



11e6 Silloth to The Grune

(Technical report by Jacobs)

Policy area: 11e6 Silloth to The Grune

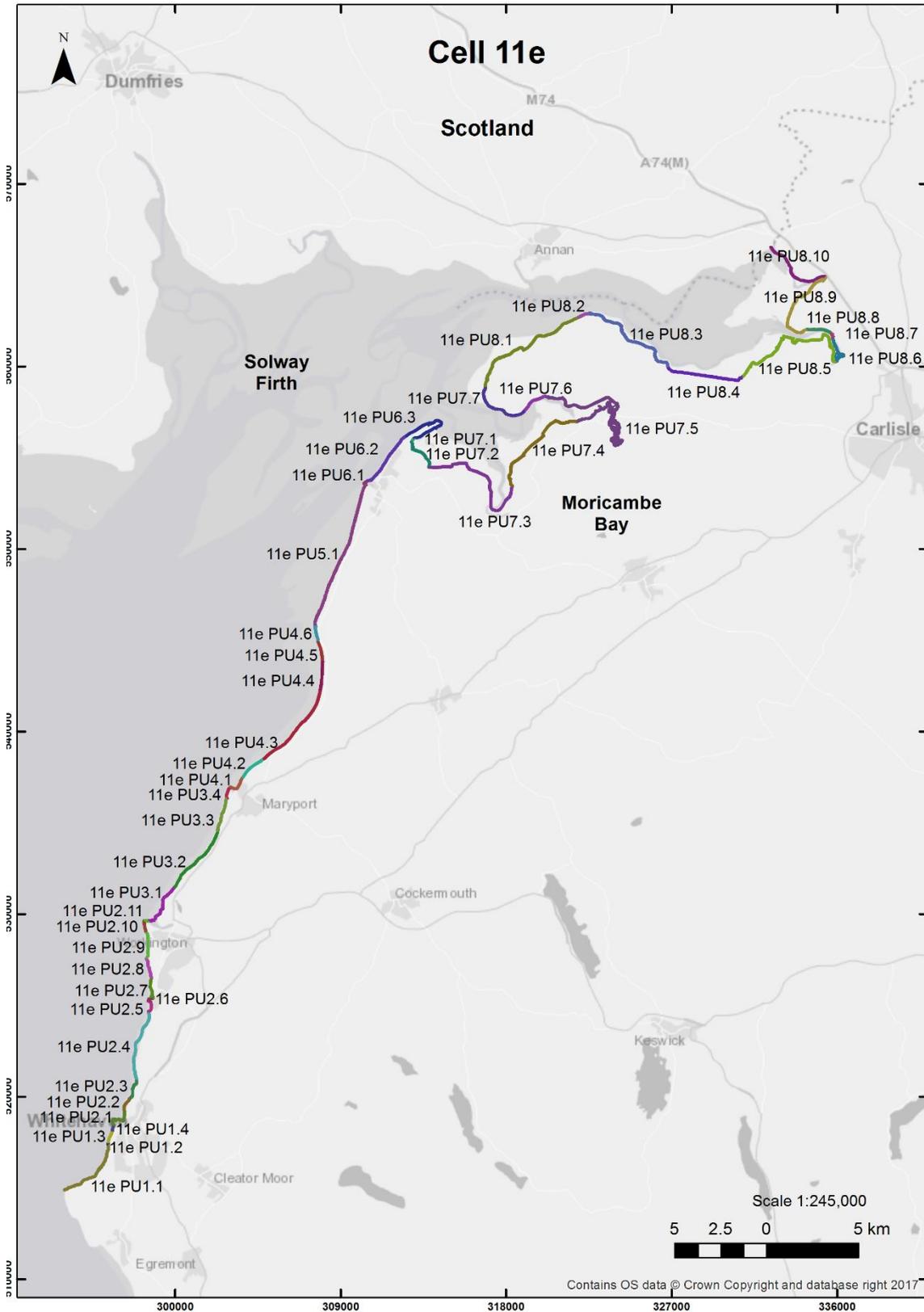


Figure 1 Sub Cell 11e St Bees Head to Scottish Border Location Plan of policy units. Baseline mapping © Ordnance Survey; licence number 100026791.

1 Introduction

1.1 Location and site description

Policy units:	11e6.1 Silloth Harbour 11e6.2 Silloth to Skinburness (priority unit) 11e6.3 The Grune
Responsibility:	Allerdale Borough Council Private Landowners
Location:	This unit covers the open coastline from Silloth Harbour to the distal end of a 2 km long natural sand and shingle spit – The Grune – on the south side of the entrance to the tidal inlet of Moricambe Bay. It includes the coastal fringes of the town of Silloth and the adjacent settlement of Skinburness.
Site overview:	<p>The shoreline across the Silloth and Skinburness frontages is protected by artificial concrete and rock armour coastal defence works that have encased the natural sand and clay deposits that naturally form the shoreline. The frontage is groyned with timber structures across its entire length. A large concrete outfall surround provides a barrier to upper beach movement at Eastcote. Along The Grune frontage the shoreline is largely unrestrained by human intervention, apart from a short section of armour stone protection that has been constructed by the owner of the isolated property (Grune House). The spit is approximately 100 to 200 metres wide, with saltmarsh fringing the bay side flank.</p> <p>Between Silloth and Skinburness the beaches are composed of a relatively mixed sediment upper section comprising a combination of cobbles, shingle and sand and a mid to lower section comprising largely sand and mud. The upper beach across this section has been artificially reinforced with quarried cobble, which has mixed in with the indigenous sediment. The frontage is influenced by the main channel of the Solway Firth “the Swatchway”, which is located adjacent to the shoreline, with a consequent narrow intertidal zone, at the southern end of the frontage. Moving northward, the “Swatchway” moves away from the shoreline and the lower beach widens. Concurrently, the upper beach generally becomes sandier; due to material from the lower beach being moved landward by wind and waves. North of the armour protection to Grune House, the upper beach is primarily gravelly sand with little cobble and shingle in evidence.</p> <p>The hinterland across the Silloth and Skinburness comprises predominantly residential developments. At the southern end property is setback from the shoreline and separated by largely public open space. From Eastcote to Skinburness, property is located immediately behind the defences separated only by local access roads and paths. The generally coarse nature of the beach, its low elevation at the toe of the defences and narrow intertidal width (particularly at the southern end) do not make it particularly conducive to amenity usage. At Skinburness a short section of properties is located at the shoreline. On the Grune there are isolated properties with land use predominantly agricultural (grazing).</p> <p>The intertidal zone and dune habitats of the Grune are heavily designated of national or international importance for conservation area - SSSI, SPA, SAC, Ramsar and national importance for landscape and heritage – AONB and WHS.</p> <p>Silloth Harbour, at the southern end, is a locally important bulk cargo and fishing port that handles about 200,000 tonnes of cargo per year.</p>

1.2 Current SMP policy

The policy details for the whole policy area are shown in the table below, taken directly from the SMP2 (Halcrow, 2011); non priority units have been greyed out.

Table 1 Current SMP Policy for policy area 11e6

Overview: *Managing the flood and erosion risk to local people, property and infrastructure, whilst preserving and where possible enhancing environmental habitats is the primary basis for Shoreline Management Policy within this policy area. The location of the harbour at the south end essentially fixes the shoreline here and this in combination with the current defences moving north are holding the shoreline in advance of its natural position. There is scope due to the land available, for setting back the defences between the harbour and Eastcote, if there was a local will, but this does not accord with the policy defined. Accordingly holding the line here will always be a battle to resist the forcing processes applying.*

Across The Grune there is no economic, environmental or social grounds for artificial intervention unless there was a significant risk of breaching of the spit occurring.

Location		Policy and Approach (from 2010)		
		0-20 years	20-50 years	50-100 years
11e6.1	Silloth Harbour	Hold the Line – By maintaining harbour walls– assumes harbour remains operational.	Hold the Line – By maintaining or upgrading harbour walls – assumes harbour remains operational.	Hold the Line – By maintaining or upgrading harbour walls – assumes harbour remains operational.
11e6.2	Silloth to Skinburness	Hold the Line – By maintaining stepped seawall and rock revetment and repairing or upgrading groynes, beach recharge or material bypass. (strategy study, including Coastal Process and Habitats Regulations Assessment required to confirm policies for Silloth to Moricambe Bay).	Hold the Line – Depending on strategic review, hold the line by maintaining or upgrading defences, potential to construct defences across the neck of the spit to reduce risk to the village from backdoor flooding if the spit breaches.	Hold the Line – Depending on strategic review, hold the line by maintaining or upgrading defences.
11e6.3	The Grune	No active intervention – Allow continued natural coastal evolution.	No active intervention – Allow continued natural coastal evolution.	No active intervention – Allow continued natural coastal evolution.

2 Appraisal of priority units

One unit within this area has been defined as a priority unit:

- 11e6.2 Silloth to Skinburness

2.1 Existing approach to flood and coastal risk management

2.1.1 Justification of current SMP policy

Section 1.2 sets out the SMP policies for these priority units. The primary justifications for the policies at the SMP level were:

- **Social:** For policy units 6.1 and 6.2 the Hold the line policy maintains the integrity of coastal settlements, but long term the sustainability of isolated coastal settlements will need to be reviewed.
- **Environmental:** Holding the line in policy units 6.1 and 6.2 could, dependant on the form of construction, potentially have an adverse impact or detrimental effect on the designated environmental sites, that requires careful consideration. In policy unit 6.3 linkages between The Grune and the adjacent internationally designated sites require detailed examination.
- **Economic:** The economic viability of the policy in 11e6.1 relates to the ongoing economic operation of the harbour, whilst in 11e6.2 it is the impact of flooding through breaches of the existing defences on people, property and infrastructure, that will determine the viability of different approaches. In 11e6.3 there is no tangible justification for intervention.

2.1.2 Current defences

No specific design details are available for this frontage. Based upon the most recent asset inspections (CH2M, 2017a), undertaken as part of the North West Regional Monitoring Programme, and a recent site visit undertaken March 2018, the condition of the existing defences ranges from Fair (3) to Good (2). Table 2 provides a summary of the condition and estimate residual life for the various defence structures, whilst the following text provides further detail regarding current condition and recent management, based upon information taken from the most recent asset inspection report (CH2M, 2017a) and previous inspection reports by Coastal Engineering UK and Capita Symonds (reported in CH2M, 2017a).

Table 2 Existing defence condition and estimated residual life

Unit	Location	EA Asset Ref	Defence Type	Condition	Residual Life (years)
11e6.2	Silloth North Pier	011KE90480101C02	Vertical concrete seawall with sheet piled toe	Fair (3)	20-50
11e6.2	Silloth Bay	011KE90480101C03	Stepped concrete revetment with sheet piled toe	Fair (3)	11-20
11e6.2	Solway Lido to Eastcote Farm	011KE90480101C04	Stepped concrete revetment with sheet piled toe and rear wave return wall and secondary elevated promenade and rear wall	Fair (3)	11-20
11e6.2	Skinburness	011KE90480101C05	Stepped concrete revetment with sheet piled toe and rear wave return wall	Fair (3)	20-50
11e6.2	Skinburnessbank	011KE90480101C06	Rock Revetment	Good (2)	20-50
11e6.3	The Grune	-	Rock Revetment	Good (2)	20-50

Figure 2 below shows policy units, together with a summary of defence lengths between Silloth and The Grune.

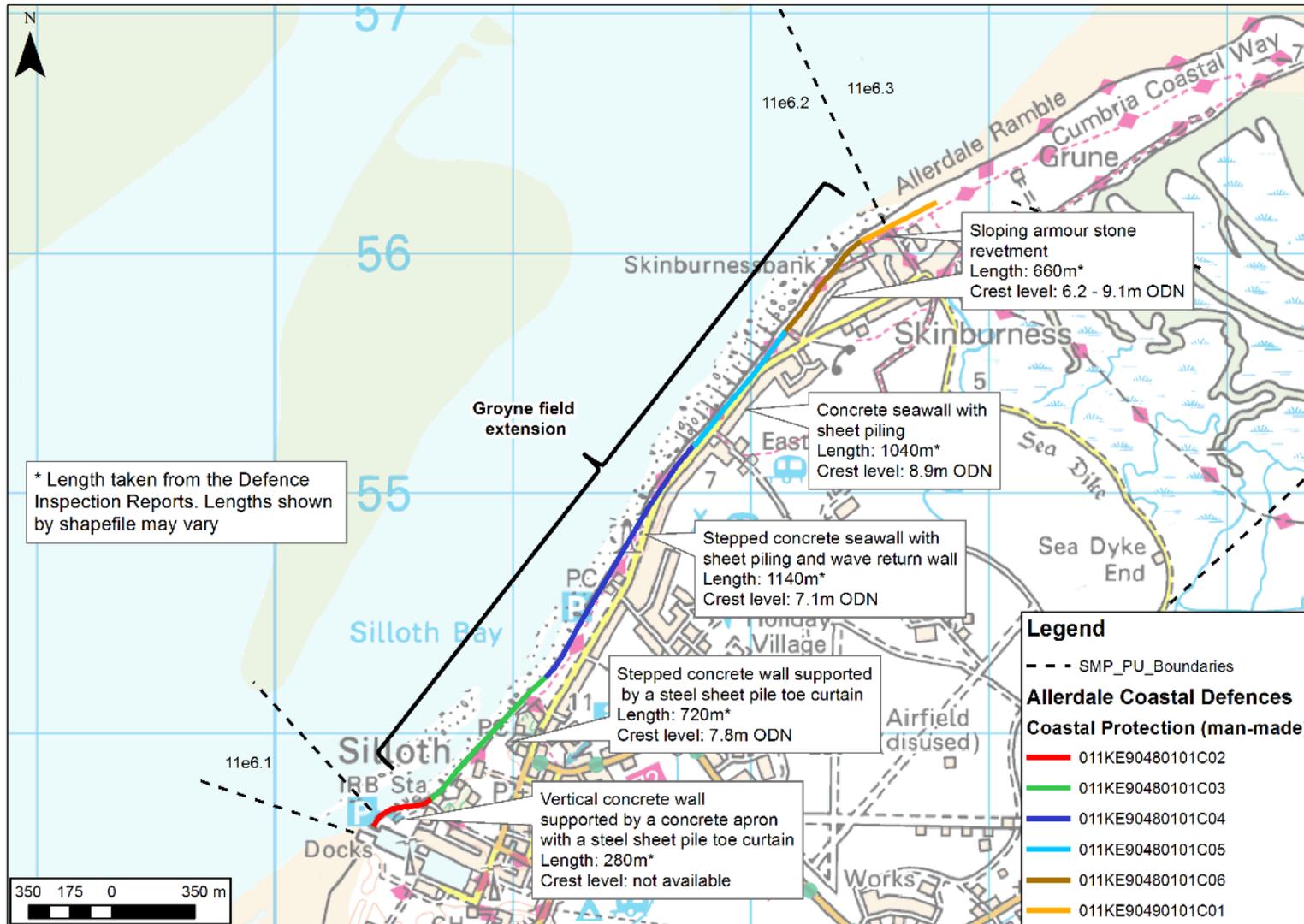


Figure 2 Policy units and summary of defence lengths between Silloth and The Grune

Policy unit 11e6.2 (Silloth to Skinburness)

Silloth North Pier: Vertical concrete seawall with sheet piled toe (280 metres) - Allerdale Borough Council



Figure 3 Vertical seawall at Silloth North Pier. Photograph taken during CEUK asset inspection (March 2016).

The defences comprise a vertical concrete wall supported by a concrete apron with a steel sheet pile toe curtain. The beach in front comprises coarse cobbles and shingle. A combination of wave reflections and the proximity of the Swatchway Channel have resulted in the denudation of finer sediments and a narrow beach width.

The structure is exhibiting normal wear and tear for its estimated age (50 to 60 years).

Silloth Bay: Stepped concrete revetment with sheet piled toe (720 metres) - Allerdale Borough Council



Figure 4 Stepped concrete revetment with sheet piled toe and timber groynes at Silloth. Photograph taken during CEUK asset inspection (March 2016).

The primary coastal defence across this frontage comprises a stepped concrete wall supported by a steel sheet pile toe curtain (mostly buried). The current defences are nearly 40 years old and exhibiting signs of wear and tear, notably:

- Abrasion and surface pitting and spalling to steps
- Cracking, notably at the northern interface with the adjacent defence section.

In addition, there is substantial algal growth on lower steps which presents a health and safety hazard to users. The foreshore is narrow due to the proximity of the Swatchway Channel, is timber groyned across its whole length and comprises a mixture of shingle and cobbles from which the finer sediments have been lost.

Additional quarried cobble has been added to this section since the 1960s. It is the nature of the coarse sediments that are predominantly responsible for the abrasion on the lower steps. Other than the general wear and tear there has been no significant deterioration in condition or major damage to the structure in the past ten years

Solway Lido to Eastcote Farm: Stepped concrete revetment with sheet piled toe and rear wave return wall and secondary elevated promenade and rear wall (1140 metres) - Allerdale Borough Council

The primary coastal defence across this frontage comprises a stepped concrete revetment (with narrower treads than on the Silloth Bay section to the south), supported by a steel sheet pile toe curtain. At the crest there is a wave return wall with a secondary promenade and rear wall to landward. The current defences are nearly 40 years old and exhibiting signs of wear and tear, notably:

- Abrasion and Surface pitting and spalling to steps;
- Cracking to steps.

In addition, there is substantial algal growth on lower steps which presents a health and safety hazard to users.

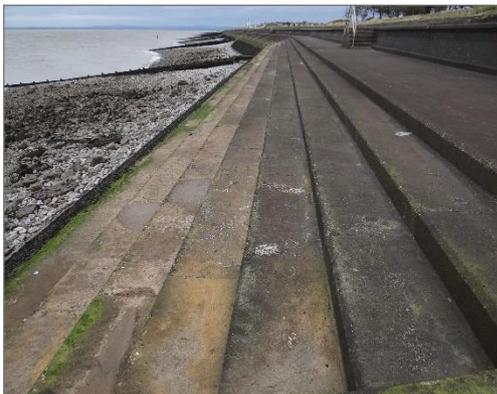


Figure 5. Stepped concrete revetment with sheet piled toe, rear wave return wall and timber groynes between Solway Lido and Eastcote. Photograph taken during CEUK asset inspection (March 2016).

The foreshore is narrow due to the proximity of the Swatchway Channel but starts to widen out towards the northern end. It is timber groyned across its whole length and comprises a mixture of shingle and cobbles from which the finer sediments have been lost. Additional quarried cobble has been added to this section since the 1960s. Despite the close spacing of the groynes, there is evidence of northerly longshore drift across this section with steps in level across groynes. The frontage terminates at the slipway at Eastcote where a substantial concrete encasement to a surface water outfall acts as a more substantial groyne preventing upper beach longshore drift.

It is the nature of the coarse sediments that are predominantly responsible for the abrasion on the lower steps. The middle section of one of the groynes collapsed in 2011 and 2012 and has not replaced. Other than the general wear and tear identified there has been no significant deterioration in condition or major damage to the structure in the past ten years.

Skinburness: Stepped concrete revetment with sheet piled toe and rear wave return wall (1040 metres) - Allerdale Borough Council



Figure 6. Stepped concrete revetment with sheet piled toe and rear wave return wall and timber groynes at Skinburness. Photograph taken during CEUK asset inspection (March 2016).

The primary coastal defence across this frontage comprises a stepped concrete revetment (with generally equal treads and risers, apart from locally at the northern end where the treads are wider), supported by a steel sheet pile toe curtain. At the crest there is a wave return wall.

It is believed that the current defences were constructed in the 1980s. These are exhibiting signs of wear and tear, notably cracking and abrasion, surface pitting and spalling to steps.

The foreshore is wider here as the Swatchway Channel is further offshore and the upper beach sediments exhibit a greater proportion of fine sediment. Lower beach sediments are predominantly sand and mud. The frontage is timber groyned across its whole length. Despite the close spacing of the groynes, there is continued evidence of northerly longshore drift across this section with steps in level across groynes and toe piles exposed in the southern half of groyne bays but buried in the northern half. Additional quarried cobble was added to this section at the end of the 20th century.

It is the nature of the coarse sediments that are predominantly responsible for the abrasion on the lower steps. There are some missing planks to timber groynes. Other than the general wear and tear identified there has been no significant deterioration in condition or major damage to the structure in the past ten years.

Skinburnessbank: Rock armour revetment (660 metres) - Allerdale Borough Council

The primary coastal defence comprises a rock armour revetment, most of which dates from 1999, although a short section at the northern end predates that. The revetment is in good condition with no obvious signs of rock movement, although overtopping waters did penetrate through the crest in places during the winter 2013 and 2014 storms. The revetment locally reduces in crest elevation in front of shoreside cottages (seen in background of Figure 7).



Figure 7. Rock armour revetment with timber groynes at Skinburnessbank. Photograph taken during CEUK asset inspection (March 2016).

The foreshore is timber groyned and comprises a mixture of cobbles, shingle and sand. Continued longshore drift northerly evident across this section with upper sections of groynes buried. Additional quarried cobble was added to this section at the end of the 20th century.

At the northern end, the adjacent undefended frontage of The Grune is setback and the terminal end of the revetment is being gradually outflanked, as can be seen in Figure 8. The northern end of the frontage is only protecting a single property. Improved management of this interface is required.



Figure 8. Terminal end of rock armour revetment at The Grune. Photograph taken during CEUK asset inspection (March 2016).

Policy unit 11e6.3 (The Grune)

The Grune: Rock armour revetment (50 metres) – Private landowner



Figure 9. Rock armour revetment at The Grune. Photograph taken during CEUK asset inspection (March 2016).

This section is the only length of artificial defence on The Grune, erected by a private landowner in 2008 to halt ongoing erosion.

The beach conditions are predominantly a mixture of shingle and sand becoming finer in a northerly direction.

2.1.3 Shoreline change

Reports are produced to report on analysis of beach level data collected as part of the North West Monitoring Programme: the most recent reports include analysis of data up to October 2016 (CH2M, 2017b).

Examination of monitoring data highlights the following key points:

- Generally, the existing groyne fields across the Silloth to Skinburness frontage controls changes in the upper foreshore with local movement occurring within groyne bays.

- The location of the Swatchway Channel influences changes in the lower beach with overall a trend of beach lowering taking place across the lower foreshore but behaviour is considered to be cyclical.
- Across The Grune there is erosion of the backshore and upper beach across the southern half but not so much change across the northern half.
- The lower foreshore across The Grune is subject to larger magnitude changes influenced by movements of sandbanks and channels in the Solway Firth.

Predictions of future erosion from NCERM suggest the following bands of change, under a scenario of No active intervention:

	By year 20	By year 50	By year 100
11e6.1 Silloth Harbour	0 m	2 to 3 m	3 to 7 m
11e6.2 Silloth to Skinburness	0 to 6 m	0 to 20 m	0 to 40 m
11e6.3 The Grune	0 to 6 m	10 to 20 m	20 to 40 m

Future change along this shoreline would, however, depend upon the future position of the Swatchway Channel relative to the coastline, and continued change along The Grune frontage.

2.2 Outline of the problem

2.2.1 Background

The current behaviour exhibited along the Silloth to The Grune frontage is primarily a function of interventions that took place initially in the 19th century and the works that were subsequently carried out in the 20th century. The construction of the harbour in the 1850s and particularly construction of a 300 m long pier structure, essentially fixed the shoreline at the southern extremity and changed the conditions to the north, effectively interrupting the natural drift that had until then fed the frontage.

Also, over the past 150 years the main Swatchway Channel has migrated landward reducing the width of the intertidal zone and providing a conduit for wave energy penetration and longshore current generation to move material northwards. This has caused steepening of the beaches, movement of finer material northwards and erosion of the shoreline, which has necessitated ongoing provision of artificial defences that are in situ today.

Artificial defence of the shoreline, which includes groynes, commenced at the beginning of the 20th century across the main Solway frontage to Eastcote. In the intervening period there have been several interventions with the current stepped defences, constructed in the early 1980s replacing a similar construction built at the southern end, 40 years previously.

There is no evidence on historical OS maps of formal coastal defences north of Eastcote up to the 1970s. The first (current) formal linear defences north of Eastcote are more recent (1980s) although groyning of this frontage commenced earlier. The rock armour at the northern end of Skinburness dates from the end of the 20th century.

The shoreline across the Silloth to Skinburness frontage is fixed in a position that is in advance of the natural location it would wish to adopt if it were unrestrained, due to a combination of the fixity provided by the harbour in conjunction with the artificial restraint provided by the linear defences.

Further details are provided for each policy unit in Section 4.

2.2.2 Issues, constraints and opportunities

The SMP policies for the frontage will maintain the shoreline in its present position for the foreseeable future whilst allowing The Grune to develop naturally in response to the forcing conditions applying.

The current concrete stepped defences are rigid in nature and provide a distinct interface between the mobile beach conditions and the hinterland. They provide a fixed barrier with the sea but are functional in reducing overtopping and preventing erosion of the coastline. At the northern end the use of rock armour provides for an improved defence and foreshore interface and better hydraulic performance compared to the concrete defences.

The concrete elements are prone to damage resulting from settlement and abrasion.

The primary risk to people property and infrastructure across the frontage is along the Eastcote to Skinburness frontage, where residential property is located just behind the sea defences. To the south public open space and, in particular, "Silloth Green", provides a buffer between the shoreline and property and infrastructure in Silloth. It is this most southerly section of the frontage, due to the proximity of the channel and narrow intertidal zone that is the most exposed in terms of tide and wave conditions.

The primary issues associated with the frontage over the next 100 years are:

- Structural integrity of the older sections of defences
- Increased overtopping risk that will be expected to occur as a result of predicted rising sea levels
- Future geomorphological development of the Grune Spit.

The statutory conservation and landscape designations mean that there will be environmental constraints and potential opportunities associated with ongoing shoreline management for the frontage. The intertidal zone and dune habitats of the Grune are designated as national or international importance for conservation: Upper Solway Flats and Marshes Ramsar and SPA, Solway Firth SAC, Upper Solway Flats and Marshes SSSI, Silloth Dunes SSSI and Mawbay Banks SSSI. The Solway Firth is also a recommended marine conservation zone (rMCZ). The area has a high landscape and heritage value, designated as Solway Coast (11e6.3 only) and lying within the buffer zone of the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site.

2.2.3 Strategy considerations and general approach

Key considerations

Since the SMP was produced there have been no significant changes in defence conditions or land use, although at the interface with The Grune the northern end of the defences is being outflanked, requiring improved management to be considered. Also further monitoring data has been collected, collated and examined.

The strategy has considered the following:

- variation in levels of risk along the frontage
- current defence conditions and level of risk (detailed defence profiles required)
- future management options.

Strategy approach

The following situations arise along this frontage, and will be addressed as follows:

- SMP appropriate - the SMP2 policy does not need review so the aim of the strategy is to develop measures to implement the policy. Future works to manage flood and erosion risk may be eligible for a proportion of FDGiA funding and the economic appraisal will consider

costs and benefits, following FCERM-AG guidance. This needs to take account of the lack of property and infrastructure at immediate risk across the Silloth Green frontage and the balance between the cost of maintaining public protection and preservation of a local amenity asset.

- Privately owned or funded defences – there is a location where private defences were constructed, prior to the SMP2 policy (No active intervention) being determined but where the SMP1 policy was Do nothing. It is uncertain whether the defences received the necessary approvals.

2.3 Options development and appraisal

The main Options Development report defined the long list options, each of these has been screened at a high level against technical, economic and environmental criteria to develop a list for final detailed appraisal.

For the single priority unit of 11e6.2, the following long listed options have been considered:

- Do nothing
- Do minimum
- Hold the line: maintain through proactive maintenance
- Hold the line: sustain through reinforcing and raising existing defences
- Hold the line: improve through constructing new revetments or seawalls
- Hold the line: improve through constructing new shore control structures
- Hold the line: improve through constructing new offshore structures
- Hold the line: improve through beach recharge

The second stage has been to appraise the short listed options, section 2.4 outlines the shortlisted options and approaches (measures) that could be adopted to achieve these.

Do nothing has been appraised as a baseline in all frontages. This option assumes that no further works would be undertaken and the existing defences would deteriorate over time, resulting in failure.

Additional information on environmental impacts is provided in a **Strategic Environmental Assessment: Environmental Report** which systematically appraises the potential environmental consequences of the proposed strategy and recommend any actions needed to mitigate and monitor identified adverse effects.

The economic feasibility of implementing a particular option has been appraised through considering the packages of measures required for its implementation. These have been costed and the benefits of the strategic options identified and evaluated. The Do nothing option provides the baseline for the economic appraisal. This is reported in the **Economic assessment** report.

2.4 11e6.2: Silloth to Skinburnessbank

Throughout 11e6.2 hard defences have been erected to prevent further erosion of the shoreline and to limit overtopping. At present there is insufficient data available to establish the risk level posed by the latter.

2.4.1 11e6.2 - Initial screening of options

The policy here is to continue to Hold the Line through to the long term (50 – 100 years), based on the assumption that the harbour continues as a viable operation, which essentially continues to fix the shoreline at its southern end.

Table 3 below summarises the rationale for taking long list options forward to the short list stage.

Table 3 Screening of long list options for 11e6.2

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option would not manage erosion and overtopping risks across the frontage. It is assessed for baseline and comparative purposes only.
Do minimum	Reactive patch and repair of defences only.	Baseline only	<p>This option would require initial investment to address defects identified from current asset inspections, including recasting of abraded or damaged steps, sealing cracks, joint maintenance and replacing missing or damaged groyne timbers and subsequent repairs of defects as they became evident. This would not manage long term risk of damage and overtopping risks.</p> <p>This option is the default arrangement if funding cannot be justified or is not available.</p>
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	Yes	<p>In addition to the initial works identified under the Do minimum option, this would provide a predefined maintenance programme, comprising:</p> <ul style="list-style-type: none"> • Replacement of sections of steps that require maintenance; • local topping up of beach levels based on predetermined beach management requirements; • maintenance of existing timber groynes; • armour structure rock resetting and replacement. <p>Through appropriate planning and management this approach can maintain the defences for at least the first two epochs but does not address the increasing overtopping risk or risk of damage to rigid structures presented by climate change.</p>
Hold the line: sustain through modifying but not replacing existing defences	Provides measures such as rock toe works or replacement toe piling and new and improved secondary crest works to maintain standard of protection and improve longevity of existing defences.	Yes	<p>Would require the proactive maintain responses but in addition would include the provision of improved secondary toe or crest works to sustain levels of protection by limiting risk of undermining or toe failure or overtopping. Requires full empirical analysis of current standards of protection and changes that would be expected over time.</p> <p>Consideration would be given to modifying alignment of defences at northern end.</p>
Hold the line: improve through constructing new linear defences	New shore parallel defences replacing or extending existing defences	Yes	<p>Programme of replacement of existing defences with either like for like constructions or more hydraulically efficient defences e.g. rock armour revetments. Historically concrete stepped revetments have been shown to be life limited across this section of frontage. Provides potential through reducing footprint, to increase beach width, specifically towards southern end, where potential for setback of defence line could also be considered. Could provide improved promenade or secondary crest walls to limit overtopping.</p> <p>Likely to be of high capital cost but use of rock armour would reduce ongoing maintenance may offer a suitable approach to future management of assets along this coastline, although consideration needs to</p>

			be given to the expected performance and design life to be attained. It is a viable option to be considered.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as shore normal timber or rock groynes.	Yes	<p>The historical requirement and use of structures to retain beach material has been demonstrated across this frontage. Extension of existing timber groynes or replacement with more substantial rock structures could provide the option of moving the Swatchway channel further away from the shoreline and increasing the beach width and levels. From Silloth to Eastcote. Not really applicable or required across the Eastcote to Skinburnessbank frontage. Rock structures could potentially include options to improve amenity e.g. incorporation of fishing platforms.</p> <p>Due to the lack of available beach material currently would require artificial beach recharge as well.</p> <p>Likely to be very expensive but worthy of consideration as could provide multiple benefits.</p>
Hold the line: improve through constructing new offshore shore control structures	New shore parallel offshore structures to control exposure conditions.	No	<p>Although structures would limit wave exposure the proximity of the channel to the shoreline and the likely wider impact of structures means such an option would be unsuitable across the majority of the frontage.</p> <p>Therefore, this option has not been taken forward for further consideration.</p>
Hold the line: improve through beach recharge	Addition of new material to beaches.	Yes	To be considered at small scale through proactive maintenance option and at larger scale in combination with modification of existing or construction of new shore normal control structures, as above.

2.4.2 11e6.2 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	<p>At present, the existing seawalls appear to be overall structurally sound apart from several specific defects that have been identified to primary elements. Without any further maintenance, the condition of the defects will worsen and the integrity of the structure will eventually be comprised.</p> <p>The risks to the structure arise primarily from episodic events where loadings are above normal levels and from the potential for the material behind the revetments to leach out through joints, gaps or damaged sections. The integrity of the toe of the structure is dependent on the condition and rate of corrosion of the toe piling, which if it fails will lead to undermining and collapse of the structure.</p> <p>Without investment the SMP2 identified that the concrete structures had a residual life of 10 to 20 years and the rock armour structures 20 to 50 years, 10 years ago. Whilst there has been some worsening of the defects in the interim, notably between Silloth and Eastcote, it is not considered that this assessment should be changed.</p>
Environmental	<p>This option would result in a high risk of damage to, or loss by coastal erosion of residential property, Silloth Promenade, recreational features (e.g. the Green, Cumbrian Coastal Way and Allerdale Ramble), heritage features of the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site, including two Scheduled Monuments and access roads, as well as a risk of increased frequency and severity of flood events, which may damage or impede access to the properties. There is a risk of loss of the Silloth Lifeboat Station, which would put local residents' safety at risk as well as removing safety cover for a large area of the outer Solway. There would be a potential risk of breach into the Silloth Harbour due to coastal erosion. This would impact on the local communities directly and together with the deteriorating defences, would reduce the attractiveness of the local area to tourists, which is a significant input into the local economy.</p> <p>Additionally, uncontrolled changes in coastal processes have the potential to affect sedimentation and thus the condition of shellfish beds located off the coast of Moricambe.</p>

	<p>With the eventual loss of the defences, there is potential opportunity to allow reinstatement of more natural processes, which would support some of the WFD objectives. Currently, there are areas of priority habitat partially made up of vegetated shingle present along the defences. If the frontage is allowed to retreat landward, there is potential for natural migration inland of this habitat, enhancing the biodiversity designations as well as the NCA and the identity and landscape character of the AONB features.</p> <p>Further consideration would need to be given to the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Additionally, further assessment may be required to consider any changes to the SSSI (Countryside and Rights of Way Act 2000).</p>
Cost	There are no costs associated with the Do nothing option, although some costs may be incurred to make safe the areas of defences once they have failed.
Damages	The key damages are associated with failure of the defences, which will be potential loss of RNL station at Silloth, loss of public open space between Silloth and Eastcote and potential damage to or loss of infrastructure and property between Eastcote and Skinburness. The damages are estimated to be £26,520 k.

Do minimum (Option 2)

This is also considered as a baseline against which other options can be appraised. Under this option only reactive maintenance would be undertaken, with no works to address any increase in risk due to sea level rise.	
Technical	<p>As works would be low cost and reactive only, as for Do nothing the future lifespan of the existing defences would depend upon future conditions, for example storm frequency and magnitude. Where repairs are not carried out in a timely manner, then further problems can arise which can then accelerate time to failure.</p> <p>This does not provide a long term solution, particularly along this stretch where previous interventions suggest there have been problems in the past. This option would revert to Do nothing once the defences fail.</p>
Environmental	Once defences fail, the impacts would be as for the Do nothing option. See Option 1 for further details
Costs	There are no Present Value Capital Works, since works are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,370 k.
Damages	The key damages would ultimately be as described for the Do nothing associated with impacts for property and infrastructure but with a delay to anticipated failure beyond that estimated for Option 1 and residual life of concrete sections likely to be improved by 10 to 20 years. The damages are estimated to be £25,810 k.

Hold the line: maintain through proactive maintenance (Option 3)

Measures to maintain the existing defences. This would be a programmed maintenance regime, comprising concrete step replacement and other defect repairs, local beach replenishment, groyne maintenance and rock armour reprofiling, based upon regular inspections and as part of a scheduled programme of works.	
Technical	<p>These works will have similar affect to Option 2 but would extend the useful life of the concrete structures into the second or more likely the third epoch. The use of advanced concrete repair techniques and materials to provide better resistance to abrasion or impact damage will increase longevity of structures.</p> <p>There would be no additional works undertaken to address overtopping risk; therefore, this would remain a vulnerability of the existing defences and would increase in magnitude over time.</p>
Environmental	<p>In the short to medium term, there would be continued protection of assets in the hinterland of the defences including infrastructure, heritage assets and recreational features. In the long term, defences are expected to fail; the impacts of this would be the same as in Option 1. If the defences do not fail in the third epoch there is still a residual risk of overtopping as a result of sea level rise which would lead to risk of flood damage similar to options 1 and 2.</p> <p>In the long term requirements for maintenance and repair works will become increasingly frequent and potentially disruptive to the surrounding natural environment and to amenity use of the promenades.</p> <p>Further consideration would need to be given to the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites.</p>

	Additionally, further assessment may be required to consider any changes to the SSSI (Countryside and Rights of Way Act 2000).
Costs	The Present Value Capital Works are estimated to be £420 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,420 k.
Damages	The key damages would ultimately be as described for the Do nothing associated with impacts for property and infrastructure but with a delay to anticipated failure beyond that estimated for Option 1 and residual life of concrete sections likely to be improved by 20 to 50 years. The damages are estimated to be £25,810 k.

Hold the line: sustain through modifying but not replacing existing defences (Option 4)

This would involve more low cost measures to maintain, but not improve, the existing standard of protection.	
Technical	<p>As well as the programme of defects management identified in Option 3 this would include for provision of new toe works before the existing piling becomes life expired and the modification of crest works e.g. higher wave return walls, setback secondary defences, where appropriate in order to maintain the level of protection at its current standard allowing for sea level rise.</p> <p>It is unlikely that such an approach would be sustainable throughout the whole strategy timescale and review would be required at the end of the medium term at the latest.</p>
Environmental	<p>Effects of this option would be similar to Option 3 as this option similarly does not address the potential for eventual failure of the defences.</p> <p>Setback defences may defend against sea level rise, however there would be impacts related to their construction. The northern half of the frontage is currently described as consisting of coastal sand dunes, which are a priority habitat, part of both national and international designations and linked to the aesthetics of the area.</p>
Costs	The Present Value Capital Works are estimated to be £4,630 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £9,780 k.
Benefits	Protection of assets for the next 20 to 50 years is potentially conceivable but ultimately without capital replacement works then delayed Option 1 damages would take place. The benefits are estimated to be £720 k.

Hold the line: improve existing defences (Option 5)

This would involve more substantial measures to replace the existing assets either a) as part of a major current rebuilding programme or b) as part of a longer term programme as assets become life expired.	
Technical	<p>This would only involve the concrete revetment sections with the section between Silloth and Eastcote being higher priority, as it is older and in worse condition.</p> <p>Options would be either like for like replacement, as happened in 1979 between Silloth and Eastcote, or alternatively using rock armour as at Skinburnessbank, which is hydraulically more efficient and could be constructed to a smaller footprint, potentially increasing available beach width. Due to the open space land behind, consideration of further setback could also be considered. The new defences would be designed to withstand the higher sea levels, wave forces, and foreshore lowering that might be expected and provide a long term solution to issues of undermining and overtopping</p> <p>The overtopping risk would be minimised through increasing the crest level or setback of a new secondary defence line, or provision of a new promenade or crest wall behind the armour stone. This would present some difficulties at Skinburnessbank where there is little scope for landward construction behind the current armour crest line. Such works will require further investigations into land ownership and access arrangements.</p>
Environmental	<p>Impacts of potential set back defences would depend on their location, nature, and footprint. However, the potential to reduce the footprint of the new defences may present an opportunity for the migration of intertidal habitat inland. Setting the defences back where there is sufficient open space would avoid encroachment into the designated Natura 2000 SPA, SAC and Ramsar foreshore, which would require mitigation or compensation.</p> <p>For both a setback line and new defences, further consideration would need to be given to the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Additionally, further assessment may be required to consider any changes to the SSSI (Countryside and Rights of Way Act 2000).</p>

	The construction of new defences has the potential to affect landscape character and visual amenity within the AONB, with potential to affect views afforded of the sea.
Costs	<p>a) The Present Value Capital Works are estimated to be £18,810 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £32,850 k.</p> <p>b) The Present Value Capital Works are estimated to be £30,070 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £49,250 k.</p>
Benefits	Property and Infrastructure would remain protected throughout strategy timescale. The benefits are estimated to be £19,460 k.

Hold the line: improve through constructing new (modified) control structures (Option 6)

This may involve either modifying existing timber groynes or removal of existing groynes and construction of new rock groynes.	
Technical	<p>This option would extend the existing groyne structures seaward effectively moving the Swatchway Channel further offshore to increase beach width at the southern end.</p> <p>Extension of existing timber structures would most appropriately be in rock to force the channel away from the shoreline with care being taken to provide sacrificial stone to account for scour. Similarly, replacement of the existing slender timber structures with larger rock fishtail type groynes would be equally efficient but would require around 4 or 5 structures to be constructed across the Silloth to Eastcote section and potentially 2 to 3 between Eastcote and Skinburnessbank.</p> <p>To reduce the impacts on the existing sea wall and due to the scarcity of natural material being brought into the frontage from longshore and offshore, beach levels between the structures would also needed to be artificially improved although with appropriate design, the use of finer sediment than currently exists could be considered.</p> <p>This option would require development of a suitable ongoing beach management plan.</p>
Environmental	<p>This option would reduce the long term risk of flooding to properties, land use (including Grade 3 agricultural land), recreational and heritage assets, and infrastructure in the area. Additionally, the extended groynes may create an extended area of beach that would be accessible to the public, thereby enhancing local tourism. This may also create further intertidal soft sediment areas which are important habitats for marine organisms.</p> <p>This option would require construction seaward, within the SAC, SPA, Ramsar site, rMCZ, and SSSI.</p> <p>The impacts of constructing rock armour extended beach control structures within the designated Natura 2000 sites would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. As the works would result in the direct loss of intertidal habitat and would artificially fix the shoreline, this option would likely be considered to have a significant effect and so would need to pass the tests of 'no feasible alternatives' and 'imperative reasons of overriding public interest'. Additionally, further assessment may be required to consider any changes to the SSSI (Countryside and Rights of Way Act 2000) and rMCZ (under the Marine and Coastal Access Act 2009). The ongoing impacts of the change in groyne structures would have to be under ongoing monitoring.</p> <p>Constructing control structures that extend offshore would likely have negative effects on the water quality status of the coastal water body, and may compromise the achievement of WFD objectives. Additionally, the works will change the landscape character of the AONB.</p> <p>The proposal for beach recharge would require careful consideration as this may require frequent input of foreign material into the system and would require frequent vehicle journeys to the site. The characteristics of the beach recharge would have to be carefully considered to ensure that it is of a similar size and colour to the existing so that it blends into its surrounding landscape, and to ensure that it does not impact on the sensitive habitats.</p>
Costs	<p>a) The Present Value Capital Works are estimated to be £2,370 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £26,010 k.</p> <p>b) The Present Value Capital Works are estimated to be £6,350 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £15,590 k.</p>
Benefits	Property and Infrastructure would remain protected throughout strategy timescale. Potential for delivery of wider benefits e.g. amenity, community etc. The benefits are estimated to be £19,460 k.

Hold the line: improve through beach recharge (Option 7)

This would involve supplementing existing beach levels with coarse quarried gravel.	
Technical	Beach recharge with crushed rock cobbles has sporadically been carried out since the 1960s (Ref SMP1) as part of planned capital and maintenance works, in order to protect the lower parts of wall structures from undermining and reduce exposure conditions to the sea wall. Such an option could be carried out periodically in the future but would need to be carried out in conjunction with options 2 or 3 above or alternatively as part of option 5. Use of coarser material, increases ongoing abrasion risk to hard surfaces and groyne timbers. Movement of material within groyne bays would still occur and would be subject to ongoing reprofiling and management. Future periodic topping up would also be expected – say every 20 to 30 years.
Environmental	<p>Option assessed on its impacts as its influence on SOP would be largely dependent on the option that it was implemented alongside.</p> <p>The characteristics (size, colour etc) of the beach recharge material would have to be carefully considered to ensure that it blends with its surroundings.</p> <p>Further consideration would need to be given to the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects of the recharge works on the integrity of the Natura 2000 sites. Additionally, further assessment may be required to consider any changes to the SSSI (Countryside and Rights of Way Act 2000).</p>
Costs	The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,910 k.
Benefits	Property and Infrastructure would remain protected throughout strategy timescale. The benefits are estimated to be £19,460 k.

2.4.3 11e6.2 - Discussion of options

Table 4 summaries the cost and benefit calculations for the various options presented above.

There is a need to better understand the level of overtopping risk across the frontage and the likely erosion limits under the Do nothing scenario. The timing of losses and expected flood damages will determine the likely scale of works that can be justified.

Based on the current understanding there is likely to be little economic justification for full scale capital replacement works (Options 5 or 6) now but small scale reactive or proactive maintenance (Options 2 to 4) would likely be justifiable to realise life expectancy of existing assets in the short term followed by replacement in the medium to long term. Of the options considered, Option 6, which would modify defence arrangements applying, provides the greater chance of realising wider benefits for the community. The impacts on this frontage of any proposed works in the adjacent unit (11e6.3) need to be considered when confirming the management approach in this unit.

Table 4 Policy Unit 11e6.2 Summary of economics

Option		Present Value Capital Works £m	Present Value Total cost (PVC)* £m	PV Benefit (Damage Avoided) £m	Average Benefit Cost Ratio
Option 1 Do nothing		0.00	0.00	0.00	-
Option 2 Do minimum		0.00	1.37	0.71	<1
Option 3 Hold the line: maintain through proactive maintenance		0.42	2.42	0.71	<1
Option 4 Hold the line: sustain through modifying but not replacing existing defences		4.63	9.78	0.71	<1
Option 5 Hold the line: improve existing defences	a	18.81	32.85	19.46	<1
	b	30.07	49.25	19.46	<1
	a	2.37	26.01	19.46	<1

Option 6 Hold the line: improve through construction of new (modified) control structures	b	6.35	15.59	19.46	1.25
Option 7 Hold the line: improve through beach recharge <i>(Costs Include Option 6b Hold the line)</i>		0.00	17.5	19.46	1.1
<i>*Present Value cost (PVC) inclusive of 60% optimism bias</i>					

For comment

3 Appraisal of non priority units

There are two additional policy units within this area, which has been defined as a non priority unit:

- 11e6.1 Silloth Harbour
- 11e6.3 The Grune

A light touch review has been undertaken of current SMP recommendations, taking into account conclusions from option appraisals for the adjacent frontage.

3.1 11e6.1 -Silloth Harbour

3.1.1 Existing approach to flood and coastal erosion risk management

The SMP policy for 11e6.1 Silloth Harbour is Hold the Line through to the long term (50 to 100 years) by maintaining or upgrading harbour walls where necessary. This policy assumes the harbour remains operational. The primary justification for the policy was to maintain the integrity of Silloth, although it was noted that while the Hold the Line policy manages the risk to Silloth there was potentially detrimental effects on the international sites (Upper Solway Flats and Marshes SPA, Ramsar and the Solway Firth SAC).

The defences on the south side of the harbour are buried by the historical accumulation of sand dunes since the harbour was originally built, apart from the port's rock armour breakwater extension training wall at the harbour entrance.

3.1.2 Strategy considerations

The SMP noted that the economic justification for the policy may be compromised by funding prioritisation due to the low Benefit Cost Ratio. However, under the current funding policy there would be an expectation that private or third party funding would meet a large proportion of the costs and that Defra, Environment Agency FCERM-grant in Aid would only fund a portion.

The SMP also noted that strategy and coastal process studies were needed to confirm policies for Silloth to Moricambe Bay, to address the issues of interruption of shoreline sediment transport and confirm longer term policy for Silloth to Skinburness frontage.

The analytical report for the regional coastal monitoring undertaken for the Allerdale frontage (CH2M, 2017b) notes that historically the construction of Silloth Harbour has led to the narrowing and shortening of the spit, and reduction in natural drift supplying the Silloth to Skinburness frontage to the north. However, it also notes that the recession seen in the recent monitoring data may be linked to the landward movement of the Swatchway Channel. Although the headland formed by Silloth Harbour has stabilised the shoreline to the south by trapping alongshore drift on the upper part of the beach profile it does not restrict sediment transported further offshore by the strong tidal currents, as is evident from the dynamic movements of banks and channels further offshore.

The headland formed by the harbour is fundamental to the stability of the dune system to the south, which is designated as a SSSI.

3.1.3 Discussion

It should be noted that appraisal of options for Silloth North Pier has been included within the above section for 11e6.2 because the structure is integral with the defences to the north.

Since the SMP2 was adopted there have been no significant changes in land use or changes in environmental designations. The port remains operational, with the facility being locally and regionally important for bulk cargo.

There is not considered to be justification for changes to the SMP policy at the current time, as the situation has not changed significantly since the SMP was developed.

Future actions include:

- Continued monitoring of beach changes, as part of the North West Regional Monitoring Programme.
- Continued inspection and maintenance of the existing structures, with repairs and remedial works undertaken as necessary. Consider development of a management plan to indicate the need for advance planning of works, including identification of possible funding sources.

3.2 11e6.3: The Grune

3.2.1 Existing approach to flood and coastal erosion risk management

The SMP policy for The Grune is No active intervention in all three epochs. The primary justifications for this policy at SMP2 level were the International and National designation of the foreshore and dunes for conservation importance and the lack of any tangible assets at risk.

Apart from a short section of local privately funded and managed defences in the vicinity of Grune House (see Figure 10, left) and the terminal end of the hard defences across the Skinburnessbank frontage (see Figure 10, right), there are no defences on the Grune and the natural shoreline features react to the physical process regime. The two sections of defences are influencing behaviour with backshore erosion taking place at a greater rate here. In addition, this is occurring where ground levels indicate that there is the greatest risk of flood waters linking across the neck of the spit. If this behaviour continues, there is a risk of outflanking in the future, presenting a risk to the property that the defences are protecting.



Figure 10 Juxtaposition of private defences on the Grune and terminal end of ABC rock armour revetment at Skinburnessbank. (Photograph © North West Regional Monitoring Programme, October 2015).

3.2.2 Strategy considerations

The intertidal and coastal habitats from a part of multiple international designations, a SSSI and an rMCZ. With no further intervention, these designations would be allowed to develop naturally, enhancing their natural value and in addition contributing to the landscape designations also present. This would also contribute to the WFD objectives of the waterbody.

There is a scheduled monument which is a feature of the Frontiers of the Roman Empire (Hadrian's Wall) World Heritage Site that is at potential risk of damage from flooding.

Also, since the SMP2, monitoring of The Grune (CH2M, 2017) has identified that there has been progressive erosion of the dune front. Erosion of the backshore is greatest in the south of the area but less so in the north where there is a wider foreshore between the Swatchway and the shoreline.

Evolution of The Grune since the development of the harbour at Silloth in the mid 19th century has been linked to: both the interference in drift, caused by the harbour and ancillary works construction, artificial protection of the shoreline between Silloth and Skinburness, and changes in the position of the Swatchway Channel and the associated sandbanks. Over that period, the impacts have not all been negative, with The Grune experiencing periods of stability and accretion as well as erosion.

3.2.3 Discussion

Since the SMP2 was adopted there have been no changes in environmental designations although the southerly boundary of the recommended Solway Firth Marine Conservation Zone (rMCZ) includes the seaward face of The Grune frontage. In addition, there have been no changes in land use and no development has taken place.

Future evolution of The Grune will be influenced by a number of factors, including:

- Ongoing movement of offshore channels and banks;
- Availability of sediment supply to the frontage from offshore and longshore driven by winds, waves and currents;
- Sea level rise and storm frequency;
- Potential impacts induced by modifications to defences between Silloth and Skinburness.

Whilst the first two of these factors are primarily linked to natural variations, the latter two are more anthropogenically influenced. The Grune is generally low lying with the northern half generally lower than the predicted 0.5% APE tide level. With predicted climate change, in 100 years' time that tide level will have a 5 to 10% APE with a concomitant increase in the risk of inundation. In addition, there are potential flood pathways that could link across the neck of The Grune at its landward end, which have the potential to lead to localised flooding of nearby properties, Grune House becoming unsustainable in the future and major change to the role The Grune plays in providing shelter to Moricambe Bay.

Accordingly, it is likely that there will be more significant change to the Grune that may require review and reappraisal of management actions, throughout the next century. Ongoing monitoring of conditions therefore forms a key part of management of the shoreline and there is the need in the short term to examine whether modification of the present arrangements is required to reduce the risk of permanent impacts adversely impacting long term evolution.

At present there is no justification to change the SMP policy for the frontage and overall the approach will be to Do nothing in terms of intervention in the short term and allow the spit to react to any change in physical processes by natural modification but to monitor behaviour and review management requirements at regular intervals. Under the policy no works of modification to the private defences are allowed but there will need to be liaison with the landowner to ensure that nothing further is done that may also have an adverse impact on long term evolutionary behaviour.

Future actions include:

- Continued monitoring of shoreline and beach changes, as part of the North West Regional Monitoring Programme, to assess ongoing trends and impacts of the current defences.
- Consultation with the landowner with responsibility for the private defences regarding their appropriate future management and consent requirements related to the environmental designations.

- Following a period of further monitoring, review coastal defence requirements at the north end of the Allerdale BC defences at Skinburness to review risk.
- Future consultation with Historic England regarding increasing risks due to sea level rise and ongoing shoreline evolution to the World Heritage Site and Scheduled Monument and potential requirements for local mitigation.

For comment

4 References

Coastal Engineering UK (CEUK) (2016). Allerdale and Carlisle Annual Local Monitoring Report 2015. Prepared for Allerdale Borough Council, as part of the North West Regional Monitoring Programme.

CH2M (2017a). Allerdale and Carlisle Asset Inspection Report, 2017. Prepared for Allerdale Borough Council and Carlisle City Council, as part of the North West Regional Monitoring Programme. December 2017. October 2017.

CH2M (2017b). Allerdale and Carlisle Analytical Report, 2016. Prepared for Allerdale Borough Council and Carlisle City Council, as part of the North West Regional Monitoring Programme. December 2017.

For comment