on local businesses, further information on 'additional' damages are presented in the Economics Report in Appendix C.

The overall Present Value (PV as defined in the Economics Appendix) damages across the frontage throughout the 100-year appraisal period are presented in Table 2-2.

Table 2-2: Total PV damages predicted in the next 100 years

Damage type	Unit A	Unit B	Total
Erosion	£36,500	£5,765,200	£5,801,700
Flooding	£0	£60,500	£60,500
Additional	£1,015,500	£879,800	£1,895,300
Total	£1,052,000	£6,705,500	£7,757,500

3. Supporting information

3.1 Informing the process

Throughout the development of a plan to manage coastal flood and erosion risks in Hunstanton it has been necessary to understand the key features, issues, constraints and opportunities that exist along the frontage. As a result, a number of additional studies have been undertaken in the preparation of the Coastal Management Plan. This supplementary work has been listed below and is summarised in the following sections:

- **Condition assessment** of the existing defences (Unit B) was undertaken to build upon on the work of previous inspections in order to estimate the residual lives of the existing structures, identify any immediate need for remedial works and quantify the potential future maintenance requirements. The condition inspection report can be found in Appendix A.

- **Coastal processes analysis** was undertaken to determine the local wave, tidal, current and weather climates, estimate the extreme water levels and understand any variations or patterns in beach profiles along the frontage. The coastal processes analysis can be found in Appendix B.

- **Preliminary environmental assessment** was completed to highlight key environmental considerations and constraints for the Plan including land use, environmental designations, historic environment, local habitats and a water framework directive assessment. The preliminary environmental assessment can be found in Appendix B.

- **Preliminary geotechnical assessment of the Hunstanton Cliff (Unit A)** was undertaken to determine the failure mechanisms of the cliff and identify any potential options to reduce the erosion rate. The preliminary geotechnical assessment can be found in Appendix B.

- **Economic Assessment** has been undertaken as detailed in Section 2 (above). Further details of how the economic assessment was undertaken can be found in the economics report in Appendix C.

- An extensive **Option Appraisal** has been undertaken to comparatively consider all the potential coastal defence management options comparatively in terms of their technical and environmental performance and estimated whole life costs. The option appraisal is discussed in more detail in Section 4 of this report and Appendix D.

- **Public and Stakeholder consultation** was undertaken at various stages of the Plan's development to ensure that both the public and local stakeholders were kept informed and to capture feedback and any potential ideas. Various mediums have been used including meetings, drop-in exhibitions and online surveys. The public consultation report can be found in Appendix E.

3.1.1 Previous studies and strategic context

In addition to the work detailed above, the development of the coastal management plan also included the careful consideration and review of the previous works on the management of the Hunstanton frontage including:

1. Wash East Coastal Management Strategy, 2015 (The Strategy):
2. The Wash Shoreline Management Plan Review, Environment Agency, 2010 (SMP2)

Unit A – Hunstanton Cliffs

The agreed intent of The Wash Shoreline Management Plan Review, Environment Agency, 2010 (SMP2) is to continue to allow the cliffs to erode naturally and provide sediment to help maintain the beaches to the south, until the erosion starts to threaten cliff top properties and the cliff road. This is expected to occur in approximately 50 years (although there is a significant uncertainty in this date). From that time on, the SMP2's intent is to prevent further cliff erosion to sustain the properties and the road in Unit A.

The Strategy concluded that the preferred approach to managing the erosion in Unit A in the future, should be to pilot a range of low-cost options that reduce erosion caused by wave action at specific locations. This trial of options would determine their effectiveness in slowing erosion. Options identified in The Strategy were base netting, sand bags, gabions and a rock sill (rock revetment). The Strategy identified from the key Stakeholder Group that there was a clear consensus that it is not realistic or desirable to stop erosion, but options such as these to slow the erosion rate should be pursued.

Unit B – Hunstanton Town

In Unit B the preferred management approach of both the SMP2 and The Strategy is to 'Hold the Line' by maintaining the existing promenade, seawall and groyne defences and replacing these structures when required (predicted residual life of theses defences (excluding groynes) in the Strategy was typically 15-20 years).

It should be noted that Unit C to the south of the study area (Wolferton Creek to South Hunstanton) is managed by the Environment Agency and a Community Interest Company, work is currently being undertaken in this area and the Study should assess the opportunities for an integrated approach with this Unit.

3.2 Summary of supporting information

From the studies that have taken place to inform the development of the CMP the key findings are summarised in the sections below in order to provide understanding of how the plan has been developed.

3.2.1 Condition assessment summary

A visual condition inspection was undertaken by AECOM to provide an update to the previous condition assessments that have been carried out in Unit B (there are no existing defences in Unit A). Previous work had included ground penetrating radar, concrete cores, trial pits and falling weight deflectometer investigations as well as visual inspections. The winter 2017 inspection included and assessment of the seawall, promenade, groynes and the floodwall located at the rear of the promenade. The referencing system used to identify different sections of the defences was the same as used in previous surveys to maintain consistency. Using this system, the frontage was divided into seven sections (A to G) based on the different types of seawall, as shown in Figure 3-1.

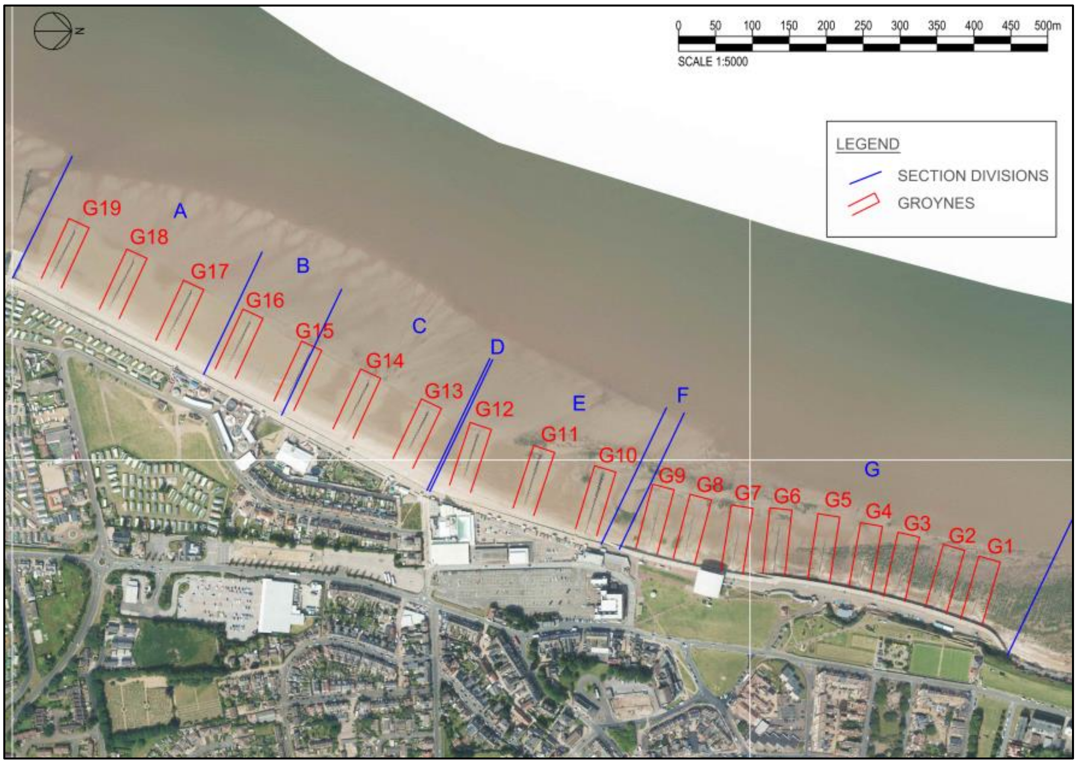

Figure 3-1: Asset identification system of existing defences in Unit B (aerial imagery ©2017 CCO)

The condition of the defences was assessed in line with Environment Agency guidance and a 5 grade/rating system ranging from very poor to very good was applied. From the results of the condition assessment estimates of the seawalls residual life were produced based on the rating and type of structure. The seawall is critical to stopping erosion of the coastline. If the seawall was to fail the promenade and rear wave wall would be undermined and would also fail. However, if the promenade or rear wave wall were to fail erosion would not begin whilst the seawall remains in place. The residual life is the time until the structure is no longer able to perform its intended function and is considered to have failed. The residual life results from the visual inspection were then considered along with the results from the previous survey works (using different investigation methods) to produce an updated residual life estimate for each of the different defences. This information was used to inform the economics assessment and options appraisal. The predicted residual lives of the defences in Unit B under the current management regime (i.e. Do Minimum maintenance) are presented in Table 3-1.

Table 3-1: Predicted residual lives of defence sections (with low levels of maintenance)

Defence Section	Seawall - Estimated Residual Life (years)	Groynes - Estimated Residual Life (years)
Section A	35	5-15
Section B	35	5-15
Section C	35	5-15
Section D	15	-
Section E	15	5-15
Section F	15	-
Section G	15	15-30

3.2.2 Coastal processes analysis summary

The coastal processes analysis examined the tidal levels, extreme water levels (including predicted sea level rise), the wave, current and weather regimes including near-shore numerical wave modelling, joint probability of waves and water levels and analysis of any variations in beach profiles along the frontage over time.

The results of the wave and water level analysis are found in Appendix B and were used to inform the design parameters for the outline design of the various management options in the option appraisal process.

The beach profile analysis showed that whilst there was some local variation, generally along the toe of the seawall and cliff the beach levels have appeared reasonable stable. Although some cyclic variations have been observed, longer term trends are not apparent. The maximum variability of the beach levels along the toe of the seawall has been less than 1.1m over the past 7 years. This data was also used to inform the outline design process and option appraisal process.

3.2.3 Preliminary environmental assessment summary

The preliminary environmental assessment determined the environmental baseline along the frontage by reviewing the all previous environmental studies and considered potential impacts on existing land use, environmental designations, historic environment, landscape and Water Framework Directive and any local habitats or processes (including coastal).

Unit A is typically characterised by its designated cliffs; at the southern end of Unit A the current cliff edge lies approximately 50-100 metres from the road and properties of Hunstanton and the open space provides a pubic amenity space. At the northern end of Unit A is characterised by a large open space, a car park (used mainly by visitors to the cliffs and beach), tourist facilities and the lighthouse.

Unit B is characterised by a, seawall and promenade fronted by a shingle beach with various beach control structures (groynes), seaside amenity area and numerous holiday parks, which provide year-round tourist accommodation and facilities.

The assessment highlighted that both Units A and B are also located within a number of environmental designations shown in Table 3-2. The Wash is the largest estuarine system in Britain and contains extensive saltmarshes, intertidal banks of sand and mud, shallow waters and deep channels. This habitat contains species of international importance. As well as the Wash, the cliffs in Unit A are designated as a Site of Special Scientific Interest due to their geological interest as well providing a breeding ground for a colony of Fulmars.

Table 3-2: Table showing environmental designations located on frontage

Designation Type	Name	Units
International Designations		
Ramsar Site	The Wash	Units A and B
Special Area of Conservation (SAC)	The Wash and North Norfolk Coast	Units A and B
Special Protection Area (SPA)	The Wash	Units A and B

National Designations		
Site of Special Scientific Interest (SSSI)	Hunstanton Cliffs (land)	Unit A
	The Wash (marine)	Units A and B

Each of the short-listed options identified in the option appraisal for Units A and B were both qualitatively and comparatively assessed for impacts and potential benefits against the existing environmental baseline. Similarly, any environmental enhancements have also been identified.

It is worth noting that following consultation with Natural England, it is clear that before any works can be undertaken in Unit A (where there are currently no defences), a comprehensive a monitoring programme and a full environmental impact assessment are likely to be required to ensure that the environmentally sensitive (designated) site will not be significantly impacted during the construction or operation of any proposed defences.

3.2.4 Preliminary geotechnical assessment of Hunstanton Cliff summary

The preliminary geotechnical assessment considered the current condition of the cliff located in Unit A, identified the failure and erosion mechanisms and considered the suitability of the potential measures recommended for a pilot study in the Strategy.

Photograph 3-1: Cliff falls and warning signs at Hunstanton Cliff

The preliminary assessment typically found that failures within Hunstanton Cliff and the resulting retreating cliff line are the result of several different failure mechanisms: erosion of the base of the cliff caused by wave action undercutting and causing block falls from above, erosion of the cliff face by groundwater percolating through joints in the rock, erosion of the cliff face by surface run-off water and erosion of the cliff face by water flowing from drainage pipes which outfall directly onto the cliff face.

Following the completion of this preliminary assessment, a local geological interest group have also issued a report on the Hunstanton Cliffs that confirms the retreating nature of the cliff line and also attributes the regression to the following mechanisms: ground water seepage, washout of weak material in the lower cliff and the cyclical removal of the rock apron (created by falling debris) in front of the cliff.

The preliminary assessment also considered each of the proposed erosion protection options for a potential pilot study as outlined in the Strategy (i.e. base netting, sand bags, gabions and rock sill). The assessment found that since the primary failure mechanism is considered to result from wave action that leads to undercutting and subsequent collapse of the cliff; the creation of a rock sill/revetment would be the most suitable option as it would be the most effective at reducing wave energy and it would be the most durable of the options. However, it was noted that there are potential health and safety risks that will occur in the construction of any option that requires working on the face or near the bottom of an eroding cliff, due to the risk of rock falls.

3.2.5 Public and stakeholder consultation

The public consultation has consisted of two drop-in exhibition events held in February and April 2018 at Hunstanton Town Hall. The events were arranged to communicate the development of the Plan and to gather feedback from the Public to feed into the option appraisal process. The first event presented the long-list of options and the second event provided information on the short-listed options.

The consultation also involved an online survey which took place after the drop-in exhibitions. The questions were focused to inform the selection of preferred options. There were 52 respondents who completed the survey, the results were compiled and used to inform the option appraisal process and confirm the selection of the preferred option.

The multiple stakeholder meetings have been held throughout the development of the CMP and the feedback received has also been used to inform the option appraisal process and confirm the selection of the preferred option. Following their selection, the preferred options were also presented to key stakeholders in May 2018 and feedback received has further refined the preferred options and clearly identified the consenting regime that will be required on future works to Unit A.

Details of both the public and stakeholder consultation can be found in Appendix E.

3.3 Potential development opportunities

In parallel with the development of this CMP, BCKLWN have also commissioned a study into the potential redevelopment of southern Hunstanton, which includes the southern end of Unit B.

This redevelopment study (being undertaken by Hemingway Design) is predominantly focussed on 'inland' development to improve properties, infrastructure and services within Hunstanton. However, the project is also considering some potential development opportunities along the coastal frontage that will potentially change the nature of the existing promenade and therefore impact upon the existing coastal defences.

The options being considered for the frontage include:

1. Land reclamation and new amenity beach
2. Marine lake
3. Land based lake
4. Rock groynes and new amenity beach

Other potential opportunities that are being pursued by a separate local interest group, which if successful is also likely to impact upon the coastal defences and wider coastal processes, is the campaign to replace the Hunstanton Pier.

Whilst the coastal management plan has not considered any of these potential development opportunities on an individual basis, given the likely limitations of any available funding from Flood Defence Grant in Aid (as outlined in Appendix C), it is clear that new sources of funding, such as Developers, will have to be identified and explored as capital investment will be required to maintain the existing defences.

4. Option appraisal

Having gained a detailed understanding of the processes, features and issues operating along the frontage and having defined the baseline ‘do nothing’ scenario, the identification, development and appraisal of the potential management options was undertaken. An overview of the option appraisal process which has been used in the development of the Plan is shown in Figure 4-1.

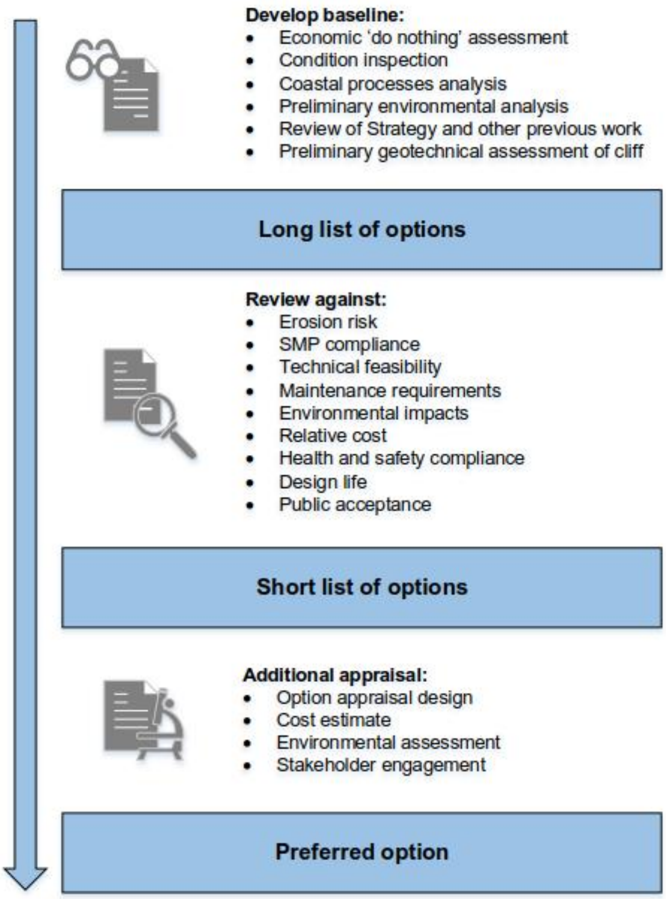

Figure 4-1: Option appraisal process

Potential management approaches were identified including: do nothing, do minimum, maintain, sustain and improve. A long-list of coastal defence options was identified that could be used to implement these management approaches.

This long-list was then reviewed to screen out the unfeasible options that do not warrant further development and more detailed appraisal, the resulting reduced list then formed the short-list. The next step was to appraise the short-list of options by considering a range of factors including economic and technical assessment, environmental impacts and stakeholder feedback to determine the preferred options. The detailed option appraisal can be found in Appendix D.

4.1 Appraisal of the long-list

The long list of options considered for Units A and B are shown in the tables below. Whilst the long-list is not exhaustive, many options from numerous sources were included at this initial stage. These long-list options were also submitted for both stakeholder and public consultation therefore providing the opportunity for any additional options to be included in the assessment.

These long-lists of options were then appraised against a range of criteria including: erosion risk (and flood in Unit B), SMP policy compliance, technical feasibility, maintenance, environmental impacts, relative cost, health and safety, design life and public acceptance. Options which scored negatively against a number of criteria were ruled out as potential options to progress to the short-list.

Table 4-1: Assessment of long-list options for Unit A

Unit A			
Option	**Description**	**Short-listed?**	**Reason if not taken forward**
No Active Intervention			
Do nothing	No future interventions.	No	The Strategy identified that whilst there might not be an economic case for large defences required to prevent wave action, some action should be taken to at least trial options to slow the erosion rate. This would provide additional information on the effectiveness of defences which would help to inform potential future schemes if the funding situation changes.
Do minimum	Ensure health and safety compliance. Erect fencing and signage at the base and top of the cliff.	No	
New Defences			
Cliff bolting	Bolts inserted into the cliff at regular intervals.	No	Not likely to be technically feasibility against wave action, would have a short design life.
Netting to base of cliff	Place a row of netting at the base of the cliff.	No	Not likely to be technically feasibility against wave action, would have a short design life.
Rock revetment/sill	Protection of cliff with large rocks designed to be stable under waves installed on the foreshore in front of the cliffs.	**Yes**	-
Timber revetments	Protection of the cliff with a timber revetment installed in front of the cliff that will protect against wave action.	**Yes**	-
Sand bags/geotubes	Sand filled geotextiles placed on the foreshore in front of the cliffs.	**Yes**	
Gabions	Rocks placed in steel wire cages and placed along the cliff toe.	No	Gabions are unlikely to be suitable for the exposed coastline subject to a vigorous wave climate.
Cliff drainage	Local improvement to cliff drainage through drilling holes and placing filters.	No	Will not address the erosion resulting from wave action. (**Please note: scoping cliff drainage out of the coastal management plan, does not preclude the Council investigating drainage improvements under a different scheme for the infrastructure on the cliff tops**).
Seawall	A continuous impermeable structure along the toe of the cliffs. Likely to be reinforced concrete with steel pile toe protection.	No	Cost of a new seawall structure would be very expensive and realistically un-fundable.

Offshore breakwaters	Construction of large off-shore structures. Likely to be made of rock or pre-cast concrete units.	No	Cost of offshore breakwaters would be very expensive and realistically un-fundable.
Beach nourishment	The placing of imported additional beach material.	**Yes**	-
Groynes (rock or timber)	Long, narrow structures built perpendicular to the cliff. Likely to be made of timber or rock.	No	Currently groynes do not exist along this frontage. If introduced there is a risk, they could significantly compromise the sediment supply from this area to the south, unless they are introduced in conjunction with beach re-nourishment.
Cliff stabilisation through re-grading	Re-grading the existing cliff resulting in a more stable slope.	No	Unlikely to be a long-term solution to prevent erosion from wave action, would have large environmental impacts and cause some properties at the top of the cliff to be affected by erosion earlier than with natural processes due to changing the angle of the cliff slope.
Relocation of key assets	Gradual adaption of communities and assets away from the erosion zone.	**Yes**	-

Table 4-2: Assessment of long-list options for Unit B

Unit B			
Option	**Description**	**Short-listed?**	**Reason if not taken forward**
Patch and repair maintenance of seawall, promenade and floodwall (Do Minimum)	Minor repair works and routine maintenance to existing structures as is currently being carried out.	**Yes**	-
Re-facing of the seawall, promenade and floodwall (Maintain existing defences)	Encase existing defence structures in layer of reinforced concrete.	**Yes**	-
Re-face and raise existing defences (Sustain existing defences)	Similar to Maintain but raise levels in line with the impacts of climate change (to sustain current standard of protection provided against flood risk).	**Yes**	-
Replacement seawall, promenade and floodwall (Improve existing defences)	Replacement structures after existing structures have reached the end of their lives to improve on the current standard of protection against flood risk provided.	**Yes**	-
Repair of groynes	Carry out repairs to areas of the existing groynes in poor condition. Would involve the replacement of certain elements of the structures.	**Yes**	-

Rock revetment	Protection of seawall with large rocks designed to be stable under waves installed at the toe of the seawall’s toe to protect against increased exposure due to erosion of the beach.	No	The footprint of the structure would mean a loss of beach/amenity space; this is unlikely to be acceptable to users of the beach.
Sand bags/geotubes	Sand filled geotextiles placed at the toe of the seawall’s toe to protect against increased exposure due to erosion of the beach – generally placed below the existing beach level.	No	The footprint of the structure would mean a loss of beach/amenity space; this is unlikely to be acceptable to users of the beach. The also would have a shorter design life in comparison to the rock option.
Gabions	Rocks placed in steel wire cages and placed along seawall’s toe to protect against increased exposure due to erosion of the beach.	No	Gabions are unlikely to be suitable for the exposed coastline subject to a vigorous wave climate.
Initial replacement seawall, promenade and floodwall	Replace the existing seawall and promenade. Likely to be reinforced concrete with steel pile toe protection.	No	Replacing the existing defences now would be very high cost and realistically un-fundable. This option would also not make the most of the existing defences.
Offshore breakwater	Construction of large off-shore structures. Likely to be made of rock or pre-cast concrete units.	No	Cost of offshore breakwaters would be very expensive and realistically un-fundable.
Beach nourishment	The placing of additional imported beach material.	No	This option would be dependent on being combined with an option to improve the groynes. It would likely be prohibitively expensive.
Timber revetments	Protection of seawall with a timber revetment installed in front of the existing defences that will protect against wave action.	No	The footprint of the structure would mean a loss of beach/amenity space; this is unlikely to be acceptable to users of the beach.
Rock groynes	Replace the existing groyne field with a series of large rock groyne structures.	**Yes**	-

Tables 4-3 and 4-4 below list each of the short-listed options for Unit A and B respectively.

Table 4-3: Short-list options for Unit A

Unit A
Rock revetment/sill
Timber revetments
Sand bags/geotubes
Beach nourishment
Relocation of key assets

Table 4-4: Short-list options for Unit B

Unit B
Patch and repair maintenance of seawall, promenade and floodwall (Do Minimum)
Re-facing of the seawall, promenade and floodwall (Maintain)
Re-face and raise existing defences (Sustain)
Replacement seawall, promenade and floodwall (Improve)
Repair of groynes
Groyne replacement (i.e. rock/enhanced timber groynes)

4.2 Appraisal of the short-list

Following the identification of the short-list options for each frontage, in order to arrive at the preferred option(s) a more detailed appraisal of the short-listed options was undertaken. This additional appraisal included developing outline designs and completing whole life cost estimates for each of the options and completing a detailed assessment of the technical and environmental benefits/impacts. This short-list option appraisal can be found in full in the Option Appraisal Report in Appendix D; however, a summary of this process is presented in the following sections.

4.3 Unit A options

4.3.1 Rock revetment/sill (Improve 1)

Option drawing

An outline design of the rock revetment/sill option can be found in Appendix F, drawing number HUN-ACM-UA-XX-DR-CE-000001.

Option description

This option involves placing rock armour protection on the foreshore approximately 10-20m in front of the cliff. It is assumed that the revetment/sill will be constructed using 1-3 tonne rock armour stones. Some minor excavation and a geotextile may be necessary to provide a robust ground profile.

Figure 4-2: Example photographs of rock revetment/sills in front of steep cliffs

Environmental assessment

A preliminary environmental assessment of this approach has been undertaken and is summarised in Table 4-5 below. In general, it was found that a rock revetment/sill in this location is likely to lead to significant impacts on the landscape and coastal processes in the area (specifically the sediment feed to the beaches in the south) and it will have a relatively large footprint on the foreshore in front of the cliffs which are both designated. It will therefore be necessary to complete a full environmental impact assessment (EIA) before any works are completed.

Table 4-5: Environmental assessment for Improve 1 – rock armour revetment / sill

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
- No significant impacts to the foreshore use (will not reduce access/amenity use of the beach) - Will slow the cliff receding and therefore protect socio-economic receptors against erosion - The rock armour is a natural material - Rock armour will potentially create new habitats along the frontage - Unlikely to inhibit tourism - The location of the rock armour away from the cliff will avoid any significant impact on the habitats located on the cliff	- Use of rock armour in this area is limited; this will lead to significant change in landscape aesthetics - The cliff erosion sediment inputs into the environment will be reduced and therefore there will be reduced sediment supply to the beach and other sites down drift - Rock works will have a relatively large footprint on the designated foreshore - slowing of erosion may harm the geological interest of the Cliffs as a SSSI	- Reduces the need for regular maintenance of e.g. timber defences - Full environmental impact assessment (including monitoring) is likely to be required in advance of any works.

Cost

The cost of protection for the full length of the unit (1325m) and for just the trial/pilot length (250m) have been based on a unit rate of £2.05k per meter length of defence (this rate includes a 30% optimism bias). Table 4-6 below presents the undiscounted (cash) capital costs for construction for both these lengths of defence.

Table 4-6: Undiscounted capital construction costs for Improve 1 – rock armour revetment / sill

Description	Price rate (£k/m)*	Pilot study cost (250m frontage)	Full frontage cost (1325m frontage + 50m tie-in)
Improve 1 – Rock armour revetment / sill	2.05	£511k**	£2,813k**

**Note that a 30% optimism bias has been applied to Unit A costs*

***Note estimated costs presented in this section allow for design and construction only and exclude any potential costs associated with environmental assessments and monitoring*

Estimated whole life costs for the next 100 years are presented in Table 4-7 (Cash and PV). The whole life costs include both construction and maintenance costs and are discounted based upon the estimated year of intervention. At the option appraisal stage several intervention periods have been considered including constructing the defence now (i.e. present day), in year 15 and also in year 50. Year 50 has been assumed as the point at which it will be necessary to protect the full length of the frontage to reduce the rate of erosion to prevent assets being lost on the cliff top in the future (in line with the SMP2 and Strategy policies).

Table 4-7: Whole life cost for Improve 1 – rock armour revetment / sill

Approach	Cash whole life cost *	PV whole life cost *
Pilot study (250m) from present day	£972k	£636k
Pilot study (250m) from year 15	£921k	£381k
Pilot study (250m) from year 15, then remainder of frontage from year 50 (1075m)	£4,092k	£922k
Full frontage from present day (1325m)	£5,345k	£3,498k
Full frontage from year 50 (1325m)	£3,938k	£669k

**Note estimated costs presented in this section allow for design and construction only and exclude any potential costs associated with environmental assessments*

4.3.2 Timber revetment (Improve 2)

Option drawing

An outline design of the timber revetment option can be found in Appendix F, drawing number HUN-ACM-UA-XX-DR-CE-000002.

Option description

This option involves constructing a new tropical hardwood timber revetment (e.g. Greenheart or Ekki) on the foreshore approximately 10-20m in front of the cliff. Wherever possible, the revetment will include timber sheeters (acting as a downstand) at the front of the structure to provide erosion resistance and prevent undermining. For costing purposes, the design of the revetment has been based on the arrangement and dimensions of a similar project in North Norfolk. It should be noted that the foreshore in front of the cliffs at Hunstanton is predominantly underlain by rock with only a limited amount of beach material therefore the installation of timber piles and any downstands in the foreshore is likely to be technically challenging.

Figure 4-3: Example photographs of timber revetments in front of steep cliffs

Environmental assessment

An environmental assessment of this approach has been undertaken and is summarised in Table 4-8 below. In general, it was found that a timber revetment in this location is likely to lead to impacts on both the landscape and coastal processes in the area (specifically the sediment feed to the beaches in the south) and it will have a footprint on the foreshore in front of the cliffs which are both designated. It will therefore be necessary to complete a full environmental impact assessment (EIA) before any works are completed.

Table 4-8: Environmental assessment for Improve 2 – timber revetment

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
- No significant impacts to the use of the foreshore (i.e. will not significantly impact access or amenity use) - Will slow the cliff receding and therefore protect socio-economic receptors against erosion - Will not inhibit tourism - The location of the timber revetments away from the cliff will avoid any significant impact on the habitats located on the cliff	- By slowing cliff erosion, the sediment inputs into the environment will be reduced and therefore there will be a reduced sediment supply to areas down drift of the defences - Timber revetments will have a footprint on the beach - Tropical hardwoods must be imported with significant carbon footprint - Sourcing sustainably managed tropical hardwood is difficult / expensive - Aesthetically very different to the existing frontage with potentially detrimental impacts on the existing landscape - Slowing of erosion may harm the geological interest of the Cliffs as a SSSI	- By opting for tropical hardwood, it reduces the impact of future maintenance activities when compared to oak - Full environmental impact assessment (including monitoring) is likely to be required in advance of any works.

Cost

The cost of protection for the full length of the unit (1325m) and for just the pilot/trial section (250m) have been based on a unit rate of £2.01k per meter length of defence (this rate includes a 30% optimism bias). Table 4-9 below presents the undiscounted capital costs for construction for each length of defence.

Table 4-9: Undiscounted capital construction costs for Improve 2 – timber revetment

Description	Price rate (£k/m)*	Pilot study cost (250m frontage)	Full frontage cost (1325m frontage + 50m tie-in)
Improve 2 – Timber revetment	2.01	£502k	£2,764k

**Note that a 30% optimism bias has been applied to Unit A costs*

Estimated whole life costs for the next 100 years are presented in Table 4-10 (Cash and PV). The whole life costs include construction and maintenance costs and are discounted based upon the estimated year of intervention over the next 100 years. Different intervention periods have been considered; i.e. constructing the defence now (present day), in year 15 and also in year 50. It has been assumed that year 50 is the point at which it will be necessary to protect the full length of the frontage to reduce the rate of erosion to prevent properties being lost at the cliff top in the future (in line with the SMP2 and Strategy policies).

Table 4-10: Whole life cost for Improve 2 – timber revetment

Approach	Cash whole life cost	PV whole life cost
Pilot study (250m) from present day	£1,809k	£826k
Pilot study (250m) from year 15	£1,708k	£500k
Pilot study (250m) from year 15, then remainder of frontage from year 50 (1075m)	£5,276k	£1,066k
Full frontage from present day (1325m)	£9,949k	£4,545k
Full frontage from year 50 (1325m)	£4,974k	£769k

4.3.3 Geotubes/sandbags (Improve 3)

Option drawing

An outline design of the geotubes/sandbags option can be found in Appendix F, drawing number HUN-ACM-UA-XX-DR-CE-000003.

Option description

This option involves placing several Tencate Geotube units (or similar) on the foreshore approximately 10-20m in front of the cliffs. Each Geotube will have an approximate 4m diameter. The Geotubes will be stacked to provide the required crest height. Where necessary the existing beach profile will be prepared and in-filled with a suitable rock infill to establish an appropriate bed for the Geotubes. The Geotube units will be hydraulically filled in situ with local sand to provide a mass-gravity structure that is erosion resistant.

Figure 4-4: Example photographs of sand filled Geotubes in front of steep cliffs

Environmental assessment

An environmental assessment of this approach has been undertaken and is summarised in Table 4-11 below. In general, it was found that a Geotube revetment in this location is likely to lead to impacts on the coastal processes in the area (specifically the sediment feed to the beach) and will have a footprint on the foreshore in front of the cliffs which are both designated. It will therefore be necessary to complete a full environmental impact assessment (EIA) before any works are completed.

Table 4-11: Environmental assessment for Improve 3 – Geotube revetment

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
- No significant impacts to the foreshore (will not significantly impact access or amenity use of the beach) - Will slow the cliff receding and therefore protect socio-economic receptors against erosion - Will not inhibit tourism - The location of the Geotubes away from the cliff will avoid any significant impact on the habitats located on the cliff	- By slowing cliff erosion, the sediment inputs into the environment will be reduced and therefore there will be a reduced sediment supply to areas down drift of the defences - Geotube revetment will have a footprint on the beach - Aesthetically very different to the existing frontage with potentially detrimental impacts on the existing landscape - The slowing of erosion may harm the geological interest of the Cliffs as a SSSI - In order to be filled the Geotubes will remove sand from the local coastal system.	- The area of beach immediately behind the Geotubes will be protected from wave action and new habitats could develop there - Full environmental impact assessment (including monitoring) is likely to be required in advance of any works.

Cost

The cost of protection for the full length of the unit (1325m) and for the shorter pilot/trial section (250m) have been based on a unit rate of £2.07k per metre length of defence (this rate includes a 30% optimism bias). Table 4-12 below presents the undiscounted capital costs for construction for each length of defence.

Table 4-12: Undiscounted capital construction costs for Improve 3 – Geotube revetment

Description	Price rate (£k/m)*	Pilot study cost (250m frontage)	Full frontage cost (1325m frontage + 50m tie-in)
Improve 3 – Geotube revetment	2.07	£516k	£2,840k

**Note that a 30% optimism bias has been applied to Unit A costs*

Estimated whole life costs for the next 100 years are presented in Table 4-13 (Cash and PV). The whole life costs include construction and maintenance costs and are discounted based upon the estimated year of intervention over the next 100 years. Different intervention periods have been considered; i.e. constructing the defence now (present day), in year 15 and also in year 50. It has been assumed that year 50 is the point at which it will be necessary to protect the full length of the frontage to reduce the rate of erosion to prevent properties being lost at the cliff top in the future (in line with the SMP2 and Strategy policies).

Table 4-13: Whole life cost for Improve 3 – Geotube revetment

Approach	Cash whole life cost	PV whole life cost
Pilot study (250m) from present day	£2,840k	£1,106k
Pilot study (250m) from year 15	£2,788k	£677k
Pilot study (250m) from year 15, then remainder of frontage from year 50 (1075m)	£8,674k	£1,429k
Full frontage from present day (1325m)	£15,618k	£6,081k
Full frontage from year 50 (1325m)	£9,087k	£1,120k

4.3.4 Beach nourishment (Improve 4)

Option drawing

An outline design of the beach nourishment option can be found in Appendix F, drawing number HUN-ACM-UA-XX-DR-CE-000004.

Option description

The beach nourishment option involves the addition of new imported material to the foreshore to increase the level of the beach. The recharge would supply material from off-shore onto the foreshore; the material would match the existing beach material in terms of grain size so that is performs equally under the local hydrodynamic and wave conditions. The increase in the beach level will cause waves to break further down the beach which will reduce the amount of wave energy reaching the cliff.

For costing purposes, the design of the beach includes increasing the level of the top of the beach to a greater height than the present day 1 in 200-year event water level (annual exceedance probability). It has also been assumed that the scheme will terminate at the line of mean sea level. In addition to the recharge, the scheme may also require some form of beach management structure (such as groynes) to be constructed to help to hold the material in place, but costs for these structures have not been included at this stage. The option will also require periodic 'top-ups' and repeat recharges in order to maintain the beach levels and counter the removal of beach material over time.

Figure 4-5: Example photographs of beach nourishment

Environmental assessment

An environmental assessment of this approach has been undertaken and is summarise in Table 4-14 below. In general, it was found that beach nourishment in this location is likely to lead to impacts on the various habitats along the foreshore and local coastal processes (specifically the sediment movement around the foreshore). The relative footprint of this option on the foreshore in front of the cliffs which are both designated will inevitably be significantly large. It will therefore be necessary to complete a full environmental impact assessment (EIA) before any works are completed.

Table 4-14: Environmental assessment for Improve 4 – beach nourishment

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
- Likely to have a positive impact on the local landscape - Will enhance the amenity use of the beach - Enhanced beach levels will offer the cliffs greater protection and therefore	- Re-nourishment activities are likely to have a negative impact on the local environment by changing habitats - Re-nourishment activities are likely to interfere with existing coastal processes - Significant disruption during construction	- Increased levels are likely to enhance the local amenity values of the beach and enhance local tourism - Likely to have a positive impact on the local landscape

protect socio-economic receptors against erosion - Enhancing beach levels will benefit local tourism (beyond construction) - Works will not directly impact on the designated cliffs - Introducing additional sediment to this frontage will be a benefit for down drift locations	- slowing of erosion may harm the geological interest of the Cliffs as a SSSI	- Full environmental impact assessment (including monitoring) is likely to be required in advance of any works

Cost

The cost of providing protection through an enhanced beach for the full length of the unit (1325m) and for the shorter pilot/trial section (250m) have been based on a unit rate of £6.6k per metre length of defence (this rate includes a 30% optimism bias). Table 4-15 below presents the undiscounted capital costs for beach nourishment for each length of beach defence.

Table 4-15: Undiscounted capital construction costs for Improve 4 – beach nourishment

Description	Price rate (£k/m)*	Pilot study cost (250m frontage)	Full frontage cost (1325m frontage)
Improve 4 – Beach nourishment	6.6	£1,648k	£8,733k

**Note that a 30% optimism bias has been applied to Unit A costs*

Estimated whole life costs for the next 100 years are presented in Table 4-16 (Cash and PV). The whole life costs include the initial nourishment and subsequent top up and recycling costs and are discounted based upon the estimated year of intervention over the next 100 years. Different intervention periods have been considered; i.e. constructing the defence now (present day), in year 15 and also in year 50. It has been assumed that year 50 is the point at which it will be necessary to protect the full length of the frontage to reduce the rate of erosion to prevent properties being lost at the cliff top in the future (in line with the SMP2 and Strategy policies).

Table 4-16: Whole life cost for Improve 4 – beach nourishment

Approach	Cash whole life cost	PV whole life cost
Pilot study (250m) from present day	£6,591k	£2,696k
Pilot study (250m) from year 15	£6,064k	£1,628k
Pilot study (250m) from year 15, then remainder of frontage from year 50 (1075m)	£25,960k	£4,226k
Full frontage from present day (1325m)	£43,665k	£17,859k
Full frontage from year 50 (1325m)	£25,763k	£3,322k

4.3.5 Relocation of key assets (Improve 5)

Option description

This option involves the relocation of the key assets along the frontage which are at risk of erosion. The most prominent of these are the lighthouse (holiday let) and the ruins of St. Edmunds Chapel, but also the Coastguard Lookout (holiday let) and the Lighthouse Café. Moving the structures 15-20m inland is potentially feasible but this would not provide a long-term solution as continued erosion of the cliff and the presence of properties behind the seafront road would ensure that space for additional asset moves in the future are limited.

Figure 4-6: Lighthouse which would require relocation

Environmental assessment

A high-level environmental assessment of this approach has been undertaken (and is presented in the Option Appraisal report in Appendix D) and whilst it may be technically feasible, it is however, unlikely to be environmentally acceptable, particularly from an archaeological perspective. Works of this nature are likely to require both a full environmental impact assessment and a historic impact assessment to be completed before the necessary consents will even be considered.

Cost

High level cost estimates for moving the lighthouse inland by 15-20m are approximately £750k. It has therefore been assumed that similar proportionate costs will be incurred for moving the other structures as well. At this stage the cost estimates do not include land purchase costs which will potentially increase the costs significantly. In addition, moving the assets inland would not prevent future erosion, only delay the impact. Table 4-17 provides a summary of the high-level relocation costs for this option. However, it should be noted that these costs do not include any allowance for additional costs associated with environmental/historical assessments or the various consents that this option would inevitably require.

Table 4-17: Undiscounted capital construction costs for Improve 5 – relocation

Asset to be moved	**Approx. cost**
Lighthouse	£750k
Coastguard Lookout and Lighthouse Cafe	£800k (2x £400k)
Ruins of St Edmund's Chapel	£750k (Gross estimate)
Optimism bias (60%)*	£1,380k
Total	£3,680k

**Note that a 60% optimism bias has been applied to these costs as it is more uncertain than Improve options 1-4*

Whole life costs for the next 100 years are presented in Table 4-18 (Cash and PV). These whole life costs only allow for one relocation of the assets at risk and are discounted based upon the estimated year of intervention over the next 100 years. Various intervention dates have been considered including undertaking the relocation now (present day), in year 30, in year 50 and in year 70.

Table 4-18: Present value whole life cost for Improve 5 - relocation

Approach	**Whole life cash cost**	**Whole life PV cost**
Relocate from present day	£3,680k	£3,680k
Relocate from year 30	£3,680k	£1,311k
Relocate from year 50	£3,680k	£726k
Relocate from year 70	£3,680k	£402k

4.3.6 Unit A preferred option

An economic analysis of the short-listed options has been undertaken for the Unit A frontage. The results of this analysis have been used alongside the option appraisal and feedback from the public consultation as well as the aims and objectives of BCKLWN to identify the preferred option for Unit A.

For comparison purposes the economic analysis considered two different implementation periods when assessing the various options; (1) undertake works in the short term and (2) undertake works in the longer term. This comparison provided the necessary evidence to help decide on whether it is optimal (in economic terms) to construct new defences now or to wait until the future. For the purposes of this indicative analysis the two implementation periods considered were: year 0 for the short term and year 50 for the longer term, however, it should be noted that the implementation of works will not be limited to these periods.

A comparison of the options costs and benefits for the two implementation periods considered is summarised in Table 4-19 below. The Average benefit to cost ratio (Ave. BCR) for each of the options is <1, which shows that it is not economic to deliver any of the proposed options. However, it has been observed that the Ave. BCR's for the options implemented in 50 years' time are approximately double that of those in the present day, which suggests that it is economically advantageous to wait before implementing the options (although the Ave. BCR's are still <1).

Table 4-19: Summary of Benefit Cost assessment for Unit A (full unit A frontage)

Option	Total benefits (PV)	Cost (PV)	Ave. BCR
Do Nothing	-	-	-
Improve 1 (present day) Rock revetment/sill	£1,052k	£3,498k	0.30
Improve 2 (present day) Timber revetment	£1,052k	4,545	0.23
Improve 3 (present day) Sand bags/geotubes	£1,052k	6,081	0.17
Improve 4 (present day) Beach nourishment	£1,052k	17,859	0.06
Improve 5 (present day) Relocation of key assets	£37k	£3,680k	0.01
Improve 1 (year 50) Rock revetment/sill	£411k	£669k	0.61
Improve 2 (year 50) Timber revetment	£411k	£769k	0.53
Improve 3 (year 50) Sand bags/geotubes	£411k	£1,120k	0.37
Improve 4 (year 50) Beach nourishment	£411k	£3,322k	0.12
Improve 5 (year 50) Relocation of key assets	£13k	£726k	0.02

Both the 2010 SMP2 and 2015 Strategic policies for Unit A are to hold the line in the future (from approximately year 50). However, a consequence of the Ave. BCR's being <1 is that the options do not meet Defra's Flood and Coastal Risk Management (FCERM) criteria and will therefore be unlikely to qualify for any public Grant in Aid funding (under the current guidelines). Therefore, in order to deliver the hold the line policy in the future, it will be necessary for BCKLWN to fund any of the options through alternative means (i.e. private funding, contributions etc.).

The analysis demonstrated that the option with the highest Ave. BCR and therefore the most cost effective is Improve option 1 (rock revetment/sill) and if works are implemented in year 50 rather than in the present day then the cost effectiveness improves. Although Option 5 (Relocation of key assets) has the lowest estimated costs, it was found to provide limited economic benefits and was therefore not considered further economically.

Based on the analysis undertaken the economically favoured approach for this unit is therefore Improve option 1: to construct a rock revetment/sill from year 50. Please note the full economics assessment can be found in the Economics Report Appendix C.

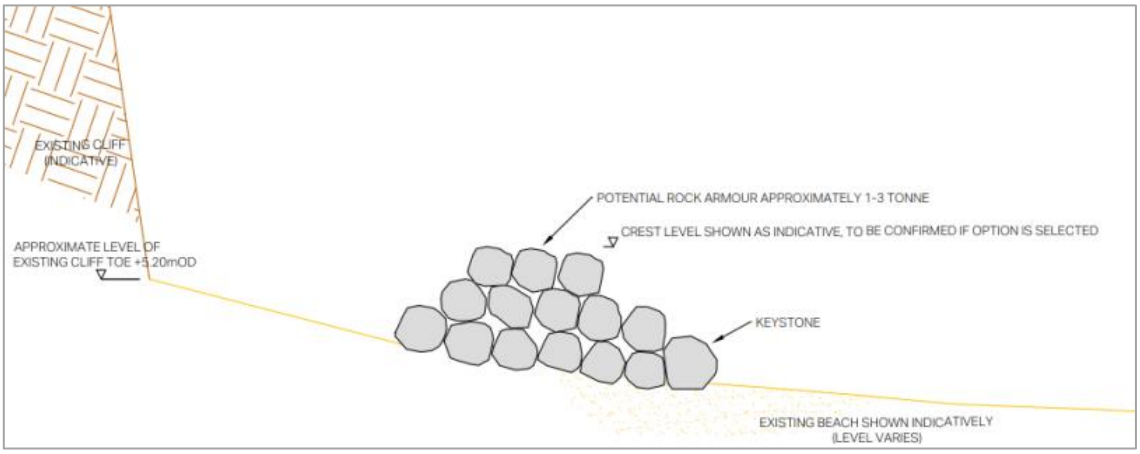

Figure 4-7: Indicative section of rock armour revetment/sill (preferred option Unit A)

Following the option appraisal process the preferred technical option was also identified as Option 1: Rock armour revetment/sill (subject to affordability) and this selection has been further supported by feedback from the public consultation which also indicated that a rock revetment/sill was the preferred defence type for this unit.

Although it should be noted that there are some negative environmental impacts associated with this option, including potential impacts on the landscape, coastal processes and the designated foreshore and cliffs. However, these impacts are not exclusive to this option as they also apply to options 2, 3 and 4, and following consultation with key stakeholders it is confirmed that it will be necessary to complete a full environmental impact assessment (EIA) before any works are completed.

An additional approach considered throughout the appraisal process (as recommended by the 2015 Strategy) is to implement a 250m 'pilot' section of the rock armour protection in the short term (i.e. relatively early in the appraisal period) and to then to construct the remaining 1075m of defence in the longer term (i.e. relatively late in the appraisal period).

This approach is favoured by BCKLWN as it will provide protection to key assets at risk in the short-medium term (lighthouse etc.) and then protect the rest of the frontage in the future when the risk of erosion to local properties increases and the works are more cost effective to implement. This form of 'pilot approach' will also enable BCKLWN to undertake detailed monitoring of both the performance (in terms of erosion protection) and any potential environmental impacts of the defence before the protection measures are implemented along the rest of the frontage.

Therefore, based on the evidence considered, the preferred option for Unit A is to construct an initial 250m stretch of rock armour protection on the foreshore in front of the cliff around the lighthouse in the short term, then construct the remaining 1075m of the defence along the rest of the frontage in the longer term. The exact time periods of construction are considered in more detail in Section 5.1.

4.4 Unit B options

4.4.1 Do Nothing

The Do Nothing option represents a hypothetical 'walk away' scenario which is used as a baseline against which to appraise the various 'Do Something' management options (see Section 2).

Under Do Nothing the existing defences will be abandoned in terms of maintenance or repair, and no remedial or additional protection works will be carried out. In addition, adaptation to predicted sea level rise or other climate change responses will not be addressed.

Under this approach, the existing defences along the frontage will be expected to fail at the end of their residual service lives and the land behind will be subject to both flooding and erosion risks.

The Do Nothing scenario is only being considered in accordance with the Defra guidance for comparison purposes and is not being considered for implementation by BCKLWN.

4.4.2 Do Minimum - Patch and repair maintenance of seawall, promenade and floodwall

Option description

The Do Minimum option essentially represents the existing 'status quo'. Under this approach, small scale reactive maintenance and patch repair work, as well as activities to maintain Health and Safety compliance will be undertaken. An example of the type of repair work that the 'Do Minimum' approach includes is shown in Photograph 4-1. Doing Minimum will help to increase the residual life of the assets and delay the point at which they are expected to fail. For the purpose of the economic assessment it has been assumed that the residual life of the defences will be extended by 5-10 years compared to the Do Nothing scenario. However, once the defences fail it is assumed that no further works will be undertaken.

In addition, under the Do Minimum approach it is assumed that the floodgates along the rear floodwall on the promenade will continue to operate until the defences fail which will reduce the flood risk along the frontage (compared to the Do Nothing scenario). Do Minimum does not allow for any adaptation to predicted sea level rise or other climate change responses (such as crest raising) so flood risk through overtopping of the defences is expected to increase in the future.

Photograph 4-1: Example of patch repair undertaken on Hunstanton frontage

Environmental assessment

An environmental assessment of this approach has been undertaken and summarised in Table 4-20 below. In general, it was found that Do Minimum is likely to lead to the longer-term loss of habitats and significant social and economic damage.

Table 4-20: Environmental assessment for Do Minimum

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
- Will allow nature to take its course - Potential expansion of the intertidal area - Avoids construction works	- Significant loss of habitats and amenity areas - Significant social and economic damage	- Low cost environmental enhancement possible such as groyne vertipools

Costs

Table 4-21 below presents the estimated undiscounted annual costs for patch and repair works for the full length of the Unit B frontage to deliver the Do Minimum option. It has been assumed that both the groynes and seawall will require patch and repair maintenance works. The total annual cost for the Do Minimum option for Unit B, encompassing patch and repair works has been estimated to be approximately £21.5k per year (using the Environment Agency's cost estimation for coastal protection guidance, 2015 (Report – SC080039/R7)).

Table 4-21: Undiscounted costs for Do Minimum

Description	Seawall patch and repair rate	Groyne patch and repair rate	Total annual cost
Patch and repair	£820 per km per year	£1,050 per groyne per year	£21.5k per year

Present value whole life costs for the next 100 years are presented in Table 4-22. The whole life costs assume a consistent annual investment of £21.5k per year for the duration of the 100-year appraisal period. However, it should be noted that this level of investment will not be enough to maintain the defences in their current condition and the defences are likely to fail at the end of their extended service life. This could lead to both erosion and flood risk to the properties and infrastructure behind the defences.

Table 4-22: Whole life costs for Do Minimum

Option	Includes	Cash whole life cost	PV whole life cost
Do Minimum	- Seawall patch and repair - Groynes patch and repair	£2,150k	£641k

Note that a 60% optimism bias has been applied to Unit B costs

4.4.3 Re-facing of the seawall, promenade and floodwall (Maintain)

Option drawing

An outline details of the maintain option through re-facing the defences can be found in Appendix F, drawing number HUN-ACM-UA-XX-DR-CE-000005.

Option description

The Maintain option represents a proactive approach to maintenance and refurbishment and involves scheduled capital refurbishments of the existing defences to extend the life of the defences throughout the entire 100-year appraisal period. This approach will require increased investment compared to the existing 'status quo'. The Maintain approach will ensure that the existing line of defences is kept in place at its current level for the duration of the appraisal period and will support the SMP2's Hold the Line policy. This will provide significant erosion benefits to the study area.

The most suitable combination of long-list measures for Unit B has been identified to implement this option, balancing feasibility, cost and environmental impacts. The approach involves re-facing the existing defences by encasing the face of the existing seawall and promenade with a reinforced concrete layer. This is expected to extend the service life of the defences by approximately 30 years and represents the most cost-effective way to maintain the line of the existing defences and prevent erosion. In addition to this, the floodgates (Photograph 4-2) situated along the floodwall will also be replaced as required and raised to accommodate the encasement of the promenade.

Photograph 4-2: Example of floodgate located along the flood wall at the rear of the promenade

The proposed works to the timber and concrete groynes under the Maintain approach are discussed in Section 4.4.6.

Under this option, it is assumed that the initial capital refurbishments of the existing defences will not be carried out immediately, but towards the end of the residual service life of the existing structures. The option also assumes that repeat interventions will be required over the duration of the next 100 years towards the end of the extended service lives of the re-faced / refurbished defences. For the purpose of costing it has been assumed that repeat interventions will be required typically every 30 years.

As with the Do Minimum approach, the floodgates along the rear wave return wall at the back of the promenade will remain operational under the Maintain option and will therefore reduce the flood risk along the frontage (compared to Do Nothing). Also, like the Do minimum approach the Maintain option does not allow for any adaptation to predicted sea level rise or other climate change responses (i.e. the crest of the defences will not be significantly raised during capital refurbishment works) so flood risk through overtopping of the defences is expected to increase in the future.

Figure 4-8: Photograph examples of re-facing seawall defences

Environmental assessment

A preliminary environmental assessment of this approach has been undertaken and summarised in Table 4-23 below, In general, it was found that the maintain option is likely to lead to disruption during construction where there is the potential for contaminants to be released, otherwise maintaining the existing structures is not expected to have any additional significant environmental impacts.

Table 4-23: Environmental assessment for Maintain

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
- Will enable the seawall to continue to protect socio-economic receptors against erosion - Likely to be supported by the public - No significant change in the footprint / aesthetic of the structure	- Some disruption to public access of the promenade and beach during the construction works - Potential release of contaminants during construction - Will not enhance the natural environment	- Low cost environmental enhancement possible such as groyne vertipools - Construction during off-peak times (i.e. during winter)

Cost

The whole life cash (undiscounted) and present value costs for the Maintain option are presented in Table 4-24 below.

Table 4-24: Whole life costs for the Maintain option

Option	Includes	Cash whole life cost	PV whole life cost
Maintain	- Repeat re-facings of seawall, promenade and floodwall, approx. every 30 years - Repeat refurbishments of timber and concrete groynes	£31,001k	£7,853k

Note that a 60% optimism bias has been applied to Unit B costs

4.4.4 Re-face and raise existing defences (Sustain)

Option drawing

An outline design of the sustain option can be found in Appendix F, drawing number HUN-ACM-UA-XX-DR-CE-000006.

Option description

The Sustain option involves raising the crest level of the defences over time to keep pace with predicted sea level rise and ensure that the flood risk does not increase (compared to the existing standards of protection). In addition, the approach to maintaining the defences as outlined in the Maintain option will also be implemented to prolong the residual life of the existing defences ensuring that the defences remain structurally sound and continue to protect against erosion.

By maintaining the position of the defences and sustaining the Standard of Protection (SoP) this option provides both erosion and flood risk benefits in the future. This approach complies with the SMP2's Hold the Line policy for the duration of the appraisal period.

The most suitable long-list measures to implement this option across Unit B have been identified, balancing feasibility, cost and environmental impacts. The approach will involve raising the height of the floodwall at the rear of the promenade. This could be achieved by installing an additional reinforced concrete capping on top of the existing defence. The option also assumes that it will also be necessary to replace the existing floodgates with new larger floodgates accordingly.

Photograph 4-3: Floodwall along rear of promenade to be raised as part of Sustain approach

For the purpose of costing it has been assumed that the crest levels of the defences will be raised in three intervals throughout the 100-year appraisal period to match the levels of sea level rise which are expected over the next century. It has been assumed that these works will coincide with the scheduled refurbishments of the defences as per the Maintain Option (i.e. not immediately and typically every 30 years thereafter). By adopting this phased approach, it ensures that the Sustain Option will remain adaptive and allow the crest level of future raising activities to be adjusted based on the rates of sea level rise that are observed / predicted in the future.

The works undertaken to the timber and concrete groynes under the Sustain approach are discussed in Section 4.4.6.

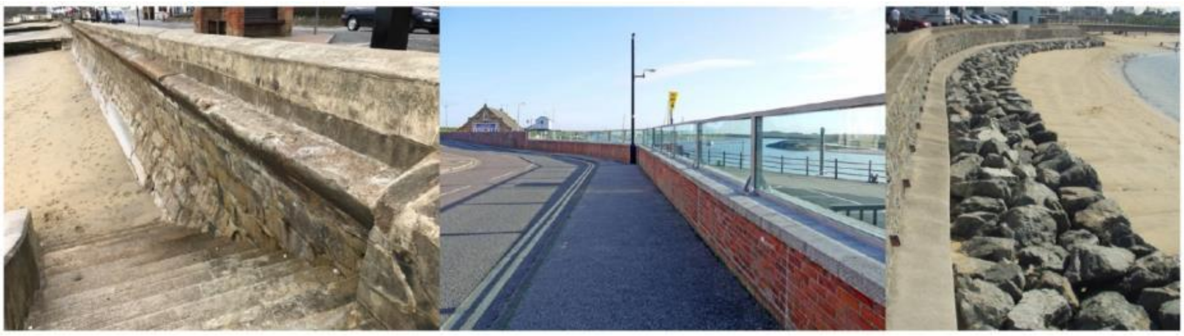

Figure 4-9: Photograph examples of crest raising to structures to increase the existing height of the defences

Environmental assessment

An environmental assessment of this approach has been undertaken and is summarised in Table 4-25 below. In general, it was found that the Sustain approach is likely to lead to disruption during construction, where there is potential for contaminants to be released. It was also found that increasing the height of the existing defences is likely to impact on the visual and landscape aesthetics of the area.

Table 4-25: Environmental assessment for Sustain

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
- Will enable the seawall to provide the same level of flood protection to socio-economic receptors despite climate change predictions - Will enable the seawall to continue protecting against erosion risk - No significant change in the footprint / aesthetic of the structure	- Some disruption to public access of the promenade and beach during the construction works - Potential release of contaminants during construction - Will not enhance the natural environment - Will potentially impact on visual and landscape aesthetics	- Low cost environmental enhancement possible such as groyne vertipools - Construction during off-peak times (i.e. during winter) - Glass based crest raising to sustain views of the seafront

Cost

The whole life cash (undiscounted) and present value costs for the Sustain option are presented in Table 4-26 below.

Table 4-26: Whole life costs for the Sustain option

Option	Includes	Cash whole life cost	PV whole life cost
Sustain	- Crest raising at 30-year intervals - Repeat re-facings of seawall, promenade and floodwall, approx. every 30 years - Repeat refurbishments of timber and concrete groynes	£36,656k	£9,208k

Note that a 60% optimism bias has been applied to Unit B costs

4.4.5 Replacement seawall, promenade and floodwall (Improve)

Option drawing

An outline design of a potential improve option can be found in Appendix F, drawing number HUN-ACM-UA-XX-DR-CE-000007.

Option description

The Improve option involves actively improving the standard of protection against flooding and erosion. This approach requires the greatest investment of the management options but will deliver the highest level of protection and therefore the largest economic benefits. The improve option is precautionary, in that crest levels will be raised in one implementation (rather than in multiple interventions like the Sustain option). It has been assumed for costing purposes that this intervention will take place at the end of the residual life of the existing defences.

The most suitable long-list measure for Unit B to implement this option has been identified, balancing feasibility, cost and environmental impacts. The approach will involve the construction of a new seawall along the frontage, in place of the existing defences (including floodgates) at the end of their service life. In addition, where there are currently groynes present, these will be replaced with new structures at the end of their residual service life. The works undertaken to the timber and concrete groynes under the Improve approach are discussed in Section 4.4.6.

Figure 4-10: Photograph examples of new seawall construction/structures

Environmental assessment

An environmental assessment of this approach has been undertaken and is summarised in Table 4-27 below. In general, it was found that the improve option is likely to lead to significant disruption during construction, where there is the potential for contaminants to be released. Increasing the height and footprint of the existing defences will also impact the visual and landscape aesthetics of the area, although this is unlikely to have a significant impact on local coastal processes or local designations.

Table 4-27: Environmental assessment for Improve

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
- Will enhance the level of flood protection to socio-economic receptors despite climate change predictions - Will enable the seawall to continue protecting against erosion risk - Could potentially enhance the public amenity space	- Some disruption to public access of the promenade and beach during the construction works - Potential for new defence to have larger footprint and encroach into the intertidal area - Potential release of contaminants during construction - Will not enhance the natural environment - Will potentially impact on visual and landscape aesthetics - Could potentially be detrimental to the public amenity spaces	- Low cost environmental enhancement possible such as groyne vertipools - Construction during off-peak times (i.e. during winter) - Promenade improvements for access etc. - Landscaping opportunities for new defences

Cost

The whole life cash (undiscounted) and present value costs for the Improve Option are presented in Table 4-28. However, it should be noted that at this stage of the option development process the size, scale and nature of a new enhanced seawall in Hunstanton has not yet been fully determined, therefore for cost estimation and comparison purposes the Environment Agency's cost estimation for coastal protection guidance, 2015 (Report – SC080039/R7) has been used.

Table 4-28: Whole life costs for the Improve options

Option	Includes	Cash whole life cost	PV whole life cost
Improve 1	- Construction of new seawall - Construction of new timber groynes (all sections)	£50,777k	£21,014k
Improve 1A	- Construction of new seawall - Construction of new timber groynes (sections A-E) - Extended concrete groynes (section G)	£50,081k	£20,277k
Improve 2	- Construction of new seawall - Construction of new rock groynes (all sections)	£44,283k	£18,992k
Improve 2A	- Construction of new seawall - Construction of new rock groynes (sections A-E) - Extended concrete groynes (section G)	£45,632k	£19,231k

Note that a 60% optimism bias has been applied to Unit B costs

4.4.6 Details of groyne works for Maintain, Sustain and Improve options

4.4.6.1 Existing Timber groynes

The existing timber groynes in Unit B (sections A-E) currently appear to be functioning, as they act to hold the beach material in front of the seawall, despite being in a mixed state of repair.

Maintain / Sustain Options

For appraisal and pricing purposes the Maintain and Sustain options look to prolong the life of the existing timber groynes through refurbishment at regular intervals throughout the appraisal period. This will include replacing the various timber elements that are either damaged or missing with like-for-like tropical hardwood replacements. No significant changes would be made to the design of the groynes and they would remain permeable. This will help to sustain beach levels which will in turn protect the defences at the rear of the beach by absorbing wave energy along the frontage. Typically, the majority of the timber elements that need replacing are located at the seaward end of the groynes. Future works will also include the continuation of on-going routine maintenance on an annual basis.

Photograph 4-4: Existing timber groynes in Unit B

The advantages and disadvantages of refurbishing the existing timber groynes are presented in Table 4-29 below:

Table 4-29: Refurbishing Timber Groynes – Technical advantages/disadvantages

Advantages	Disadvantages
- Existing structure is very effective at maintaining beach levels in front of the seawall, refurbishing or replacing will prolong the life of the existing structures. - Refurbishing or replacing the existing groynes will improve their performance retaining beach levels. - Construction can be staggered; through condition assessment as different elements/groynes can be prioritised and planned at intervals. - The additional structure will be similar in appearance to the existing defence and therefore will have only limited impact on the visual landscape. - Known construction methodology - Tropical hardwood is comparatively more effective in marine environments than locally sourced oak. - Works will avoid impacting on the promenade	- Refurbishing/replacing the existing groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations. - Refurbishment can be technically challenging particularly with the groynes partially hidden beneath the beach. - The groynes extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and cost through an extended programme. - Although better than oak, tropical timber still has a relatively short residual life and as a consequence is expensive to maintain. - Environmental implications of importing tropical timber (and added cost of ensuring sustainably sourced).

Improve options

For the Improve options it is assumed that the existing groynes will need to be replaced with either a new timber groyne field or an alternative rock groyne option, both of which will be designed to optimise performance, yet minimise their impact on the amenity areas of the beach.

Enhanced timber groynes

The advantages and disadvantages of new enhanced timber groynes are presented in Table 4-30 below:

Table 4-30: New enhanced timber groynes – Technical advantages/disadvantages

Advantages	Disadvantages
- A new timber structure will be similar in appearance to the existing groynes and therefore will have only limited impact on the visual landscape - Known construction methodology - Longer impermeable timber groynes will have a greater ability to trap material, maintain beach levels and therefore protect the seawall	- Increasing the performance of the groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations - The groynes will extend further down the beach which means that there will be a reduced tidal window to work in, which has on impact on safety and cost through an extended programme - Construction can be technically challenging particularly with the groynes extended into the intertidal zone - Although better than oak, tropical timber has a relatively short residual life and as a consequence is expensive to maintain - Environmental implications of importing tropical timber (and added cost of ensuring sustainably sourced)

Alternative rock armour groynes

The advantages and disadvantages of new alternative rock groynes are presented in Table 4-31 below:

Table 4-31: New alternative rock groynes – Technical advantages/disadvantages

Advantages	Disadvantages
- Very durable and therefore low maintenance compared to timber alternatives	- Increasing the performance of the groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations
- Rock can easily be relocated or adjusted to optimise their position	- The groynes will extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and cost through an extended programme
- Longer rock groynes will potentially increase their ability to trap material, maintain beach level and protect the seawall	- Construction can be technically challenging particularly with the groynes extended into the intertidal zone
- Deliveries via the sea prevent any disruption to the town (i.e. traffic etc.)	- Environmental implications of importing rock
- Rock armour has the potential to create some new habitats in the intertidal zone	- Aesthetically different to the existing structures on the frontage, potential visual and landscape impact
	- Potential planning and consenting issues

Cost

Whole life costs for the groyne works in Sections A-E of Unit B over the next 100 years are presented in Table 4-32 below. Please note that these costs have respectively been included in the whole life costs for the Maintain and Sustain and Improve options presented in the sections above (i.e. the costs presented in Table 4-32 are not additional to the option costs presented above).

Table 4-32: Whole life cost estimates for timber groyne works

Approach	Options included in	Cash whole life cost	PV whole life cost
Refurbish the existing timber groynes	Maintain Sustain	£6,736k	£2,141k
New enhanced timber groynes	Improve	£10,054k	£3,415k
Alternative rock groynes	Improve	£5,604k	£2,369k

Note that a 60% optimism bias has been applied to Unit B costs

Environmental assessment

An environmental assessment of potential works to the timber groyne has been undertaken and are summarised in Table 4-33 below.

Table 4-33: Environmental assessment for groyne works (Section A-E)

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
Refurbish existing timber groynes		
- The continued use of permeable groynes will avoid interfering with existing coastal processes - Aesthetically similar in appearance to the existing defences, i.e. will not significantly impact on the existing landscape - No significant change to the footprint of the structure - No significant impacts to the amenity use of the beach - Will continue to retain beach levels to protect the seawall and therefore protect	- Tropical timbers are likely to be sourced internationally with large carbon footprints - Construction will cause significant disruption on the beach - Rock armoured toe could potentially impact on coastal processes - On-going maintenance works	- Environmental enhancement opportunities i.e. Vertipools etc. - Timing construction to cause least disruption to beach access and recreation (i.e. during the winter)

socio-economic receptors against erosion		
Enhanced timber groynes		
- Longer impermeable groynes will have an improved ability to retain beach levels to protect the seawall and therefore protect socio-economic receptors against erosion - No significant impacts to the amenity use of the beach - Aesthetically similar in appearance to the existing defences, i.e. will not significantly impact on the existing landscape	- Longer impermeable groynes will have a greater impact on coastal processes and local designations - Increasing the performance of the groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations. - Tropical timbers are likely to be sourced internationally with large carbon footprints - Construction will cause significant disruption on the beach - On-going maintenance works	- Environmental enhancement opportunities i.e. Vertipools etc. - Timing construction to cause least disruption to beach access and recreation (i.e. during the winter)
Alternative rock groynes		
- Will potentially enhance the amenity use of the beach which will benefit local tourism (beyond construction) - Will continue to retain beach levels to protect the seawall and therefore protect socio-economic receptors against erosion - Limited future maintenance requirements	- Construction will cause significant disruption on the beach - Aesthetically very different to the existing defences, and will therefore impact on the existing landscape - The increased performance of rock groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations. - Longer/larger rock groynes will have a greater impact on local coastal processes and local designations	- Environmental enhancement opportunities through new habitats created by rock armour. - Timing construction to cause least disruption to beach access and recreation (i.e. during the winter)

4.4.6.2 Existing concrete groynes

The existing concrete groynes at the northern end of Unit B (Section G) are considerably shorter than the timber alternatives to the south (Sections A-E) and whilst they appear to retain a limited amount of material at the top of each groyne bay, very little material is present across the remainder of the foreshore, indicating that the groynes are not as effective at holding material in place as the timber groynes to the south.

Photograph 4-5: Existing concrete groynes in Unit B

Although refined beach modelling has not been undertaken for this specific section of the frontage for option appraisal and costing purposes it has been assumed that the Maintain and Sustain approaches will include like-for-like refurbishment to maintain the existing concrete groynes at the end of their residual lives.

Under the Improve approach the following three options have been considered to either modified or replaced the existing groynes to improve their performance:

- Double the length of the existing concrete groynes;
- Replace the existing concrete groynes with a longer timber alternative;
- Replace the existing groynes with an extended rock armour alternative.

Extend the length of the existing concrete groynes

The advantages and disadvantages of extending the existing concrete groynes are presented in Table 4-34 below:

Table 4-34: Extending the existing concrete groynes (Section G)

Advantages	Disadvantages
- Extending the existing structure will potentially increase its ability to trap material, maintain beach levels and protect the seawall	- Increasing the performance of the groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations
- The additional structure will be similar in appearance to the existing groynes and therefore will have only limited impact on the visual landscape	- Construction can be technically challenging particularly with the groynes extended into the intertidal zone. Also, the underlying geology is likely to be rock, which will make piling very challenging.
- Very durable and therefore low maintenance compared to the timber alternatives	- The groynes will extend far down the beach which means that there will be a reduced tidal window to work in which has on impact on safety and cost through and extended programme
- Known construction methodology	- Potential planning and consenting issues

Replace with extended timber alternative

The advantages and disadvantages of replacing the concrete groynes with new timber groynes are presented in Table 4-35 below:

Table 4-35: Extended timber alternative (Section G)

Advantages	Disadvantages
- A new timber structure will be similar in appearance to the neighbouring groynes and therefore will have only limited impact on the visual landscape	- Increasing the performance of the groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations
- Known construction methodology	- The groynes will extend far down the beach which means that there will be a reduced tidal window to work in which has on impact on safety and cost through an extended programme
- Longer timber groynes will potentially increase their ability to trap material, maintain beach level and protect the seawall	- Construction can be technically challenging particularly with the groynes extended into the intertidal zone. Also, the underlying geology is likely to be rock, which will make piling very challenging.
	- Although better than oak, tropical timber has a relatively short residual life and as a consequence is expensive to maintain
	- Environmental implications of importing tropical timber (and added cost of ensuring sustainably sourced)

Replace with extended rock armour alternative

The advantages and disadvantages of a new extended rock alternative are presented in Table 4-36 below:

Table 4-36: Extended rock alternative (Section G)

Advantages	Disadvantages
- Very durable and therefore low maintenance compared to timber alternatives	- Increasing the performance of the groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations
- Rock can easily be relocated or adjusted to optimise their position	- The groynes will extend far down the beach which means that there will be a reduced tidal window to work in which has an impact on safety and cost through an extended programme

- Longer rock groynes will potentially increase their ability to trap material, maintain beach level and protect the seawall	- Construction can be technically challenging particularly with the groynes extended into the intertidal zone
- Easy to construct	- Environmental implications of importing rock
- Deliveries via the sea prevent any disruption to the town (i.e. traffic etc.)	- Aesthetically different to the existing structures on the frontage, potential visual and landscape impact
- Rock armour has the potential to create some new habitats in the intertidal zone	- Potential planning and consenting issues

Costs

Whole life costs for the concrete groyne works for the next 100 years are presented in Table 4-37 below. The extension costs have been included in the whole life costs for the Maintain and Sustain options and the replacement with timber costs have been included in the whole life costs for the Improve option (i.e. the costs are not additional to the option costs presented in the sections above).

Table 4-37: Whole life cost estimates for works to existing concrete groynes

Approach	Options included in	Cash whole life cost	PV whole life cost
Refurbish existing groynes (30%)	Maintain Sustain	£2,218k	£671
Extend existing groynes (100%)	Improve	£4,526k	£1,628k
Replace with 126m timber groynes x9	Improve	£5,072k	£2,345k
126m rock groyne alternative x5	Improve	£4,526k	£1,628k

Note that a 60% optimism bias has been applied to Unit B costs

Note no allowance has been made at this stage for the demolition of existing groynes.

Environmental assessment

An environmental assessment of the potential works to the existing concrete groyne has been undertaken and is summarised in Table 4-38 below.

Table 4-38: Combined environmental assessment for works to existing concrete groynes

Key positive effects	Key negative effects	Mitigation or enhancement opportunities
Concrete maintenance and improvements		
- Aesthetically similar in appearance to the existing groynes, i.e. may not significantly impact the landscape - Will potentially enhance the amenity use of the beach - Will enable the groynes to retain beach levels to protect the seawall and therefore protect socio-economic receptors against erosion - Maintaining beach levels will benefit local tourism (beyond construction)	- Extending the groynes will potentially impact on existing coastal processes - Construction will cause significant disruption to the beach - Enhancement options will significantly change the footprint of the structure and will encroach on the intertidal zone - Increasing the performance of the groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations.	- Environmental enhancement opportunities i.e. Vertipools etc. - Timing construction to cause least disruption to beach access and recreation (i.e. during the winter)
Enhanced timber groynes		
- New longer timber groynes will have an improved ability to retain beach levels to protect the seawall and therefore protect socio-economic receptors against erosion - Will potentially enhance the amenity use of the beach which will benefit local tourism (beyond construction)	- Longer groynes will have a greater impact on coastal processes - Aesthetically very different to the existing defences, and will therefore impact on the existing landscape - Increasing the performance of the groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations.	- Environmental enhancement opportunities i.e. Vertipools etc. - Timing construction to cause least disruption to beach access and recreation (i.e. during the winter)

	- Tropical timbers are likely to be sourced internationally with large carbon footprints - Construction will cause significant disruption on the beach - On-going maintenance works	
Alternative rock groynes		
- Will potentially enhance the amenity use of the beach which will benefit local tourism (beyond construction) - Will continue to retain beach levels to protect the seawall and therefore protect socio-economic receptors against erosion - Limited future maintenance requirements	- Construction will cause significant disruption on the beach - Aesthetically very different to the existing defences, and will therefore impact on the existing landscape - The increased performance of rock groynes will increase their ability to retain material and therefore reduces the amount of sediment available for down drift locations. - Longer/larger rock groynes will have a greater impact on local coastal processes	- Environmental enhancement opportunities through new habitats created by rock armour. - Timing construction to cause least disruption to beach access and recreation (i.e. during the winter)

4.4.7 Unit B preferred option

An economic analysis of the short-listed options has been undertaken for the Unit B frontage. The results of this analysis have been used alongside the option appraisal and feedback from the public consultation as well as the aims and objectives of BCKLWN to identify the preferred option for Unit B.

A comparison of the costs and benefits of the short-listed approaches for Unit B over the 100-year appraisal period are summarised in Table 4-39 below. Please note the full economics assessment can be found in the Economics Report Appendix C.

Table 4-39: Summary of Benefit Cost assessment for Unit B

Option	PV benefits (£k)	PV cost (£k)	Ave. BCR
Do Minimum	511	641	0.80
Maintain	6,697	7,850	0.85
Sustain	6,705	9,205	0.73
Improve 1 (Timber groynes)	6,706	21,014	0.32
Improve 1A (Timber & concrete groynes)	6,706	18,992	0.35
Improve 2 (Rock groynes)	6,706	20,277	0.33
Improve 2A (Rock & concrete groynes)	6,706	19,231	0.35

Both the 2010 SMP2 and 2015 Strategy's policies for Unit B are to hold the existing line of defence. Similar to Unit A, the consequence of the Ave. BCR's being <1 is that none of the options meet Defra's FCERM economic criteria and will therefore be unlikely to qualify for any public Grant in Aid funding (under current guidelines). Therefore, if the hold the line policy is to be delivered it will be necessary for BCKLWN to fund the preferred options through alternative means (i.e. private funding, contributions etc.).

Since none of the potential options are likely to qualify for Grant in Aid funding, the choice of the preferred option does not have to follow the FCERM decision making rules and criteria and BCKLWN does not have to necessarily use the Ave. BCR to differentiate between options. However, these parameters remain useful tools for identifying the leading economic option. Therefore, alternative cost effectiveness appraisal has been used to identify the economically preferred option.

The economic benefits of the three 'do something' options (Maintain, Sustain and Improve) are very similar (approximately £6,700k) whilst the benefits of the Do Minimum option are significantly lower (£511k). Therefore, a cost effectiveness appraisal has been undertaken for each of the 'do something' options, which all comply with the hold the line policy.

The Maintain option was found to be the most cost effective of the 'do something' options; i.e. the benefits of Maintain are only marginally less than Sustain and Improve approaches, yet the costs are much lower. Therefore, the Maintain approach is considered to be the economically preferred option.

However, as BCKLWN have stated, it is also their intention to mitigate against future flood risk by sustaining the existing level of flood protection in the medium and long term in line with any predicted increases in sea level and storminess due to climate change. Therefore, the preferred option for the floodwall is to Sustain the existing defence.

The results from the public consultation survey indicated that the Maintain option was the second most selected option by respondents behind the Improve option. However, whilst the Improve option could potentially enhance the amenity use of the frontage making it attractive to the public, it only marginally increases the economic benefits, yet the costs of implementation are significantly higher. Therefore, without greater funding certainty the improve option has not been considered any further.

Following consultation with key stakeholders, it was also found that (beyond construction) the maintaining of the existing structures under the Maintain option is not expected to have any additional significant environmental impacts. However, the iterative raising of the existing floodwall, in line with the predicted impacts of climate change under the Sustain option, will potentially impact upon the existing landscape along the frontage and will need to be considered in more detail and various consents sought before implementation.

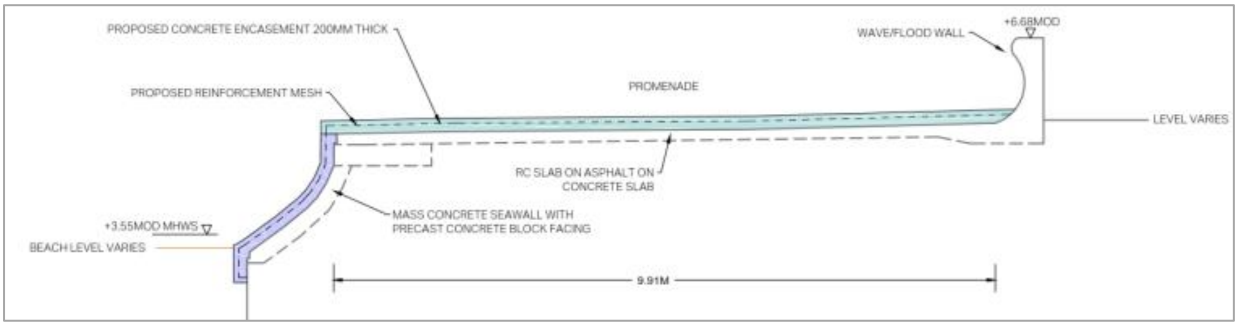

Figure 4-11: Indicative section of Maintain approach for seawall and promenade

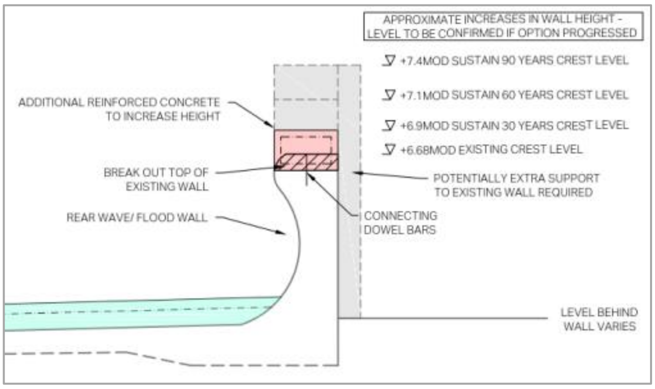

Figure 4-12: Indicative section of Sustain approach (raising floodwall at rear of promenade)

Based on the evidence considered, the preferred option for Unit B is to maintain the existing defences along the frontage throughout the appraisal period and in the medium to long term future sustain the level of flood protection by iteratively increasing the crest levels of the rear floodwall.

Maintaining the existing defences including the timber and concrete groynes will provide continued erosion protection, and then in the future as predicted sea level rise occurs the raising of defences will limit any potential flood damages from increasing beyond their current levels.

5. The Plan

Unit A

5.1 Unit A

Existing frontage

The existing Unit A frontage is formed of undefended cliffs. There are no existing defences along the frontage. There are a number of assets on top of the cliff that are predicted to be at risk of erosion in the longer term.

Photograph 5-1: Hunstanton Cliff located in Unit A

Preferred management option

The preferred management option is to construct an initial/pilot 250m stretch of rock armour protection (sill/revetment) in front of the cliff to protect the most vulnerable assets (i.e. the lighthouse area) in the short to medium term. Then in the longer term construct the remaining 1075m of the rock armour protection to protect the rest of the frontage.

Approach

There are a number of possible variations for the timings of these works. For comparison purposes the following three variations have been considered:

1. Initial 250m rock protection in year 5, remaining 1075m rock protection in year 50
2. Initial 250m rock protection in year 10, remaining 1075m rock protection in year 55
3. Initial 250m rock protection in year 15, remaining 1075m rock protection in year 60

Figure 5-1 shows the proposed location of the initial 250m of rock protection.

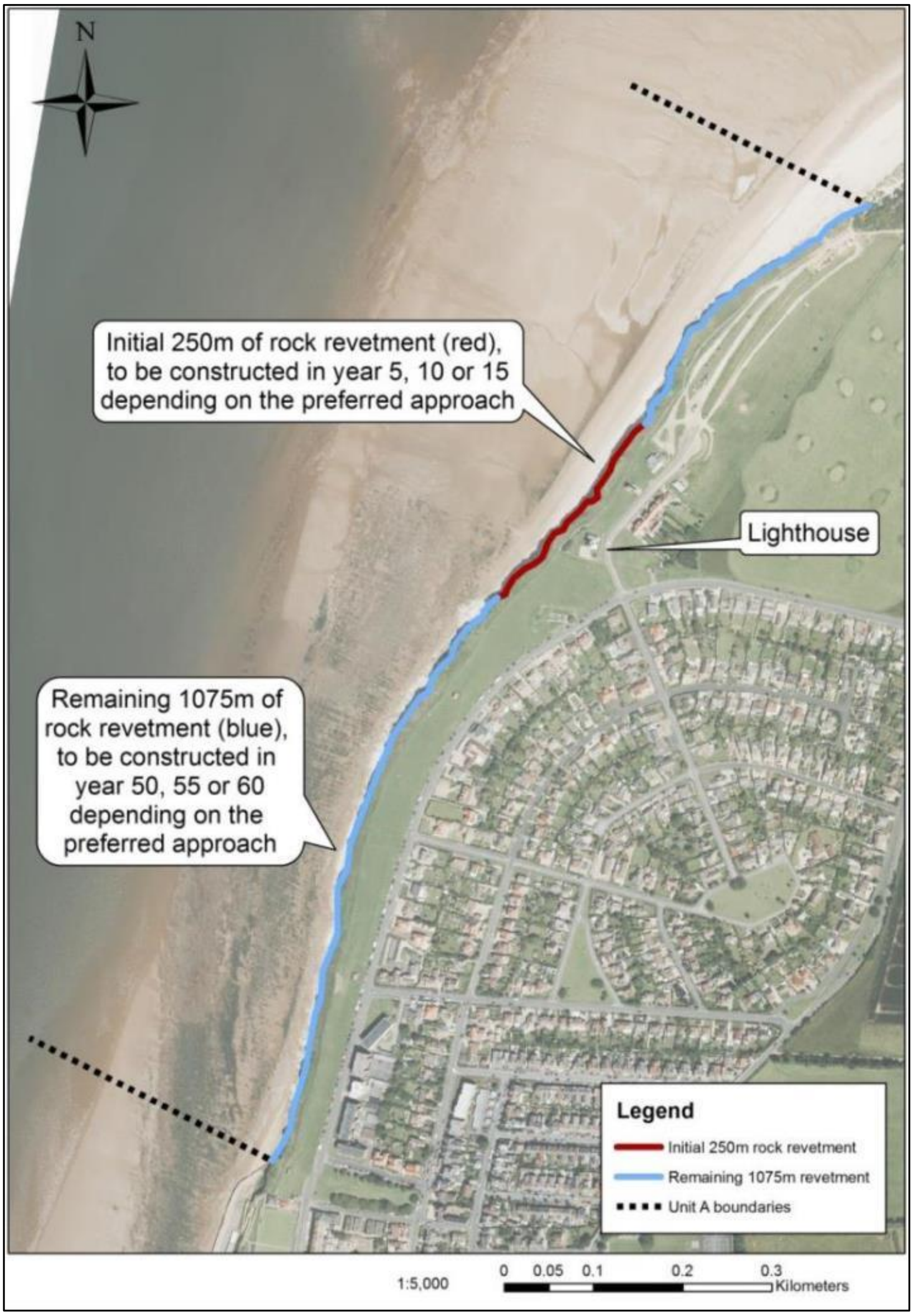

Figure 5-1: Map showing rock protection phased approach in Unit A

Environmental considerations

Whilst the detailed design will be undertaken at a later work stage, it should be noted that there is likely to be some significant environmental impacts that result from implementing this option which must be considered when progressing this option. Due to the environmentally sensitive nature of the cliffs and local designations a full Environmental Impact Assessment (EIA) along with significant environmental monitoring is likely to be required, consequently an initial estimated of £100k has now been included in the wider cost estimates to cover each of these assessments in advance of any works (i.e. £100k in advance of both the initial 250m and the later 1075m). It has been assumed for the costing and planning purposes that this environmental assessment will be commenced in advance of detailed design along with any other required ‘supporting studies.’

Cost

Estimated costs of the different approaches are presented in Table 5-1 below.

Table 5-1: Whole life costs for Unit A with different timing approaches

Approach	Initial 250m cash cost	Initial 250m PV cost	Whole life cash cost	Whole life PV cost
Initial 250m rock protection in year 5, remaining 1075m rock protection in year 50	£611k	£537k	£4,341k	£1,204k
Initial 250m rock protection in year 10, remaining 1075m rock protection in year 55	£611k	£452k	£4,341k	£1,028k
Initial 250m rock protection in year 15, remaining 1075m rock protection in year 60	£611k	£380k	£4,060k*	£864k

*Note: the third approach has a reduced whole life cost due to fewer maintenance cycles within the 100-year appraisal period.

Delivery

Table 5-2 summarises the actions required for the three different timing approaches.

In the interim period between the completion of the initial 250m section of rock armour protection and the construction of the remaining 1075m, it is recommended that both performance and environmental monitoring is carried out. The purposes of the performance monitoring will be to ensure that the initial 250m of protection is performing as expected and is reducing the rate of cliff erosion and the environmental monitoring will include the monitoring of any potential impacts on local coastal processes, habitats and designations.

In addition, it is also assumed that maintenance of the rock revetment/sill will be scheduled to occur every 10 years following the initial construction.

Table 5-2: Actions required for different timings of implementing the rock protection option

Year(s)	250m rock protection in year 5 1075m rock protection in year 50	250m rock protection in year 10 1075m rock protection in year 55	250m rock protection in year 15 1075m rock protection in year 60
3 (2022/23)	- Supporting studies and design		
4-5	- Construction 250m rock protection - Begin environmental monitoring		
8		- Supporting studies and design	
9-10		- Construction 250m rock protection - Begin environmental monitoring	
13			- Supporting studies and design
14-15	- Maintenance (estimated year 15)		- Construction 250m rock protection - Begin environmental monitoring
20-29	- Maintenance (estimated year 25)	- Maintenance (estimated year 20)	- Maintenance (estimated year 25)
30-39	- Maintenance (estimated year 35)	- Maintenance (estimated year 30)	- Maintenance (estimated year 35)
40-48	- Maintenance (estimated year 45)	- Maintenance (estimated year 40)	- Maintenance (estimated year 45)
49-53	- Supporting studies and design (year 49) - Construction 1075m rock protection (year 50)	- Maintenance (estimated year 50)	
54-58		- Supporting studies and design (year 54) - Construction 1075m rock protection (year 55)	- Maintenance (estimated year 55)
59-63	- Maintenance (estimated year 60)		- Supporting studies and design (year 59) - Construction 1075m rock protection (year 60)
64-69		- Maintenance (estimated year 65)	
70-79	- Maintenance (estimated year 70)	- Maintenance (estimated year 75)	- Maintenance (estimated year 70)
80-89	- Maintenance (estimated year 80)	- Maintenance (estimated year 85)	- Maintenance (estimated year 80)
90-99	- Maintenance (estimated year 90)	- Maintenance (estimated year 95)	- Maintenance (estimated year 90)

Cost profile

Initial 250m length of rock protection (15 years)

Table 5-3 (below) provides the estimated discounted cost profiles for the construction of the initial 250m of rock protection in years 5, 10 and 15. As presented, the total cash investment required over the next 15 years to construct and maintain the 250m rock protection is estimated to be £611k. However, in discounted Present Value (PV) terms, the total costs for constructing the initial 250m of protection fall from £537k in year 5 to £380k in year 15.

Entire 1325m frontage (whole life)

Table 5-4 (below) provides a more detailed breakdown of costs for the full 100-year appraisal period for the different implementation options. As presented, the total cash investment to implement the approaches over the full 100 years varies between £4,060-4,341k depending on the timing of construction and the number of maintenance cycles included. Of these amounts, approximately £611k is associated with constructing the initial 250m of rock protection. The remaining £3,449-3,730k is associated with constructing the remaining 1075m and maintaining the entire structure.

In PV terms, the total 100 years cost (whole life) varies from £1,204k for approach 1 (250m in year 5 and 1075m in year 50) and £864k for approach 3 (250m in year 15 and 1075m in year 60).

Table 5-3: Capital cost profile for initial 250m of rock revetment, first 15 years. All costs in cash (undiscounted terms) unless otherwise stated (e.g. PV)

Annualised capital spend profile (£k)		Yr0 2019/20	Yr1 20/21	Yr2 21/22	Yr3 22/23	Yr4 23/24	Yr5 24/25	Yr6 25/26	Yr7 26/27	Yr8 27/28	Yr9 28/29	Yr10 29/30	Yr11 30/31	Yr12 31/32	Yr13 32/33	Yr14 33/34	Total	Total (PV)
Construction year 5	Prelims / design				102												102	92
	Construction					291											291	254
	Environmental					100*											100*	88
	Maintenance																-	-
	Optimism bias					118											118	103
	Total costs (yr0-15)				102	509											611	537
Construction year 10	Prelims / design									102							102	77
	Construction										291						291	214
	Environmental										100*						100*	74
	Maintenance																-	-
	Optimism bias										118						118	87
	Total costs (yr0-15)									102	509						611	452
Construction year 15	Prelims / design														102		102	65
	Construction															291	291	180
	Environmental															100*	100*	62
	Maintenance																-	-
	Optimism bias															118	118	73
	Total costs (yr0-15)														102	509	611	380

*Note – At this stage the costs included for environmental assessments is a gross estimate and will be subject to change as the preferred option is further developed and screening/scoping studies are completed.

Table 5-4: Capital cost profile for 100-year appraisal period. All costs in cash (undiscounted terms) unless otherwise stated (e.g. PV)

Annualised capital spend profile (£k)		Yr0 2019/20	Yr3-4	Yr8-9	Yr13-15	Yr20-29	Yr30-39	Yr40-48	Yr49-53	Yr54-58	Yr59-63	Yr64-69	Yr70-79	Yr80-89	Yr90-99	Total (£k)	Total (PV) (£k)
Initial construction year 5. Remaining construction year 50.	Prelims / design		102						459							561	185
	Construction		291						1,312							1603	512
	Environmental		100*						100*							200*	106
	Maintenance				51	51	51	51			281		281	281	281	1328	193
	Optimism bias		118						531							649	208
	Total costs		611		51	51	51	51	2402		281		281	281	281	4341	1204
Initial construction year 10. Remaining construction year 55.	Prelims / design			102						459						561	158
	Construction			291						1,312						1603	437
	Environmental			100*						100*						200*	90
	Maintenance					51	51	51	51			281	281	281	281	1328	166
	Optimism bias			118						531						649	177
	Total costs			611		51	51	51	51	2402		281	281	281	281	4341	1028
Initial construction year 15. Remaining construction year 60.	Prelims / design				102						459					561	135
	Construction				291						1,312					1603	372
	Environmental				100*						100*					200*	76
	Maintenance					51	51	51		51			281	281	281	1047	130
	Optimism bias				118						531					649	151
	Total costs				611	51	51	51		51	2402		281	281	281	4060	864

*Note – At this stage the costs included for environmental assessments is a gross estimate and will be subject to change as the preferred option is further developed and screening/scoping studies are completed.

Unit B

5.2 Unit B

The preferred option for Unit B is to ***Maintain*** the existing defences and then in the future to ***Sustain*** the standard of protection through raising the heights of the defences. How this approach will be implemented on the different elements of the defence has been detailed in the sections below.

The defence elements include:

- Seawall;
- Promenade;
- Rear floodwall (including flood gates);
- Groynes.

Unit B – Seawall

5.2.1 Seawall

Existing Structure

Location

The seawall, which provides both flood and erosion protection, is located continuously along Sections A-G of Unit B as shown in Figure 5-2.

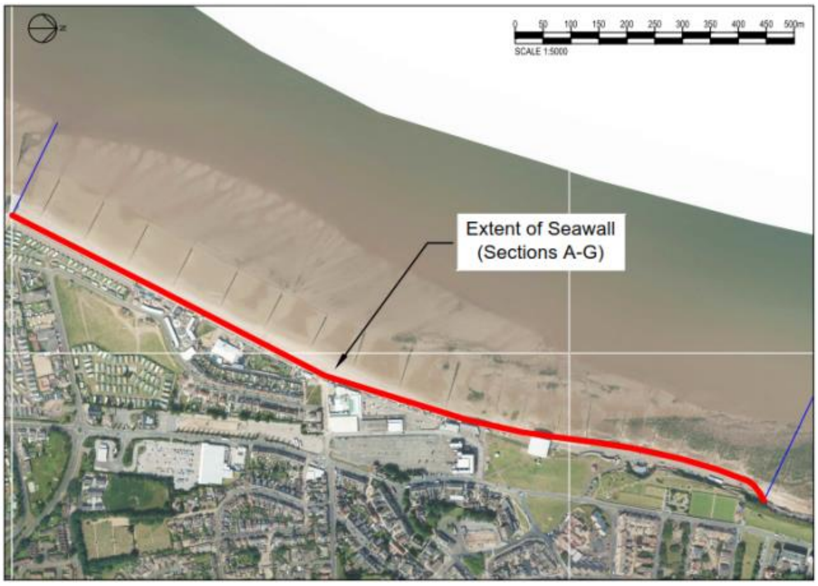

Figure 5-2: Plan showing extent of existing seawall

Existing condition

The existing condition of the seawall ranges between Fair and Good. The predicted residual life of the defences has been estimated at 35 years for Sections A-C and 15 years for Sections D-G as shown in Figure 5-3 (residual lives derived in condition assessment presented in Appendix A).

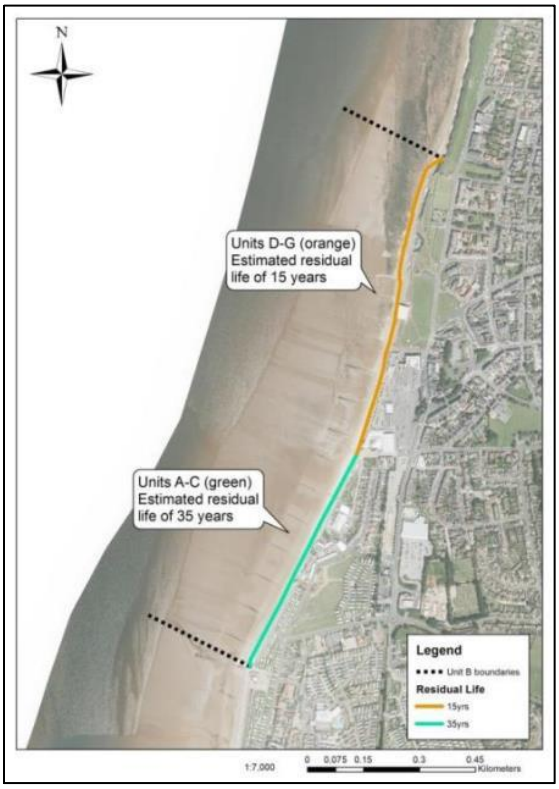

Figure 5-3: Residual lives of seawalls in Unit B

Appearance

The various sections of the seawall (A-G) reflect the different construction types that are present along the frontage. Figure 5-4 shows representative photographs of the different sections of seawall.

Section A

Section B

Section C

Section D

Section E

Section F

Section G

Figure 5-4: Photographs of existing seawall

Preferred management option

The preferred management option for the seawall, found through the Option Appraisal process, is to ***Maintain the existing structure; through encasement***.

Approaches

Since the residual life of the existing seawall structures varies, with Sections A-C having estimated residual lives of 35 years and sections D-G having estimated residual lives of 15 years, there are two different potential approaches for planning the works:

1. To undertake the initial capital encasement works at the end of the residual life of the defences, i.e. in year 15 for sections D-G and then in year 35 for sections A-C.

2. An alternative approach would be to undertake the initial encasement across all sections in one go, this would offer efficiencies through not having to mobilise construction twice and will also ensure that the seawall have a uniform residual life going forward. Under this approach the works would be completed when the first section of defence was close to failing, which is predicted to be in approximately year 15.

Up until the time of the initial encasement the current reactive maintenance activities will be continued. This includes small patch repairs to ensure health and safety compliance and to extend the life of existing structures by preventing minor cracks from deteriorating. However, this is not a long-term solution as this type of repair regime becomes progressively more expensive over time as the condition of the structures deteriorate, hence why encasement in necessary. Once the encasement is completed, its service life has been estimated to be approximately 30 years.

Cost

Estimated capital costs of the seawall encasement are provided in Table 5-5.

Table 5-5: Encasement costs per section of defence in unit B

Section	Estimated cost per encasement (approximately once every 30 years)
A	£1,435k
B	£292k
C	£512k
D	£17k
E	£620k
F	£79k
G	£1,333k
Total	**£4,288k**

Whole life costs for the next 100 years in cash and PV terms are presented in Table 5-6 (excluding on-going maintenance for the unit). This shows that as the residual lives of the existing defences vary by 20 years and are in two distinct groups it would be more cost effective in PV (discounted) terms to undertake the works in two stages.

Table 5-6: Whole life costs for repeat encasements over the next 100 years. Excluding on-going maintenance costs

Approach	Whole life cash cost	Whole life PV cost
Encasement at end of residual life of all seawall defences, then every 30 years: - Sections A-C years 35, 65, 95 - Sections D-G years 15, 45, 75	£12,864k	£2,894k
Encasement for all of Unit B at the same time in year 15, then every 30 years: - Sections A-G years 15, 45, 75	£12,864k	£3,819k

Design considerations

The encasement will provide a protective cover to the existing cracks and abrasion damage on the surface of the seawall. For it to work successfully it is dependent on the structural integrity of the existing seawall defences. A review of previous intrusive investigation work has been undertaken, and at the time of the investigation there was no evidence showing that the existing defences are structurally unsound i.e. no observed voids beneath the promenade slab or overturning of the existing seawall.

A review of beach monitoring information has also been undertaken; whilst there is some variation in beach levels (as expected), there is no evidence that beach levels in Unit B are significantly lowering over the longer term in a way that might lead to the undermining of the existing seawall. This beach monitoring work will be continued to assess long term trends and provide further confidence that the existing structure will remain stable.

The details of the design of encasement would be undertaken at a later work stage, however, it is anticipated that the new layer will be supported by the existing seawall. Consideration will have to be given as to whether to try to retain the current shape of the walls or potentially make the aesthetic more uniform. Some sections of the wall also contain drainage weep holes which will need to be extended through the encasement layer.

Unit B – Promenade

5.2.2 Promenade

Existing structure

Location

The promenade extends across Sections A-G and provides public access along the frontage above the beach and behind the seawall. The location of the promenade is shown in Figure 5-5.

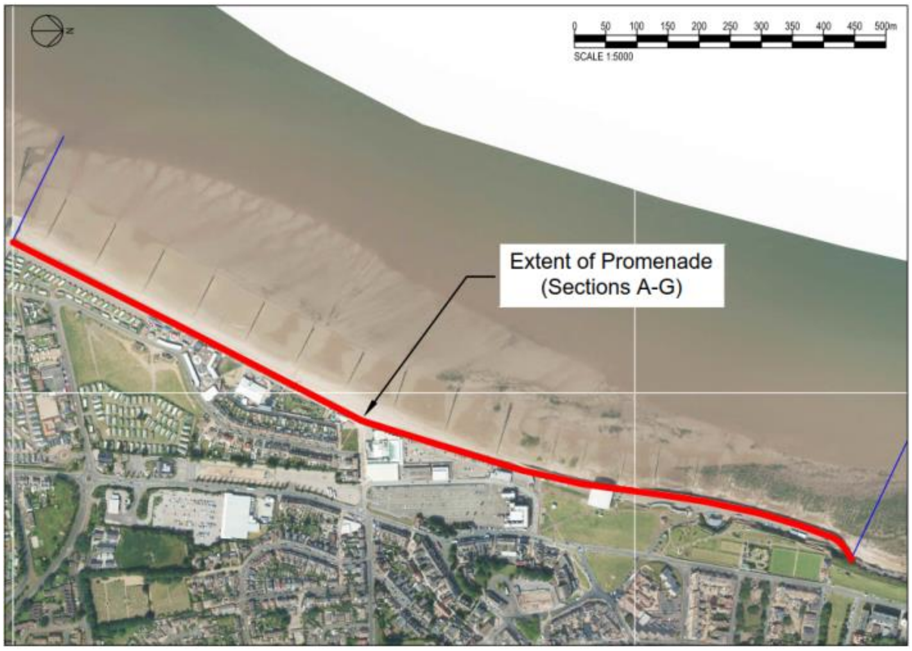

Figure 5-5: Plan showing extent of existing promenade

Existing condition

The existing condition of the promenade varies between Fair and Very Good. It should be noted that this condition grade is an assessment based on erosion and flood defence functionality. There are a number of cracks along the surface of the promenade which mean the surface is uneven in places and many ‘patch’ repairs have been undertaken to fix these types of faults previously. However, even with repairs the quality of the surface of the promenade will continue to deteriorate over time. This presents some risk to public safety and accessibility of the promenade in the future. An example of these patch repairs is shown in Photograph 5-2.

Photograph 5-2: Example of patch repair on promenade

Preferred option

The preferred option for the promenade, found through the Option Appraisal process, is to ***Maintain through resurfacing***.

Approach

Following the completion of the option appraisal process, at the request of BCKLWN, two different methods of promenade resurfacing have been considered:

1. Concrete overlay (as previously considered in the Option Appraisal); and

2. Bitumen macadam (asphalt) overlay (added following consultation with BCKLWN).

The concrete option would be more resilient and therefore longer lasting than the asphalt; however, it would also be more expensive. In terms of the service life of the different approaches, the concrete finish has been assumed to have a service life of approximately 30 years, whilst the lower cost asphalt finish has been assumed to have a service life of 10-15 years (15 years assumed for costing purposes).

It should be noted that both methods require the flood gates at the rear of the promenade to be raised, but the bitumen macadam (asphalt) method will also require the crest of the seawall (at the front of the promenade) to be raised in order to contain the asphalt and offer some edge protection from wave activity.

It should be noted that the recommended approach for the seawall is also to maintain through an encasement option. It is therefore recommended that the promenade works are undertaken alongside the seawall encasement as this could potentially lead to some efficiency savings (i.e. from use of the same Contractor, plant, decreased mobilisation costs etc.).

Cost

Estimated costs of the different promenade resurfacing approaches are provided in Table 5-7 below.

Table 5-7: Promenade resurfacing costs per section of defence in unit B

Section	Estimated cost per concrete resurface (once every 30 years)	Estimated cost per asphalt resurface (once every 15 years)
A	£491k	£383k
B	£189k	£147k
C	£338k	£264k
D	£12k	£10k
E	£431k	£336k
F	£56k	£44k
G	£927k	£722k
Total	**£2,444k**	**£1,906k**

Whole life costs for the next 100 years in both cash and PV terms are presented in Table 5-8 (excluding on-going maintenance for the unit). The approaches presented show the different types of promenade resurfacing as well as the two different timing approaches related to the seawall (as the promenade works should take place at the same time as the seawall works). This shows that over the entire appraisal period the most cost-effective surfacing approach before general on-going maintenance is considered to be the use of a concrete surface.

Table 5-8: Whole life costs for repeat resurfacing works over the next 100 years. Excluding on-going maintenance costs

Approach	Whole life cash cost	Whole life PV cost
Concrete resurface of the promenade to coincide with the encasement of the seawall at the end of its residual life, then every 30 years: - Sections A-C years 35, 65, 95 - Sections D-G years 15, 45, 75	£7,334k	£1,756k
Concrete resurface of the promenade to coincide with the encasement of all of the seawall in Unit B at the same time in year 15, then every 30 years: - Sections A-G years 15, 45, 75	£7,334k	£2,178k
Asphalt resurface of the promenade to coincide with the encasement of the seawall at the end of its residual life, then every 15 years: - Sections A-C years 35, 50, 65, 80, 95 - Sections D-G years 15, 30, 45, 60, 75, 90	£10,640k	£2,199k
Asphalt resurface of the promenade to coincide with the encasement of all of the seawall in Unit B at the same time in year 15, then every 15 years: - Sections A-G years 15, 30, 45, 60, 75, 90	£11,436k	£2,749k

Design considerations

The detailed design of the resurfacing will be undertaken at a later work stage. However, it should be noted that both methods will require the flood gates at the rear of the promenade to be raised and surface water drainage to be considered. The asphalt option will also require the crest of the seawall (at the front of the promenade) to be raised to contain the asphalt and offer some edge protection from wave activity.

In addition, it should also be noted that if the asphalt option is adopted then the existing surface to be overlain may have to be repaired in advance to remove any significant cracks, in order to avoid any ‘reflective cracking’ from occurring where any joints or cracks are transmitted to the new surface (this is not yet included in the costing).

For all the works being considered in Unit B the design will need to consider public access to the beach and attractions. Given the seasonal nature of the tourist industry in Hunstanton, it is recommended that the works are planned to occur over the winter months to minimise disruption in the popular summer months.

Unit B – Rear floodwall (including flood gates)

5.2.3 Rear floodwall (including flood gates)

Existing structure

Location

The floodwall along the back of the promenade exists in Sections A-F, it does not continue into Section G where the seawall at the front of the promenade is raised. The wall has a number of gates that when closed form a flood defence to the properties and other assets on the landward side of the promenade. The floodwall also typically has a re-curve shape to reduce wave overtopping. The location of the rear flood wall is shown in Figure 5-6.

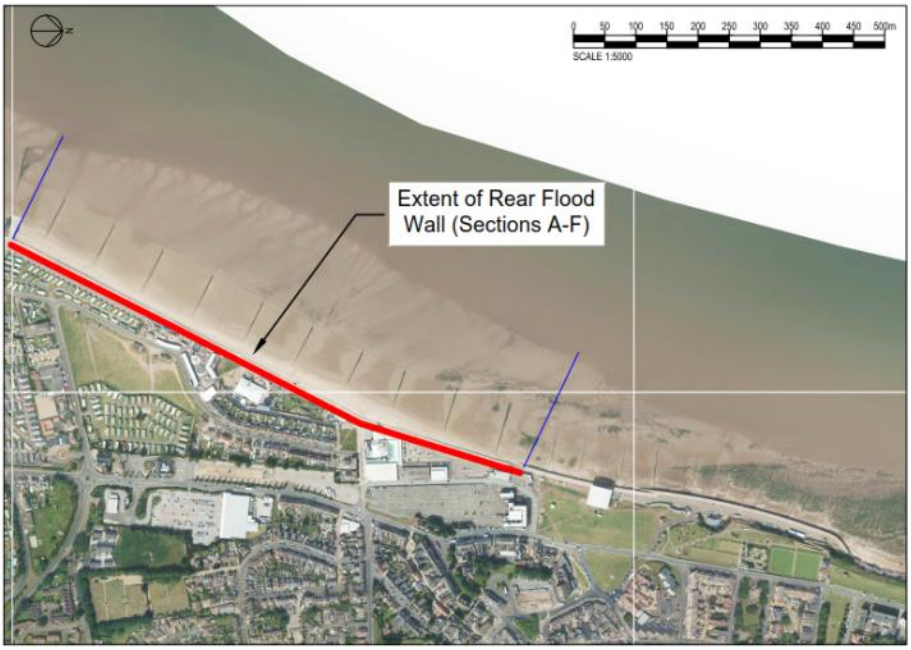

Figure 5-6: Plan showing extent of existing rear flood wall

Existing condition

The majority of the rear floodwall is in good condition. The deterioration of the condition of the wall is expected to be slow relative when compared to the seawall because it is at a higher level and therefore less exposed to seawater and wave action that can carry abrasive material in large storm events. A typical photograph of the rear floodwall is shown in Photograph 5-3.

Photograph 5-3: Rear floodwall in Good condition

Preferred option

The preferred option as described in the Option Appraisal is to ***Sustain the existing standard of protection*** that the floodwall provides by initially maintaining the wall and then raising it in the future in line with predicted sea level rise.

Approach

The current standard of protection is adequate in the present day, but the wall must be raised in the future to continue to provide this standard of protection against the predicted rising sea levels. The wall is in good condition and therefore only limited maintenance is required in the short term.

The recommended approach is to connect the timing of the raising works with the scheduled capital maintenance of the seawall and promenade. The two approaches considered for the timings of the seawall and promenade works have an earliest start date of 15 years into the future. However, the flood risk is not predicted to significantly increase during this period. Therefore, it is recommended to undertake the initial wall raising at the next encasement stage. This would be year 35 for Sections A-C and year 45 for Sections D-F or if the alternate approach is adopted; the encasement works will be undertaken all together, in this scenario the raising works will also be commenced in year 45.

It should be noted that when the level of the floodwall is increased, it will also be necessary to replace the existing floodgates along the wall with correspondingly larger system of floodgates at the same time.

Cost

Estimated costs of floodwall refurbishments (including flood gate replacements) are provided in Table 5-9 below. For the purposes of cost calculations, it has been assumed that the raising will take place in three increments, approximately every 30 years.

Table 5-9: Floodwall (including flood gates) raising costs per section of defence in unit B

Section	Estimated cost per floodwall raising (approximately once every 30 years)
A (0 floodgates)	£374k
B (6 floodgates)	£372k
C (5 floodgates)	£446k
D (1 floodgates)	£45k
E (5 floodgates)	£518k
F (1 floodgates)	£79k
G (0 floodgates)	£718k
Total	**£2,552k**

Whole life costs for the next 100 years in cash and PV terms are presented in Table 5-10 (excluding on-going maintenance for the unit).

Table 5-10: Whole life costs for repeat floodwall refurbishments (including flood gates) over the next 100 years. Excluding on-going maintenance costs

Approach	Whole life cash cost	Whole life PV cost
Floodwall refurbishment to coincide with the encasement of the seawall at the end of its residual life, then every 30 years: - Sections A-C years 35, 65, 95 - Sections D-G years 15, 45, 75	£7,658k	£1,781k
Floodwall refurbishment to coincide with the encasement of all of the seawall in Unit B at the same time in year 15, then every 30 years: - Sections A-G years 15, 45, 75	£7,658k	£2,273k

Design considerations

The detailed design of how the floodwalls will be raised will be undertaken at a later stage; however, the design will have to consider whether the existing structure can support the additional weight of a height increase or whether extra support is required. The design should also consider whether it is technically efficient to raise the extra height (0.7m to provide the current standard of protection in 100 years' time) incrementally or all in one operation. For the purposes of cost calculations, it has been assumed that the raising will take place in three increments, approximately every 30 years. Increasing to the final level in one operation would provide a higher standard of flood protection than currently provided throughout the next 100 years.

Unit B – Groynes

5.2.4 Groynes

Existing structure

Location

Along the frontage there are 10 existing timber groynes (in Sections A-E) and 9 existing concrete groynes (in Section G).

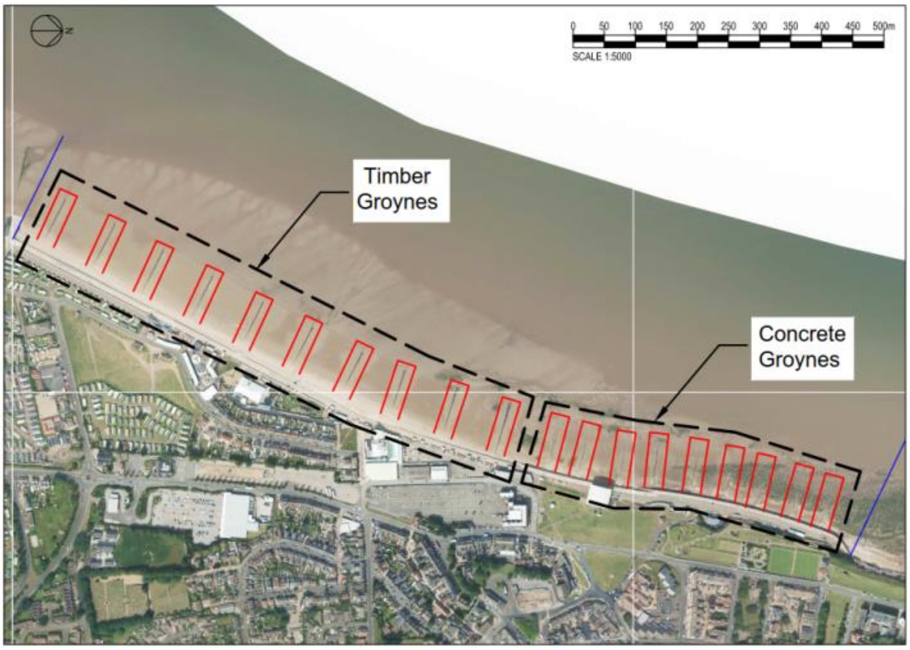

Figure 5-7: Plan showing locations of existing groynes

Existing condition

The existing timber groynes (Sections A-E) appear to be performing well and are holding beach material in front of the seawall. However, the groynes have been assessed to be in fair to poor condition. Although the piles are generally intact, on the seaward end of the groynes many vertical sheeters and cross beams are either missing or showing signs of significant abrasion. The predicted residual life of the timber groynes is 5-15 years. Photograph 5-4 shows the typical seaward end of a timber groyne.

Photograph 5-4: Seaward extent of timber groyne showing missing timber elements

The existing concrete groynes have been assessed to be in fair to good condition. Whilst there is minor cracking and spalling only two concrete planks are missing across all of the concrete groynes. The groynes appear to retain some material; however, they are shorter than the timber groynes and are therefore not as effective at maintaining beach levels. The predicted residual life of the concrete groynes is 15-30 years (subject to maintenance). Photograph 5-5 shows an existing concrete groyne.

Photograph 5-5: Concrete groyne located in Section G

Preferred option

The preferred option for the timber and concrete groynes is to ***Maintain through refurbishment***.

Approach

Under the Maintain approach the existing timber and concrete groynes are to be refurbished to extend their design life and ensure they continue to retain material to protect the frontage. Refurbishment will involve replacing the parts of the defences that have deteriorated/failed to keep the groynes functioning to retain beach material. After the timber and concrete groynes have been refurbished the service life of the refurbished structures is estimated to be approximately 30 years (subject to continued maintenance).

Similar to the promenade in practical terms it would be sensible to undertake the groyne works alongside the seawall encasement works, as in addition to the reduced mobilisation costs, the groynes extend right up to the seawall and would have to be partially demolished in order to provide working space for the seawall encasement, therefore undertaking the groynes works at the same time will increase efficiency. However, the timber groynes are only predicted to remain functional for a further 5-15 years and they are positioned in locations where the seawall currently has a much longer residual life. Therefore, it will be necessary to undertake the refurbishment of the timber groynes in advance of the seawall encasement.

For the concrete groynes, which only exist in Section G, the 15-year minimum residual life coincides with the residual life of the seawall at this location; therefore, timing the works together is achievable and practicable.

Cost

Estimated costs of the timber groyne refurbishments are provided in Table 5-11 below. Whole life costs for the next 100 years in cash and PV terms are presented in Table 5-12 (excluding on-going maintenance for the unit).

Table 5-11: Timber groyne refurbishment costs per section of defence in unit B

Section	Estimated cost of timber groyne refurbishment (approximately once every 30 years)
A	£461k
B	£294k
C	£299k
D	No groynes
E	£464k
F	No groynes
G	£478k
Total	**£1,996k**

Table 5-12: Whole life costs for repeat timber and concrete groyne refurbishments over the next 100 years (to coincide with timing of seawall options). Excluding on-going maintenance costs

Approach	Whole life cash cost	Whole life PV cost
Early refurbishment of timber groynes in sections A-C in year 5. Then refurbishments to coincide with the encasement of the seawall at the end of its residual life. Repeat refurbishments every 30 years. - Sections A-C years 5, 35, 65, 95 - Sections E years 15, 45, 75	£5,606k	£1,803k
Timber groyne refurbishments to coincide with the encasement of all of the seawall in Unit B at the same time in year 15, then every 30 years: - Sections A, B, C & E years 15, 45, 75	£4,553k	£1,352k
Timber groyne refurbishments to coincide with the encasement of all of the seawall in Unit B at the same time in year 15, then every 30 years. Concrete groyne refurbishments at the same time. - Timber groynes in sections A, B, C & E years 15, 45, 75 - Concrete groynes in sections G years 15, 45, 75	£5,987k	£1,777k

Design considerations

Refurbishment of the groynes would involve detailed surveys of the groynes to identify which elements should be replaced. Since the existing groynes have proved to be effective and deemed to be acceptable from both an environmental and coastal process perspective, a like-for-like refurbishment is recommended. The works will have to be planned accommodate any environmental constraints/consents and will also have to consider the challenges of working in a tidal environment and on a public beach.

Unit B – Delivery of Combined Option

5.2.5 Delivery of combined option

The previous sections outline the preferred management options for the different elements of the existing defences in Unit B; they also describe the various ways these options can potentially be delivered more efficiently if the works are undertaken simultaneously.

The different approaches considered for the delivery of works that have been discussed in the previous sections have been determined by:

- Timings of the seawall works
    1. Maintain the seawall by undertaking the initial capital encasement works at the end of the residual life of the existing defences, i.e. in year 15 for sections D-G and then in year 35 for sections A-C.
    2. An alternative approach would be to undertake the initial encasement across all sections simultaneously in one go by grouping them together, this would offer efficiencies through not having to mobilise construction twice. However, if all sections are to be encased at the same time then this would need to be done when the first section of defence is expected to fail, i.e. in year 15.
- Resurfacing materials for the promenade:
    1. Concrete overlay.
    2. Bitumen macadam (asphalt) overlay.

It can be seen that there are two approaches to timing the work: the end of service life approach and the grouped approach. And there are two technical approaches to delivering the promenade overlay: using concrete or bitumen macadam (asphalt). Table 5-13 and Figure 5-8Figure 5-11 below summarise all the actions required for the delivery of these different approaches.

Table 5-13: Actions required for different approaches to delivering Unit B preferred options

	Approach 1	Approach 2	Approach 3	Approach 4
Year(s)	**End of service life – no promenade resurface**	**End of service life – concrete promenade surface**	**End of service life – bitumen macadam (asphalt) promenade surface**	**All works grouped together – concrete promenade surface**
3	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design	
4-5	- Timber groyne refurbishments in sections A-C	- Timber groyne refurbishments in sections A-C	- Timber groyne refurbishments in sections A-C	
13	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design
14-15	- Construction phase for: 1. Encasement of seawall sections D-G 2. Maintenance of setback flood wall sections D-F 3. Timber groyne refurbishments in section E (no groynes in sections D and F) 4. Concrete groyne refurbishments in Section G	- Construction phase for: 1. Encasement of seawall sections D-G 2. Resurfacing of promenade sections D-G (concrete) 3. Maintenance of setback flood wall sections D-F 4. Timber groyne refurbishments in section E (no groynes in sections D and F) 5. Concrete groyne refurbishments in Section G	- Construction phase for: 1. Encasement of seawall sections D-G 2. Resurfacing of promenade sections D-G (bitumen macadam) 3. Maintenance of setback flood wall sections D-F 4. Timber groyne refurbishments in section E (no groynes in sections D and F) 5. Concrete groyne refurbishments in Section G	- Construction phase for: 1. Encasement of seawall sections A-G 2. Resurfacing of promenade sections A-G (concrete) 3. Maintenance of setback flood wall sections A-F 4. Timber groyne refurbishments in section A,B,C,E (no groynes in sections D and F) 5. Concrete groyne refurbishments in Section G
30			Resurfacing of promenade sections D-G (bitumen macadam)	
33	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design	

34-35	- Construction phase for: 1. Encasement of seawall sections A-C 2. Maintenance of setback flood wall sections A-C and potential raising 3. Timber groyne refurbishments in sections A-C	- Construction phase for: 1. Encasement of seawall sections A-C 2. Resurfacing of promenade sections A-C (concrete) 3. Maintenance of setback flood wall sections A-C and potential raising 4. Timber groyne refurbishments in sections A-C	- Construction phase for: 1. Encasement of seawall sections A-C 2. Resurfacing of promenade sections A-C (bitumen macadam) 3. Maintenance of setback flood wall sections A-C and potential raising 4. Timber groyne refurbishments in sections A-C	
43	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design
44-45	- Construction phase for: 1. Encasement of seawall sections D-G 2. Maintenance of setback flood wall sections D-F and potential raising 3. Timber groyne refurbishments in section E (no groynes in sections D and F) 4. Concrete groyne refurbishments in Section G	- Construction phase for: 1. Encasement of seawall sections D-G 2. Resurfacing of promenade sections D-G (concrete) 3. Maintenance of setback flood wall sections D-F and potential raising 4. Timber groyne refurbishments in section E (no groynes in sections D and F) 5. Concrete groyne refurbishments in Section G	- Construction phase for: 1. Encasement of seawall sections D-G 2. Resurfacing of promenade sections D-G (bitumen macadam) 3. Maintenance of setback flood wall sections D-F and potential raising 4. Timber groyne refurbishments in section E (no groynes in sections D and F) 5. Concrete groyne refurbishments in Section G	- Construction phase for: 1. Encasement of seawall sections A-G 2. Resurfacing of promenade sections A-G (concrete) 3. Maintenance of setback flood wall sections A-F and potential raising 4. Timber groyne refurbishments in section A,B,C,E (no groynes in sections D and F) 5. Concrete groyne refurbishments in Section G
50			Resurfacing of promenade sections A-C (bitumen macadam)	
60			Resurfacing of promenade sections D-G (bitumen macadam)	
63	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design	
64-65	- Construction phase for: 1. Encasement of seawall sections A-C 2. Maintenance of setback flood wall sections A-C and potential raising 3. Timber groyne refurbishments in sections A-C	- Construction phase for: 1. Encasement of seawall sections A-C 2. Resurfacing of promenade sections A-C (concrete) 3. Maintenance of setback flood wall sections A-C and potential raising 4. Timber groyne refurbishments in sections A-C	- Construction phase for: 1. Encasement of seawall sections A-C 2. Resurfacing of promenade sections A-C (bitumen macadam) 3. Maintenance of setback flood wall sections A-C and potential raising 4. Timber groyne refurbishments in sections A-C	
73	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design
74-75	- Construction phase for: 1. Encasement of seawall sections D-G 2. Maintenance of setback flood wall sections D-F and potential raising 3. Timber groyne refurbishments in section E (no groynes in sections D and F) 4. Concrete groyne refurbishments in Section G	- Construction phase for: 1. Encasement of seawall sections D-G 2. Resurfacing of promenade sections D-G (concrete) 3. Maintenance of setback flood wall sections D-F and potential raising 4. Timber groyne refurbishments in section E (no groynes in sections D and F) 5. Concrete groyne refurbishments in Section G	- Construction phase for: 1. Encasement of seawall sections D-G 2. Resurfacing of promenade sections D-G (bitumen macadam) 3. Maintenance of setback flood wall sections D-F and potential raising 4. Timber groyne refurbishments in section E (no groynes in sections D and F) 5. Concrete groyne refurbishments in Section G	- Construction phase for: 1. Encasement of seawall sections A-G 2. Resurfacing of promenade sections A-G (concrete) 3. Maintenance of setback flood wall sections A-F and potential raising 4. Timber groyne refurbishments in section A,B,C,E (no groynes in sections D and F) 5. Concrete groyne refurbishments in Section G

80			Resurfacing of promenade sections A-C (bitumen macadam)	
90			Resurfacing of promenade sections D-G (bitumen macadam)	
93	- Supporting studies and design	- Supporting studies and design	- Supporting studies and design	
94-95	- Construction phase for: 1. Encasement of seawall sections A-C 2. Maintenance of setback flood wall sections A-C and potential raising 3. Timber groyne refurbishments in sections A-C	- Construction phase for: 1. Encasement of seawall sections A-C 2. Resurfacing of promenade sections A-C (concrete) 3. Maintenance of setback flood wall sections A-C and potential raising 4. Timber groyne refurbishments in sections A-C	- Construction phase for: 1. Encasement of seawall sections A-C 2. Resurfacing of promenade sections A-C (bitumen macadam) 3. Maintenance of setback flood wall sections A-C and potential raising 4. Timber groyne refurbishments in sections A-C	

The activities for each approach are shown in the timeline distributions presented below.

End of service life – no promenade resurface

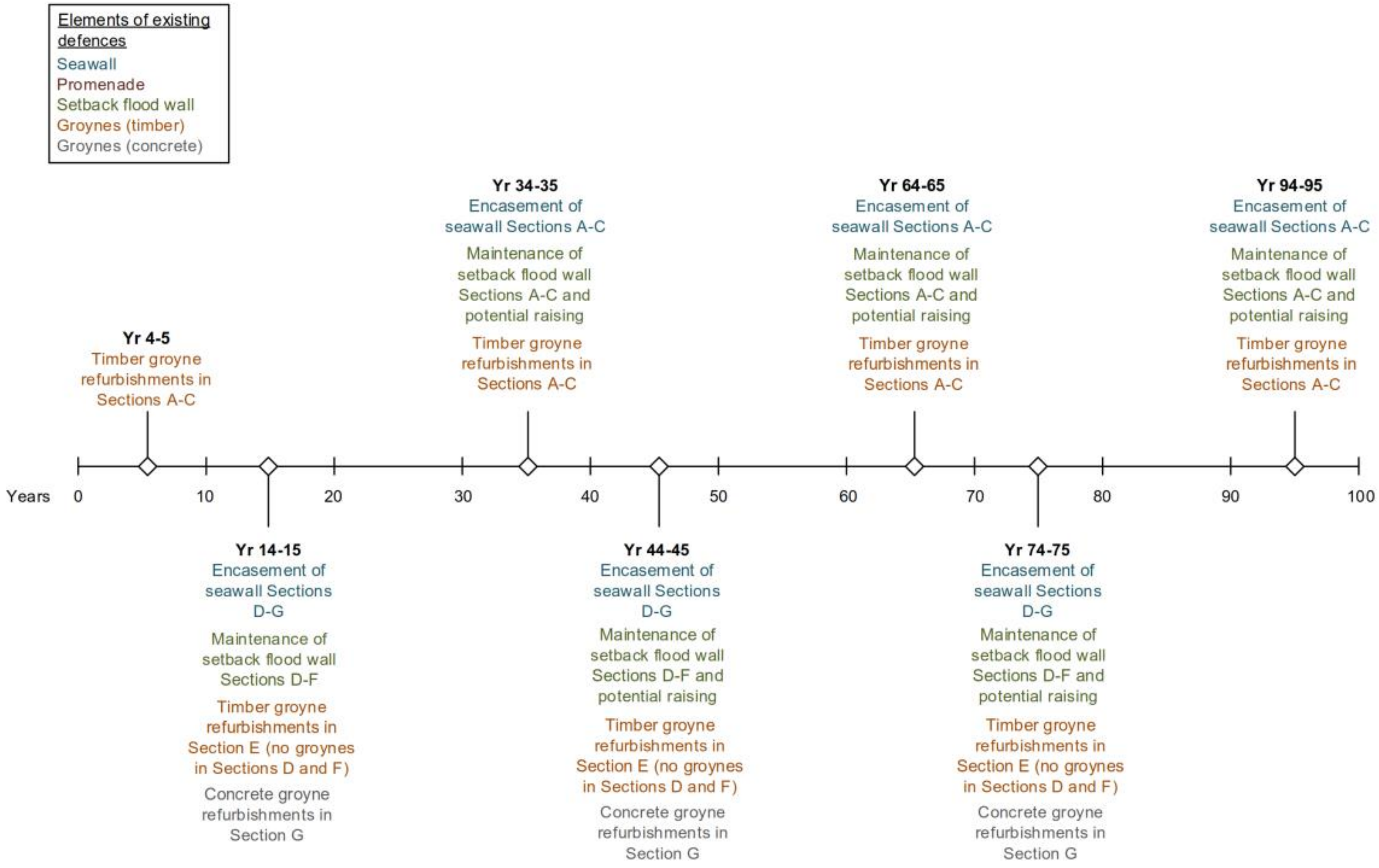

Figure 5-8: Approach 1 timeline

End of service life – concrete promenade surface

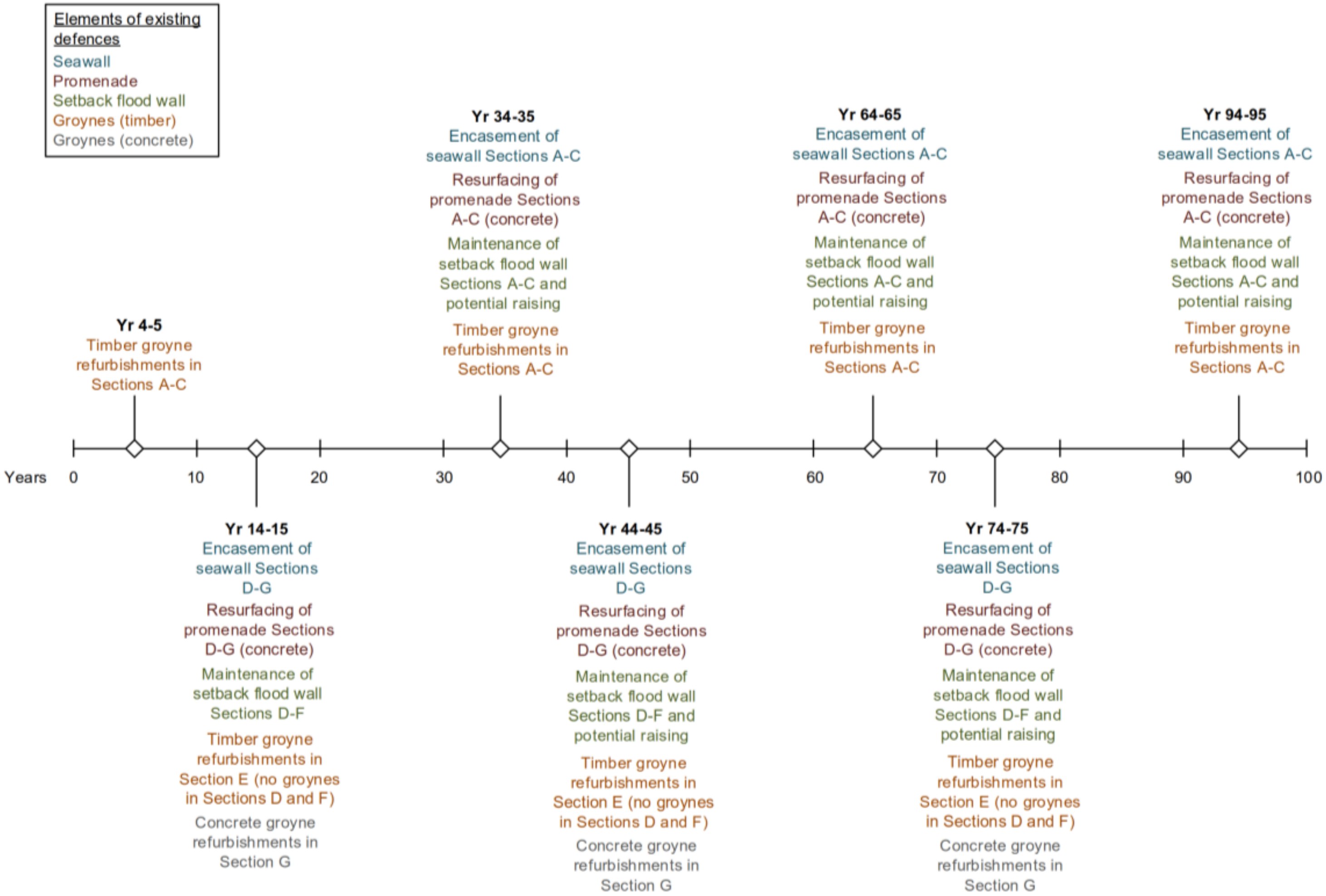

Figure 5-9: Approach 2 timeline

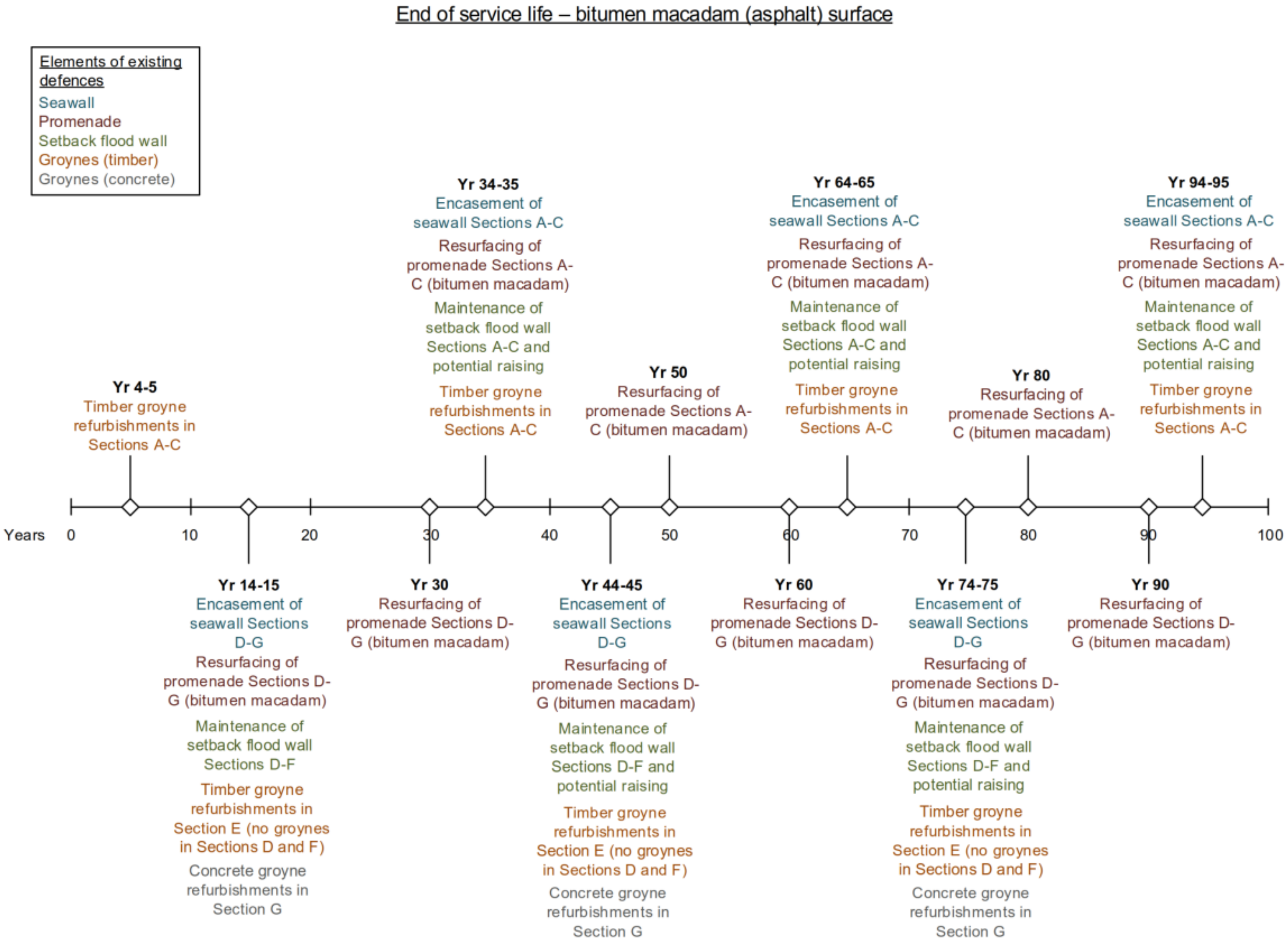

Figure 5-10: Approach 3 timeline

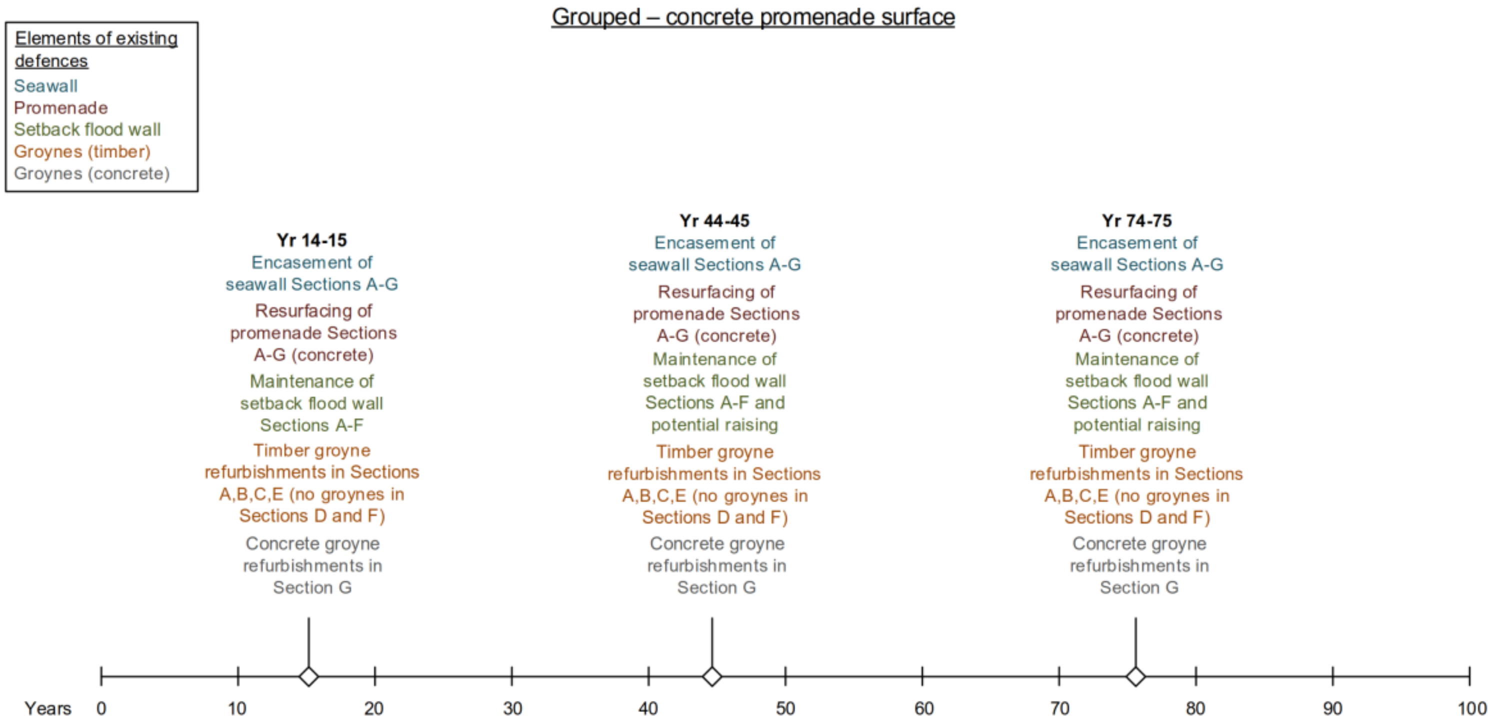

Figure 5-11: Approach 4 timeline

5.2.6 Cost profile

Table 5-14 below presents the whole life costs of the four different approaches (as outlined in Section 5.2.5) over the next 100 years for Unit B. It can be seen the cash investment required over the next 100 years to implement a preferred approach is estimated to be between £29-40million. The value depends on which approach is adopted with respect to timings of works and the resurfacing material for the promenade. In discounted PV terms, the future total costs for implementing the preferred options ranges between £7.5m-10.6m.

In cash terms, the lowest cost approach is to upgrade the defences at the end of the existing service life, whilst not resurfacing the promenade. When considering the promenade, although resurfacing it with bitumen macadam (asphalt) has a lower capital cost than a concrete alternative, because it will have to be replaced more frequently the overall cost across the 100-year appraisal period is significantly higher.

Table 5-14: Capital cost profile for 100-year appraisal period – Unit B. All costs in cash £k (undiscounted terms) unless other stated (e.g. PV)

Annualised capital spend profile (£k)		Yr0 2019/20	Yr5	Yr15	Yr30	1st Raising		Yr50	Yr60	2nd Raising		Yr80	Yr90	Yr95	Total	Total (PV)
						Yr35	Yr45			Yr65	Yr75					
End of service life – no promenade resurface	Prelims / design		171	693		718	693			718	693			718	4,404	6,811
	Construction		488	1,980		2,051	1,980			2,051	1,980			2,051	12,581	
	Environmental			Note – full extent or cost of the required environmental screening exercise has not been determined at this stage.											-	
	Optimism bias		395	1,604		1,662	1,604			1,662	1,604			1,662	10,193	
	Maintenance			Note – total maintenance costs for full 100-year appraisal period presented in total column to the right											2,150	641
	Total costs (excluding maintenance)		1,054	4,276		4,431	4,276			4,431	4,276			4,431	29,328	7,452
End of service life – concrete promenade surface	Prelims / design		171	924		883	924			883	924			883	5,616	8,567
	Construction		488	2,640		2,523	2,640			2,523	2,640			2,523	16,047	
	Environmental			Note – full extent or cost of the required environmental screening exercise has not been determined at this stage.											-	
	Optimism bias		395	2,138		2,043	2,138			2,043	2,138			2,043	12,997	
	Maintenance			Note – total maintenance costs for full 100-year appraisal period presented in total column to the right											2,150	641
	Total costs (excluding maintenance)		1,054	5,702		5,449	5,702			5,449	5,702			5,449	36,657	9,208
End of service life – bitumen macadam promenade surface	Prelims / design		171	872	179	846	872	128	179	846	872	128	179	846	6,118	9,000
	Construction		488	2,492	513	2,417	2,492	366	513	2,417	2,492	366	513	2,417	17,486	
	Environmental			Note – full extent or cost of the required environmental screening exercise has not been determined at this stage.											-	
	Optimism bias		395	2,019	415	1,958	2,019	296	415	1,958	2,019	296	415	1,958	14,163	
	Maintenance			Note – total maintenance costs for full 100-year appraisal period presented in total column to the right											2,150	641
	Total costs (excluding maintenance)		1,054	5,383	1,107	5,221	5,383	790	1,107	5,221	5,383	790	1,107	5,221	39,917	9,641
Grouped – concrete promenade resurface	Prelims / design			1,807			1,807				1,807				5,421	9,932
	Construction			5,163			5,163				5,163				15,489	
	Environmental			Note – full extent or cost of the required environmental screening exercise has not been determined at this stage.											-	
	Optimism bias			4,182			4,182				4,182				12,546	
	Maintenance			Note – total maintenance costs for full 100-year appraisal period presented in total column to the right											2,150	641
	Total costs (excluding maintenance)			11,151			11,151				11,151				35,606	10,573

6. The way forward

Funding opportunities

As outline in Section 4, the average benefit to cost ratios of the preferred approaches for both Units A and B are currently below unity (i.e. <1), consequently the options will not meet the necessary FCERM criteria and will therefore be unlikely to attract any public Grant in Aid funding (under the current guidance). It will therefore be necessary to seek alternative funding sources to deliver the preferred management options. Some potential funding sources could include:

- Public funding – e.g. Council funds
- Regional Flood and Coastal Committee (RFCC)
- Directly through developers – e.g. through redevelopment
- Potential beneficiaries of the scheme – private individuals or landowners
- Local levies e.g. local taxation
- Contributions from developers – e.g. Section 106 monies and the Community Infrastructure Levy
- Local Enterprise Partnership
- Monies collected by the local community and stakeholders
- Other external sources – e.g. Lottery or European Union funding

It is recommended that a funding strategy is prepared and updated at regular intervals. The funding strategy will help to map out the potential sources of funding and document any contributions which may be secured. It will also be important for BCKLWN to 'ring-fence' any financial contributions or savings that they may receive towards the scheme to ensure that funds are available when required in the future.

Potential development opportunities

As stated in Section 3.3, in parallel with the development of this CMP, a separate study into the potential redevelopment of southern Hunstanton is being undertaken, which includes the southern end of Unit B. Although not completed (Dec 2018), it is understood that as part of this project several potential development opportunities along the frontage are being considered that may affect the existing coastal defences, these include:

1. Land reclamation and new amenity beach
2. Marine lake
3. Land based lake
4. Rock groynes and new amenity beach

Other potential development opportunities that are being pursued by a separate local interest group, which if successful is also likely to impact upon the coastal defences and the wider coastal processes, is the campaign to replace the Hunstanton pier.

Whilst the coastal management plan has not considered any of these potential development opportunities on an individual basis, given the likely limitations of any available funding from Flood Defence Grant in Aid it is clear that opportunities with potential Developers will have to be identified and explored, because capital investments will be required to implement the preferred options and maintain the existing defences.

Planning and consents

In order for the preferred management schemes for both Units A and B to go ahead consents from various statutory bodies will be required including (but not limited to) each of the following:

1. Local Planning Authority
2. Marine Management Organisation

3. Natural England
4. Environment Agency
5. Crown Estates
6. Historic England
7. County Archaeological Officer

It is worth noting that some of these consents are likely to require detailed analysis, extensive monitoring and significant determination periods, all of which will have to be programmed well in advance of any scheduled works.

Environmental Impact Assessment

As part of the Coastal Management Plan a Preliminary Environmental Assessment (PEA) has been completed. This has highlighted the key environmental data and constraints that were considered during the development of the Plan and those that should also be considered going forward towards construction.

Due to the environmental sensitivities of the cliffs in Unit A it is highly likely that an Environmental Impact Assessment (EIA) and extensive monitoring will be required to obtain the required consents and support the planning application.

Although an environmental screening assessment will be required for works along Unit B, because the works typically involve refurbishing and enhancing existing structures without the addition of any new structures, it is not anticipated that a full EIA will be required, however, this is still to be confirmed with the relevant stakeholders.

Procurement

Procurement for the initial works will involve the procurement of detailed design, associated surveys and investigations, construction and the supporting specialist advice and expertise required to successfully manage and deliver the project. Two procurement strategies are most relevant to this type of scheme; the traditional design-bid-build approach or a specialist design and build contract. The merits of each have been summarised in Table 6-1 below.

Table 6-1: Potential procurement pathways for the scheme

Approach	Good for:	Not suited for:
Traditional (design-bid-build)	• Quality – full design pre tender • Design flexibility – variations & instructions • Specialist subcontractors • Design control	• Time – requires full detailed design pack pre tender • Cost – not a benefit if many changes are made
Design & build	• Time – fast track, overlap of design and construction • Cost – lump sum / guaranteed maximum price • Single point of responsibility – contractor design and build responsibility • Innovation – can benefit quality • Low risk for client	• Quality – cheapest route to meet contract specifications can lead to low quality products / build quality • Design flexibility – request for changes will have cost / time implications

It is anticipated that the preferred procurement strategy for the works will be determined by BCKLWN closer to the time of implementation.

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