



11c13 Bardsea to Piel Island

(Technical report by Jacobs)

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Policy area: 11c13 Bardsea to Piel Island

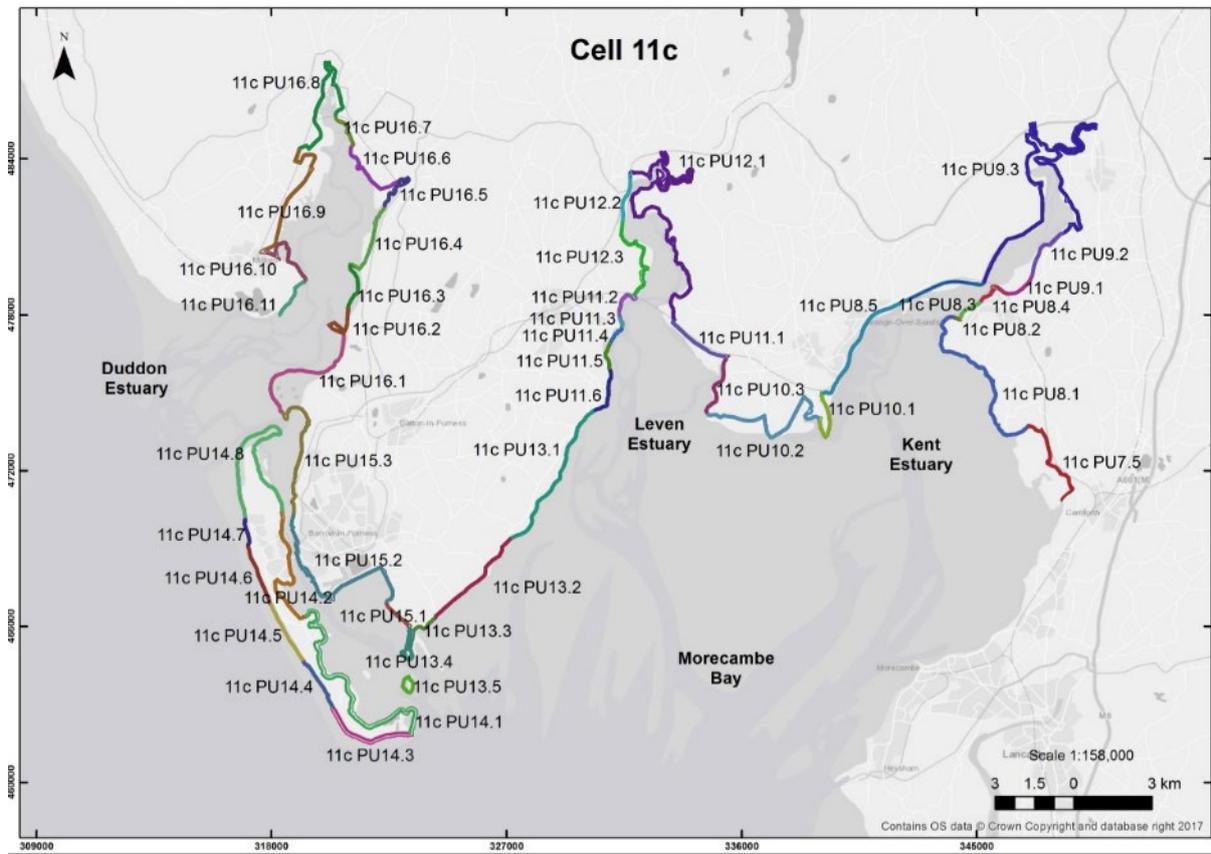


Figure 1 Sub Cell 11c Arnside to Hodbarrow Point Location Plan of policy units. Baseline mapping © Crown copyright and database rights, 2019. Ordnance Survey licence number: 1000019596.

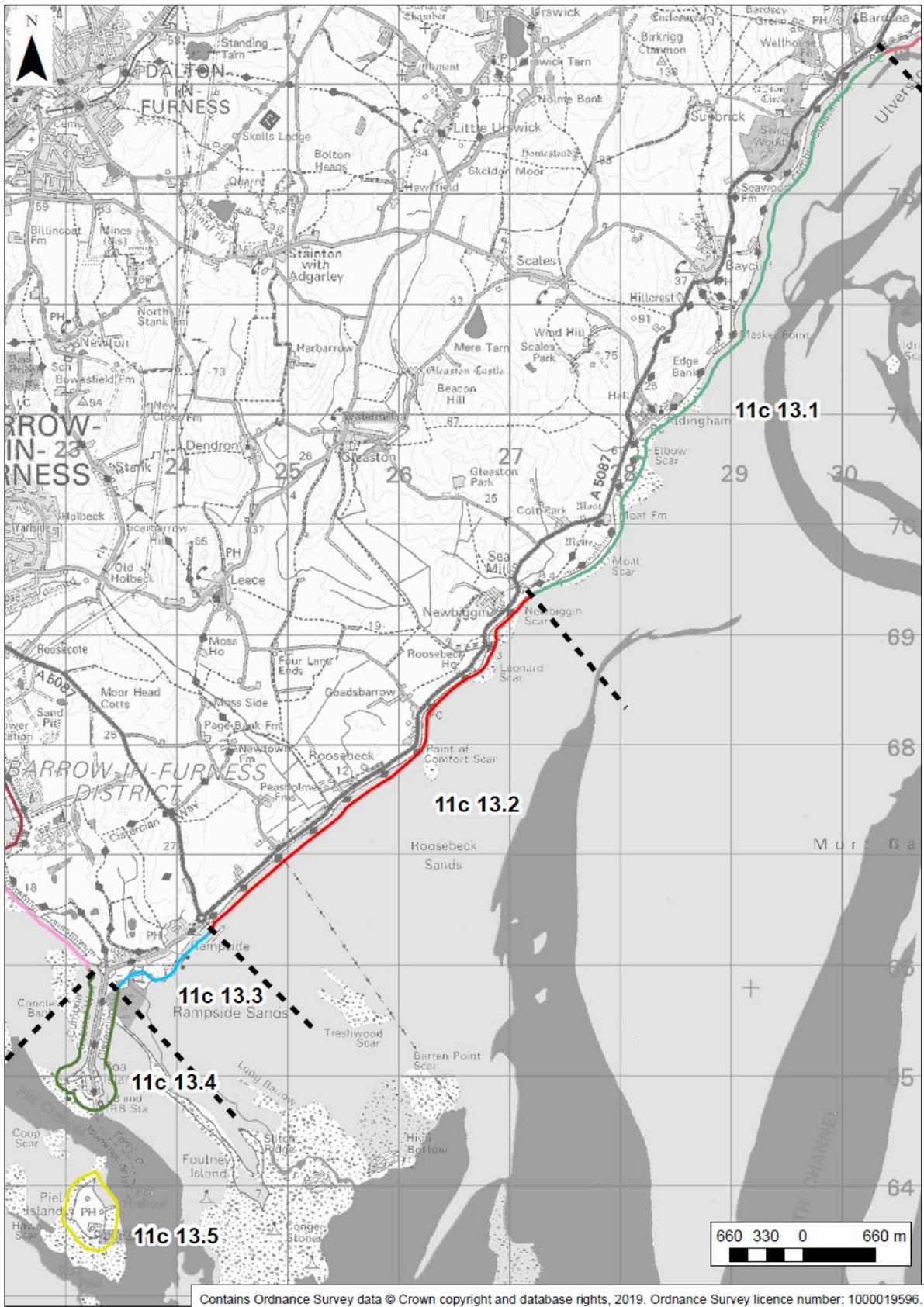


Figure 2 Location of Policy Area 11c13: Bardsea to Piel Island. Baseline mapping © Crown copyright and database rights, 2019. Ordnance Survey licence number: 1000019596.

1 Introduction

1.1 Location and site description

Policy units:	<p>11c13.1 Bardsea to Newbiggin</p> <p>11c13.2 Newbiggin to Rampside (priority unit)</p> <p>11c13.3 Rampside (priority unit)</p> <p>11c13.4 Roa Island (priority unit)</p> <p>11c13.5 Piel Island</p>
Responsibilities:	<p>South Lakeland District Council</p> <p>Barrow Borough Council</p> <p>Cumbria County Council</p> <p>Highways England (Historical Railway Estate)</p> <p>Cumbria Wildlife Trust</p> <p>Private landowners</p>
Location:	<p>The policy area falls within Sub cell 11c: (part) Arnside to Hodbarrow Point and covers the northern coast of Morecambe Bay between the Leven Estuary and Walney Island.</p>
Site overview:	<p>There are both coastal flood and erosion risks to this policy area, with the key risk being the potential consequences for the long term viability of the main coastal link road, A5087, as well as isolated properties.</p> <p>This policy area comprises the south easterly facing coastline of Morecambe Bay and is characterised by low till (boulder clay) cliffs and outcrops of limestone interspersed by areas of low lying land. Erosion of this material has resulted in the formation of localised cobble scars within the intertidal and subtidal zones as on many other areas of the Cumbrian coast. The orientation of the frontage, combined with extensive intertidal banks of Morecambe Bay and the protection provided by Walney Island, results in the shoreline being relatively sheltered from wave action compared to the west coast of Cumbria. However, locally generated waves from within Morecambe Bay have a 20 km fetch from the south and can result in damaging wave conditions along the frontage when storms coincide with high tides. Sediment transport is tidally dominated within the Bay and net direction is ultimately controlled by asymmetry between flood and ebb tides (Halcrow, 2011).</p> <p>The A5087 Coast Road runs along the shoreline through this policy unit and is a busy alternative route to the A590 between Ulverston and Barrow as well as linking villages and towns on the Furness Peninsula. There are limited defences in 11c13.1, although the road is at coastal flood and erosion risk in several places. Between Newbiggin and Rampside in 11c13.2 there are around 4 km of concrete and rock armour coastal defences protecting the road, sections of which were upgraded by Cumbria County Council between 2011 and 2014. The coastal defences along the road also protect a number of properties and caravan parks in close proximity to the beach. Some sections of defences within 11c13.2 are currently in a poor condition.</p> <p>At the south west extent, the policy area includes three small islands: Piel Island, Roa Island and Foulney Island. Roa Island is connected to the mainland by a man-made causeway, built in the 19th century as a railway embankment for the Piel Branch line. The causeway now carries the access road. Foulney Island is connected to the Roa Island Causeway by Foulney Embankment, a rock bund constructed in the 19th Century to help prevent the Walney Channel</p>

	<p>from silting up. The Roa Island Causeway and Foulney Embankment shelter the adjacent shoreline at Rampside, and have resulted in the formation of saltmarshes at Rampside Sands. Since completion of the SMP2, there has been a specific study considering Roa Island that needs to be considered in the strategy.</p> <p>The intertidal zone is nationally and internationally designated due to its importance for coastal habitats and birds, supporting a wide range of habitats and qualifying species. This includes Morecambe Bay and Duddon Estuary SPA, Morecambe Bay SAC, Ramsar and SSSI, and South Walney and Piel Channel Flats SSSI.</p> <p>The hinterland includes large tracts of agricultural land and farmsteads, interspersed with small communities. There are also a number of listed buildings within the area and the Scheduled Monument of Aldingham Motte and Bailey castle near Moat Farm. There is also an important RNLI Lifeboat station which has both an inshore lifeboat serving the local Morecambe Bay area and an offshore lifeboat serving the Irish Sea.</p>
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1.2 Current SMP policy

The policy details for the whole policy area are shown here taken directly from the SMP (Halcrow, 2011), but non priority units have been greyed out.

Overview: *The long term vision for the northern part of this coast is to allow natural functioning without intervention, although local defences would be permitted where the road or property is at risk, as they could be provided without having any detrimental impacts to coastal processes. Further south maintaining the present line will depend upon economic justification for the coast road remaining on its present alignment. The topography of this frontage limits any potential for additional habitat creation, however by realigning parts of the road and current defences to a more sustainable position and working more with natural processes many environmental and human objectives would be met.*

Location		Policy and Approach (from 2010)		
		0-20 years	20-50 years	50-100 years
11c13.1	Bardsea to Newbiggin	No active intervention – Limited defences present, allow natural processes to continue. However localised defences may be permitted subject to consent.	No active intervention – Limited defences present, allow natural processes to continue. However localised defences may be permitted subject to consent.	No active intervention – Limited defences present, allow natural processes to continue. However localised defences may be permitted subject to consent.
11c13.2	Newbiggin to Rampside	Hold the line – Manage risk to the main road by maintaining existing defences to an adequate standard. Investigate opportunities for set back defences in the medium term. Economic justification for realigning or re-routing the road should be considered.	Managed realignment – Depending on the outcome of studies, construct set back defences or realign road where appropriate, elsewhere manage flood risk by maintaining existing defences to an adequate standard.	Hold the line – Manage flood risk by maintaining setback or other defences to an adequate standard.
11c13.3	Rampside	No active intervention – Limited defences present, allow natural processes to continue. However localised defences may be permitted subject to consent.	Hold the line – When flood risk justifies intervention.	Hold the line – When flood risk justifies intervention.
11c13.4	Roa Island	Hold the line – Manage flood and erosion risk by maintaining existing	Hold the line – Manage flood and erosion risk by maintaining existing	Hold the line – Manage flood and erosion risk by maintaining existing

		defences to an appropriate standard.	defences to an appropriate standard.	defences to an appropriate standard.
11c13.5	Piel Island	No active intervention – Limited defences present, allow natural processes to continue. However localised defences may be permitted subject to consent, e.g. at Piel Castle.	No active intervention – Limited defences present, allow natural processes to continue. However localised defences may be permitted subject to consent.	No active intervention – Limited defences present, allow natural processes to continue. However localised defences may be permitted subject to consent.

2 Appraisal of priority units

Three policy units within this area have been defined as priority units:

- 11c13.2 Newbiggin to Rampside
- 11c13.3 Rampside
- 11c13.4 Roa Island

2.1 Existing approach to flood and coastal erosion risk management

2.1.1 Justification of current SMP policy

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

- **Social:** 11c13.2 Policy allows for the important road link for local communities to be maintained. 11c13.3 Manages risk to communities and amenities at Rampside. 11c13.4 Manages risk to communities and amenities at Roa Island.
- **Environmental:** 11c13.2 Possible opportunities for intertidal habitat creation under the Managed realignment policy in the medium term. 11c13.3 Allows coastline to remain natural until defences are required for community protection. Manages risk to freshwater grazing marsh in medium and long term. 11c13.4 Maintenance of Roa Island and associated embankment will continue to manage risk to neighbouring saltmarsh, mud flats, navigation channel and lifeboat station.
- **Economic:** 11c13.2 The economic viability of the policy may depend on risks to the A5087 coast road and cost effectiveness of sustaining the current alignment. 11c13.3 Policy is economically viable as only limited defences required to manage flood risk to assets. 11c13.4 The economic viability of the policy may depend on allowing for benefits of protecting access to amenities and life boat (not valued at this stage¹)

2.1.2 Current defences

The defences along this frontage generally consist of rock and concrete revetments and concrete sea walls and some historic masonry walls, many of which are associated with protection of the coast road and unclassified road at Rampside and Roa Island (Figure 3 and Figure 4).

Table 1 provides a summary of the condition and estimate residual life for the various defence structures in the priority units of this policy area, whilst the following text provides further detail regarding current condition and recent management, based upon information taken from the most recent asset inspection reports for South Lakeland (CH2M, 2018b) and Barrow (Capita, 2016). The defence conditions range from good to poor.

Table 1 Existing defence condition and estimated residual life

Unit	Location	EA Asset Ref	Defence Type	Condition	Residual Life (years)
11c13.1	Coast Road to Sea Wood	011KC90220101C01	High ground	Poor (4)	20-50
11c13.1	Sea Wood to Maskel Point	011KC90220201C01	High ground	Fair (3)	20-50
11c13.1	Maskel Point	011KC90220201C02	Gabions	Fair (3)	10-20
11c13.1	Maskel Point to Aldingham	011KC90220201C03	High ground	Fair (3)	20-50
11c13.1	Aldingham	011KC90220301C01	Stone wall	Fair (3)	10-20

¹ Policy delivery in the noted frontages may be compromised by funding prioritisation due to the low Benefit Cost Ratio and therefore opportunities for co funding need to be investigated.

Unit	Location	EA Asset Ref	Defence Type	Condition	Residual Life (years)
11c13.1	Aldingham to Moat Farm	011KC90220401C01	High ground	Poor (4)	20-50
11c13.1	Moat Farm	011KC90220401C02	Gabions	Fair (3)	10-20
11c13.1	Moat Farm to Sea Croft	011KC90220401C04	High ground	Fair (3)	20-50
11c13.1	Caravan Park	011KC90220401C05	Rock armour	Poor (4)	10-20
11c13.2	Seed Hall to Newbiggin Scar	011KC90220501C01	High ground	Good (2)	20-50
11c13.2	Newbiggin Scar to dyke outfall	011KC90220501C02	Seawall	Good (2)	10-20
11c13.2	Unnamed location	011KC90220501C03	Rock armour	Good (2)	10-20
11c13.2	Leonard Hill	011KC90220501C04	High ground	Good (2)	20-50
11c13.2	Leonard Scar	011KC90220501C05	Seawall	Very Poor or failed (5)	0
11c13.2	Unnamed location	011KC90220501C06	Apron	Fair (3)	10-20
11c13.2	Roosebeck House	011KC90220501C07	Rock armour	Good (2)	10-20
11c13.2	Roosebeck House to Point of Comfort	011KC90220501C08	Seawall	Good (2)	10-20
11c13.2	From Point of Comfort to Lane Houses	011KC90220501C10	Seawall	Good (2)	10-20
11c13.2	Peasholmes Lane A	011KC90220601C01	Rock revetment	Good (2)	5-10
11c13.2	Peasholmes Lane B	011KC90220601C02	Concrete and Rubble revetment	Poor (4)	0-5
11c13.3	Rampside	011KC90220701C01 011KC90220701C02	Revetment	Fair (3)	5-10
11c13.3	Concle	011KC90220701C03 011KC90220701C04	Revetment	Fair (3)	5-10
11c13.4	Roa Island Causeway East	011KC90220701C05 011KC90220701C99	Revetment	Fair (3)	5-10
11c13.4	Roa Island Boat Club	011KC90220701C06	Revetment	Fair (3)	5-10
11c13.4	Roa Island Watchtower Roa Island, Bosun's Locker	011KC90220701C07	Revetment Revetment	Good (2) Fair (3)	10 0-5
11c13.4	Roa Island, Marine Terrace	011KC90220701C08	Revetment	Fair (3)	5-10
11c13.4	Roa Island	011KC90220701C09	Revetment	Fair (3)	?
11c13.4	Unnamed	011KC90220701C10	Revetment	Fair (3)	?
11c13.4	Roa Island Causeway West	011KC90220701C11 011KC90220701C98	Revetment	Good (2)	5-10
11c13.4	Unnamed location	011KC90220701C12	Natural ground	-	-
11c13.5	Piel Island	011KC90230501C01 011KC90230501C02	Revetment or Gabions	Poor (4)	0-5

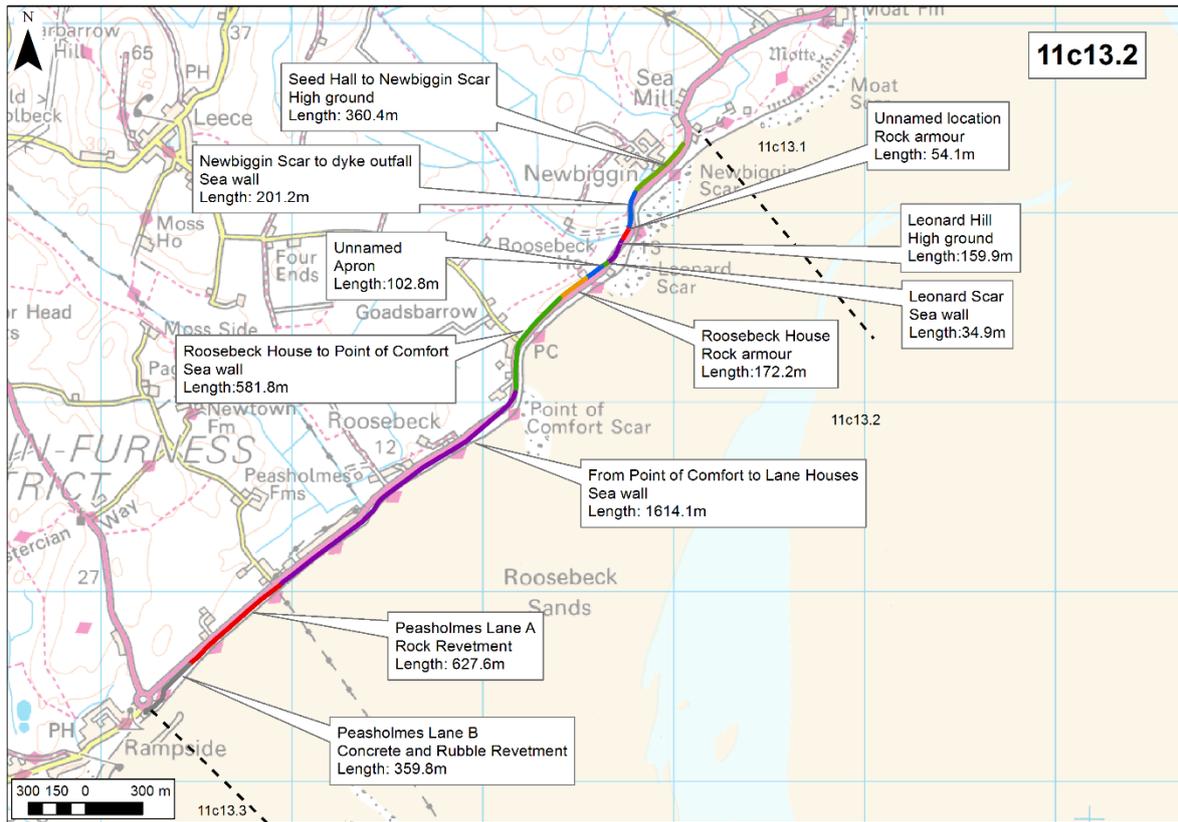


Figure 3 Policy unit location plans and defence overview for 11C13.2. Baseline mapping © Crown copyright and database rights, 2019. Ordnance Survey licence number: 1000019596.

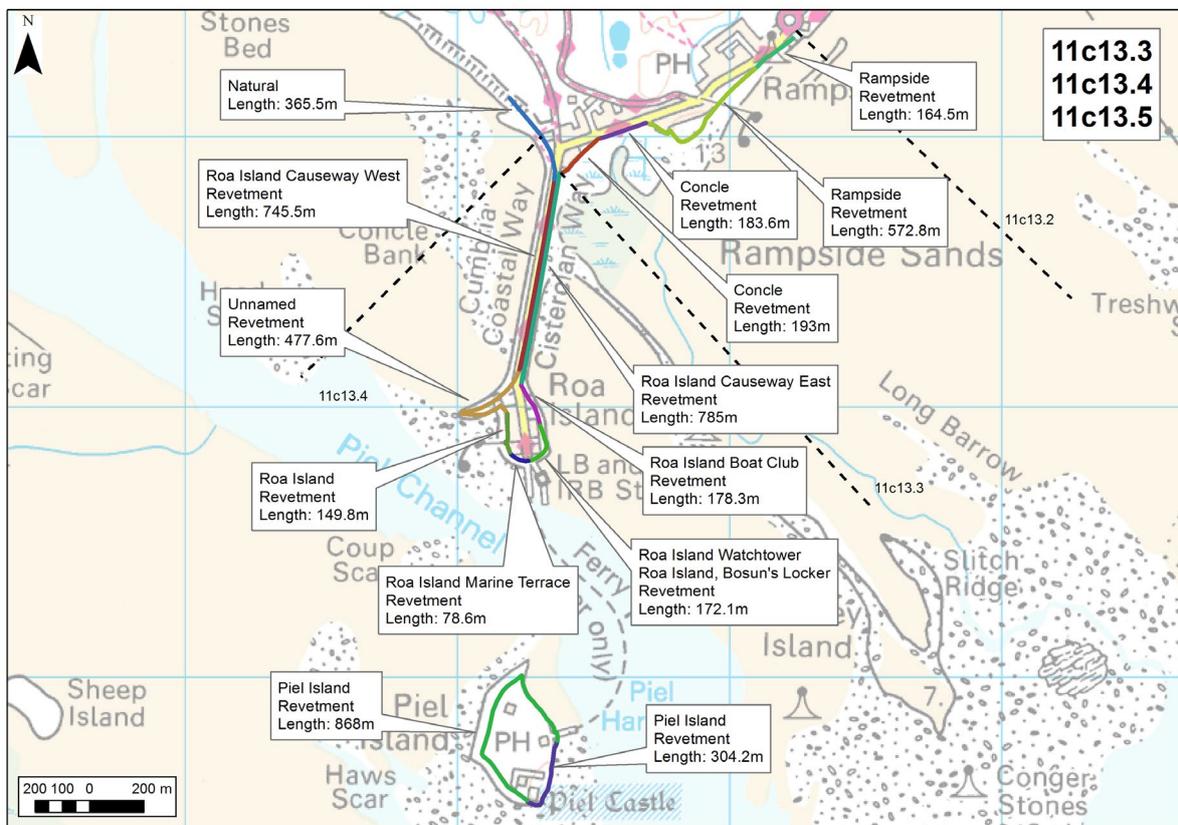


Figure 4 Policy unit location plans and defence overview for 11c13.3 to 11c13.5 Baseline mapping © Crown copyright and database rights, 2019. Ordnance Survey licence number: 1000019596.

2.1.2.1 Policy unit 11c13.2 Newbiggin to Rampside

Seed Hall to Newbiggin Scar (11c13.2) – 360 m – defence managed by CCC in a good condition, estimated residual life of 20 to 50 years (Figure 5). Sloped sea wall is also in fair condition with one void visible in isolated location, a few cracks are visible on the curved sea wall, with toe undermined at numerous locations. In 2014 emergency works were undertaken along this frontage, approximately 150 m of failed wall was replaced with rock armour and approximately 50 m of the existing wave wall at the southern end of the asset retained with additional rock placed. The rock armour is in good condition with no displacement visible (CH2M, 2018b).



Figure 5 Seed Hall to Newbiggin Scar. Taken from CH2M (2018b).

Newbiggin Scar to dyke outfall (11c13.2) – 200 m – concrete sloping revetment and seawall managed by CCC in a good condition, residual life of 10 to 20 years (Figure 6).

Newbiggin 1 (11c13.2) – 55 m – private rock and stone revetment in a good condition, residual life 10 to 20 years, (Figure 6).



Figure 6 Newbiggin Scar to dyke outfall and Newbiggin 1 revetment. Taken from CH2M (2018b).

Leonard Hill (11c13.2) – 160 m – privately owned frontage consists of high ground and extent of rock armour. CH2M (2018b) inspection report recommended that the asset be split into two defence sections due to high ground and rock armour being present at different locations. Overall good condition, with a residual life of 20 to 50 years.

Leonard Scar (11c13.2) – 35 m – privately owned stone wall which has suffered complete failure with large sections of wall deposited along the beach. Severe structural collapse has occurred with stone debris strewn on both sides of wall, consequently, the high ground behind is being eroded with cliffs forming due to no protection (Figure 7).



Figure 7 Leonard Hill and Leonard Scar failed stone wall. Taken from CH2M (2018b).

Newbiggin 2 (11c13.2) – 103 m – Concrete wall and rock and stone revetment. The rock armour has been placed onto wall as added protection. Rock armour is in good condition with no displacement visible, residual life 10 to 20 years.



Figure 8 Erosion outflanking rock armour at west end of Leonard Scar. Taken from CH2M (2018b).

Roosebeck House (11c13.2) – 173 m – rock and stone revetment, overall good condition with a residual life of 10 to 20 years.



Figure 9 Newbiggin 2 and Roosebeck House rock revetment. Taken from CH2M (2018b).

Roosebeck House to Point of Comfort (11c13.2) – 581 m - concrete seawall, steel sheet piling and rock armour defences managed by CCC in an overall good condition, residual life 10 to 20 years. The channel side in poor condition as lack of width to beach which is providing limited protection to higher ground. The piling at the toe of the slope is corroded along length of the asset but is in fair condition. The sloped revetment and splash wall is in fair condition, with an area of rebar exposed from abrasion of exposed face (Figure 10).

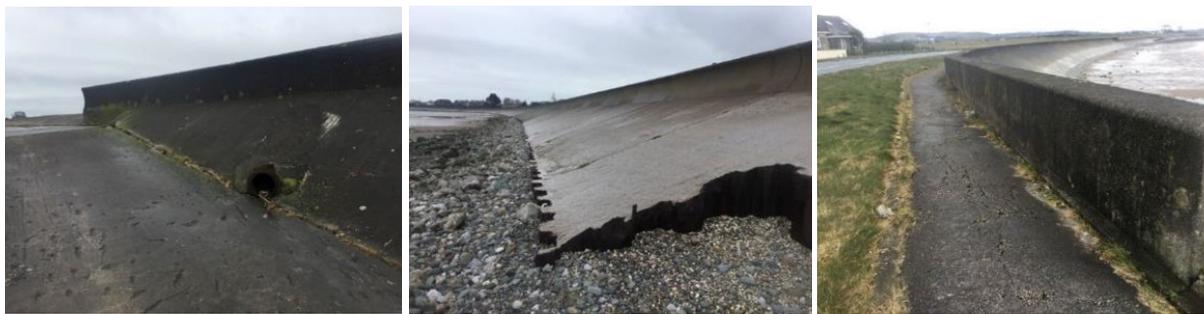


Figure 10 Roosebeck House to Point of Comfort (11c13.2). Taken from CH2M (2018b).

Point of Comfort to Lane Houses (11c13.2) – 1615 m – concrete seawall managed by CCC as highway defences in good overall condition with residual life of 10 to 20 years (Figure 11). Maintenance of sea wall elements was undertaken in 2014. Sea walls including the splash deck and splash wall are all in good condition. Timber groynes are, however, in very poor condition, with missing planks and piles.

It was noted in the latest defence asset inspection report (CH2M, 2018b) that pebbles have filled drainage pipes that are located at toe of sea wall along length of assets from Roosebeck House to Lane Houses; that this may impede road drainage along the A5087 coast road.



Figure 11 Point of Comfort to Lane Houses (11c13.2). Taken from CH2M (2018b).

At Peasholme Lane (11c13.2) – 630 m - the rock armour is densely packed having been constructed by CCC in recent years and its overall condition is good. However, the remaining concrete section of the revetment is generally in a poor condition.



Figure 12 Peasholme Lane (11c13.2). Taken from CH2M (2018b).

2.1.2.2 Policy unit 11c13.3 Rampside

The concrete revetment adjacent to the road in the east section is protected by a wide saltmarsh and sheltered by Foulney Embankment and Island. Its overall condition is Fair, (Figure 13). On the west side of the Back House Point headland near the Concle the revetment is heavily vegetated; up to 90% covered in parts. Spalling and cracking of the concrete is evident in areas not protected by vegetation. Its overall condition is Fair.



Figure 13 Rampside (11c13.3). Taken from CH2M (2018b).

2.1.2.3 Policy unit 11c13.4 Roa Island

The causeway to Roa Island is protected by revetments on both side with a variety of forms due to various historical repairs and upgrades to the original cobble pitching. The defences to the causeway were formerly the responsibility of British Rail and were subsequently maintained by BRB (Residuary) Limited (Mott MacDonald (2010)). In 2013 BRB (Residuary) Ltd was abolished and the responsibility transferred to Highways England as part of their management of the Historic Railways Estate. A large proportion of the revetment on the west side was renewed in bituminised aggregate grouted rock by BRB (Residuary) Limited between 2000 and 2005 and is in good condition.



Figure 14 Roa Island Causeway (11c13.4). Taken from CH2M (2018b).

On the east side of the causeway and other parts of the west side sections of revetment consist of sections of either original cobbles, gabion mattresses and asphalt grout and poured concrete repairs and the overall condition is fair.

On Roa Island itself most of the defences are privately owned and maintained. The Watch Tower frontage underwent repairs in 2012 to reinforce the structure of the revetment but requires ongoing works; overall condition is fair. Marine Terrace and Roa Island Boat Club revetments are both in fair condition, with minor cracking and some damage or undercutting to the toe of the revetments. The small passenger ferry jetty on Roa Island adjacent to the lifeboat station was replaced in 2014 or 2015 by Barrow Borough Council.



Figure 15 Roa Island Lifeboat station and jetty and adjacent patched revetments (11c13.4). Taken from CH2M (2018b).

The Foulney Embankment was not included in the Capita (2016) defence inspections for the Barrow BC area. However, the Shorelink Sustainability Study (Mott MacDonald, 2010) documents significant deterioration of the embankment defences between 2003 and 2010 and notes that management of the embankment and island is under the responsibility of Cumbria Wildlife Trust and responsibility for the maintenance and improvement of the defences lies with the Wildlife Trust.

The Foulney Embankment was originally constructed to help stop the Walney channel from silting up, and along with the Roa Island Shorelink has sheltered the area that was formerly Rampside Sands to the north. There was significant progradation of saltmarsh here in the 1970s and 1980s. The pitched stone revetments on the embankment deteriorated significantly between 2003 and 2010 and breached in many locations along its length. Mott MacDonald (2010) recommended frequent monitoring of this embankment as the long term deterioration of the embankment will in time lead to long term degradation of the saltmarshes and increased exposure of Roa Island and Rampside.



Figure 16 Breaches through the stone pitched landward section of Foulney Embankment. Taken from CH2M (2018b).

2.1.3 Shoreline change

A narrow shingle upper beach extends along the backshore between Wadhead Scar and Newbiggin. Moving south west along the frontage from Bardsea towards Rampside, the intertidal zone widens significantly. Several scars are located along the foreshore including Wadhead Scar, Church Scar, Elbow Scar, Leonard Scar and Point of Comfort Scar. These features produce undulations in the otherwise relatively uniform shore planform and provide localised protection to the shore. A low water channel meanders close to the shore at Aldingham, resulting in increased wave exposure in this location. At the western extent of the area there are extensive further offshore scars protecting Foulney and Piel islands. As with other areas within Morecambe Bay a key control on shoreline evolution has been the variations and changes in channel and bank positions within the Bay.

Analysis of beach level data collected as part of the North West Monitoring Programme is captured in the most recent monitoring report, including analysis of data up to October 2016 (CH2M, 2017). The data indicate that from Bardsea to the Point of Comfort, the lower sandflats have been very variable over the past 10 years, likely driven by changes in the position of tidal channels. Along the frontage from Bardsea to Aldingham there was modest vertical accretion on the upper sandflats but considerable erosion of the lower sandflats as the channel progressively moved closer inshore between 2013 and 2016. The greatest change was observed at Aldingham where beach width at mean sea level reduced from 2.7 km to 1 km in width. In contrast, southwest of Newbiggin, the lower sandflats accreted as the channel moved seaward at Leonard Scar and the Point of Comfort.

There has been relative stability of the lower profiles southwest of the Point of Comfort and all profiles on Roa Island. This is likely to be due to the shelter provided by Foulney Island, Walney Island and the extensive group of surrounding scars, which act to both fix the channels away from the shoreline and reduce wave heights reaching the shoreline here. The only notable change around Roa Island was the landward growth of Concle Bank and the gravel ridge near the Foulney Embankment.

Predictions of future erosion under the Do nothing option are dependent upon the residual life of existing defences. The SMP2 assessments suggested 2 to 10 m of erosion by year 20, 5 to 25 m by year 50 and 10 to 50 m by year 100 for the whole policy area. Predictions from NCERM suggest similar bands of change, under a scenario of No active intervention:

	By year 20	By year 50	By year 100
11c13.2 Newbiggin to Rampside	0 m to 8 m	0 m to 20 m	0 m to 40 m
11c13.3 Rampside	0 m to 8 m	10 m to 20 m	20 m to 40 m

2.2 Outline of the problem

2.2.1 Background

There are both flood and erosion risks to this frontage, with potential consequences for the future viability of the main coastal link road, A5087, as well as isolated properties. Some sections of defences within 11c13.2 are currently in a poor condition. Future sea level rise will result in additional risk to the road. Historical mapping indicates that the coast road and some of the associated defences have been in place since at least the 1930s although the Roa Island Causeway and defences on the Island associated with the railway date back to the 1840s.

The intertidal zone of the whole frontage is nationally and internationally designated as Morecambe Bay SSSI, Morecambe Bay and Duddon Estuary, Morecambe Bay SAC and Ramsar and South Walney and Piel Channel Flats SSSI due to the importance of its habitats and the birds supported. There are particularly sensitive habitats in the intertidal zone around Roa Island that options to implement the Hold the line policy need to consider. Since completion of the SMP2, there has been a specific study considering Roa Island and there have also been schemes to upgrade sections of the coastal defences alongside the A5087.

2.2.2 Issues, constraints and opportunities

Recognising the costs of larger defences that may be required to Hold the line along the road in future due to sea level rise, the SMP2 proposed that opportunities for realigning sections of the road and setting back defences in the medium term should be considered before Hold the line in the long term.

There are limited potential environmental opportunities in 11c13.2 through implementing Managed realignment due to the relatively high hinterland adjacent to the coast apart from the floodplain of Deep Meadows and Sarah Becks near Roosebeck.

The hinterland includes large tracts of agricultural land and farmsteads, small communities, sections of the main coastal road (A5087), local access roads, several caravan parks, a Scheduled Monument and communities and amenities at Rampside and Roa Island. There are also United Utilities assets within policy unit 11c13.3 as part of Rampside Wastewater Pumping Station (WwPS):

- Overflow from Rampside Village WwPS which discharges to Morecambe Bay, 350 m out from the WwPS. Significant sediment movement would pose a risk to the capability to discharge
- 300 mm sewers on the road at Rampside Sands on the Coast Road.

Within policy unit 11c13.4, United Utilities assets include an outfall from Piel Street to the Walney Channel through a 225 mm outfall pipe and small scale Wastewater Treatment Works infrastructure serving properties on the island that could be at risk of flooding. There is also a risk of saline intrusion at Roa Island.

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

- Structural integrity of the older sections of defences and consequential risk to coastal properties and the A5087 transport link
- Increased overtopping risk that will be expected to occur as a result of predicted rising sea levels

- Future geomorphological change that together with sea level rise may impact on the balance of loss and gain of saltmarsh and intertidal flats

The statutory nature conservation designations mean that there will be environmental constraints and potential opportunities associated with ongoing shoreline management for the frontage.

2.2.3 Strategy considerations and general approach

2.2.3.1 Key considerations

Since the SMP was produced further monitoring data has been collated. The strategy has considered this more recent data to appraise:

- Current defence conditions and risks
- Consider strategic management of defences to protect A5087, in line with any long term plans
- Consider appropriate implementation measures around Roa Island, given the sensitivity of intertidal habitats – taking account of conclusions from the Roa Island Study (2010)

2.2.3.2 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.
- Possible change to SMP2 policy – issues have been raised regarding the current policy. The strategy will consider possible measures taking account of a possible change to 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.

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.

The table below summarises the long list options for each policy unit covered in this section, in addition to the baseline options of:

- Do nothing,
- Do minimum.

Table 2 Long list options considered for priority units 11c13.2, 11c13.3 and 11c13.4

Priority Unit	Hold the line								Managed realignment				Other considerations	
	Maintain: proactive maintenance	Maintain: reinforce existing defences	Sustain: reinforce existing defences	Improve: improve existing defences	Improve: construct new shore control structures	Improve: construct new revetments or seawalls	Improve: beach recharge	Improve: cliff or slope stabilisation measure	Construct erosion slowing defences	Construct defences once set back	Construct secondary embankments	Remove existing defences	Adaptive management of assets	Potential habitat creation
11c13.2 Newbiggin to Rampside	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓
11c13.3 Rampside	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓
11c13.4 Roa Island	✓	✓	✓	✓	✓	✓					✓	✓		✓

The second stage has been to appraise the short listed options. Each of the sections below (Sections 2.4 to 2.6) outline for each frontage 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 will be provided in a **Strategic Environmental Assessment: Environmental Report** which systematically appraises the potential environmental consequences of the proposed strategy and recommends 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 which have then been costed and the benefits of the strategic options identified and evaluated. The No active intervention option provides the baseline for the economic appraisal. This is reported in the **Economic assessment** report.

2.4 11c13.2 Newbiggin to Rampside

There are formal defences along the whole of this section apart from a short length of coast at Leonard Scar, where the coast road is set back slightly further inland. The defences are mostly maintained by Cumbria County Council as highway structures protecting the A5087. At the toe of the defences there is an intermittent and narrow upper shingle beach with a wide intertidal flat to seaward.

Along much of the frontage the road is slightly set back from the wall with a number of formal and informal parking areas seaward of the road and a footpath running along the back of the defences.

The SMP policy allows for the important road link for local communities to be maintained through holding the line, but recognises that in the future the economic viability of the policy may depend on risks to the A5087 coast road and that sustaining the current alignment may not be cost effective. The recommendation was therefore to manage risk to the main road by maintaining existing defences to an adequate standard, but that in the medium term economic justification for realigning or re-routing the road should be considered.

2.4.1 11c13.2 - Initial screening of options

The table below summarises the rationale for taking long list options forward to the short list stage.

Table 3 Screening of long list options for 11c13.2

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 the risk of erosion and flooding. It has been assessed for comparative purposes only.
Do minimum	Reactive patch and repair of existing defences only.	Baseline only	Considered as a baseline, only reactive patch and repair maintenance would be undertaken. Only applicable as short term measure, until longer term strategic approach is confirmed.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	Yes	In accordance with current practice of regular inspections and necessary repairs.
Hold the line: maintain through reinforcing existing defences	Measures such as additional rock armour or new concrete overlay panels	Yes	Allows for upgrading sections as they reach end of service life, in accordance with current practice.
Hold the line: sustain through reinforcing existing defences	Measures such as additional rock armour or new concrete overlay panels	No	In this case this option is not significantly different from maintain through reinforcing existing defences.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Allows for consideration of adaptation to sea level rise. This could involve extending recent rock armour works to additional lengths, overlaying existing seawall with a more robust form of construction, replacing crest walls with higher profiles or adding crest walls on sections that do not have crest wall at present.
Hold the line: improve through constructing new revetments or seawalls	New shore parallel defences replacing or extending existing defences	No	Equivalent to "Improve Existing Defences" option, therefore not considered further.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwaters.	No	There were formerly timber groynes along parts of the frontage, but there is no evidence to show that they were effective in holding an upper beach due to the flat foreshore and limited amount of shingle on the upper beach. Also, the intertidal zone is environmentally designated habitat and shore control structures are unlikely to be conducive to the designation objectives.
Managed realignment: construct defences once set back	Construct new rock or concrete linear defences at set back locations if or where road realigned.	Yes	There may be sections of the road that could be slightly realigned to give a more cost effective alignment of road and defences and adapt to future sea level rise.

Long list options	Description	Short listed?	Rationale
Managed realignment: construct secondary embankment	Construct new set back flood embankments.	No	The main asset at risk is the coast road and associated infrastructure. Not considered to be justification to construct set back flood embankments. Considered as part of "Potential habitat creation sites"
Managed realignment: remove existing defences	Remove existing defences and allow the shoreline to adopt a more natural alignment.	No	This would not protect the road or other assets and unless undertaken as part of "Manage Realignment: construct defences set back" would not be in accordance with SMP Policy.
Other considerations: potential habitat creation sites	Consideration of creation of new intertidal habitat by constructing new secondary embankment and regulated tidal exchange beneath the road.	Yes	On its own this could not meet objective, but could be considered alongside Hold the line approaches as an approach to offset long term habitat loss impacts of the defences on designated intertidal habitats.
Other considerations: adaptive management of assets	Low cost rock toe protection if required to adapt to future foreshore lowering or crest raising to adapt to rising sea levels	No	Equivalent to "Hold the line: Improve existing defences" in this location, therefore not considered further.

2.4.2 11c13.2 - Development and appraisal of short listed options

2.4.2.1 Do nothing (Option 1)

This would not be in accordance with SMP policy but is required to be 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	Along most of the frontage the current defences are in good or fair condition, with residual life 10 to 20 years or greater. The sections with poor condition defences present (Peasholme Lane B) or undefended frontage (Leonard Scar) would result in the road becoming at risk of erosion damage within 5 to 10 years.
Environmental	<p>This option would not reduce risk of flooding and coastal erosion to the A5087 or its associated infrastructure beyond 5 to 10 years and would result in breaches to the road, loss of the important transportation link it provides as well and loss of access to and increased risk to properties and communities. The loss of this road would also put the health of the local population at risk by increasing the response time of any emergency vehicles that would be required to the area.</p> <p>This option may result in losses to or limitations on the use of the recreational facilities including the National Cycle Route 700 which follows the A5087, footpath (e.g. Cumbrian Coastal Way) or promenades adjacent to the seawall, two caravan sites and informal car parking areas for recreational users of the beaches. Some assets may require relocation. These changes, in addition to damaging the agricultural land along the front may impact on the economy of the area by impacting on two significant sources of income (agriculture and tourism).</p> <p>Additionally, there would be an increasing flood risk to listed buildings and potential damage to a barrow (listed on the Cumbria CC HER) due to a Do nothing option, which is considered of medium importance).</p> <p>This option may allow natural progression of areas, which may be of benefit to the designated intertidal habitats and species of Morecambe Bay. However there may be negative impacts as a result of debris arising from the failed defences disturbing along the coastline. Due to the presence of multiple European designations within the estuary, there will be a requirement for Habitat Regulations Assessment to assess potential impacts on these sites and required mitigation. There is a potential for loss of freshwater grazing marsh backing due to the increasing tidal flood risk.</p>
Cost	There are no costs associated with the No active intervention option.

Damages	<p>Loss of public highway access requiring diversion routes. Increased risk to life due to longer response times for emergency services and increased stress, for residents of villages between Ulverston and Barrow. Loss of recreational and tourism facilities associated with the coastal defences including adjacent properties. Loss of only A road diversion route when there are problems on the A590 between Ulverston and Barrow.</p> <p>Medium and long term loss of properties and agricultural land located landwards of the road. The damages are estimated to be £16,390 k.</p>
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2.4.2.2 Do minimum (Option 2)

<p>This is also considered as a baseline against which other options can be appraised. Under this option only reactive patch and repair maintenance would be undertaken, with no works to address any increase in risk due to sea level rise. There would be no capital works such as replacement or upgrade of defences once time expired.</p>	
Technical	<p>This would maintain the protection to current defences in the short term by repairing any damage on a reactive ad hoc approach. As there would be no capital works the option would not be sustainable into the long term, but could add 10 to 20 years to the residual life of the defences, after which the option would revert to Do nothing. As the work would be reactive to storm damage there would be periods when the road would be closed whilst repairs are organised and undertaken causing disruption and requiring temporary diversions.</p>
Environmental	<p>Once the defences failed after the delayed timescale then impacts will be as described in option 1</p>
Costs	<p>The Present Value Capital Works are estimated to be £470 k (to include refurbishment to return structures to maintainable standards) and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,380 k.</p>
Benefits	<p>Delay of onset of Do nothing damages in short term, with a design life of up to 20 years but as Do nothing in long term. The benefits are estimated to be £6,710 k.</p>

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

<p>This option assumes that the current defence management practices would be continued with a planned programme of regular inspections and necessary repairs undertaken in a proactive approach.</p>	
Technical	<p>This would maintain the protection to current defences in the short to medium term with a planned programme of inspections and repairs to damage undertaken in a proactive approach. As there would be no capital works the option would also not be sustainable into the long term, but could add 20 to 30 years to the residual life of the defences. In the longer term the option would revert to Do nothing. As the work would be planned there would be less disruption in the short term.</p>
Environmental	<p>This option would maintain the existing defences through the short term, within existing footprints and does not include any capital works. Once the defences fail after the delayed timescale then impacts will be as described in option 1.</p>
Cost	<p>The Present Value Capital Works are estimated to be £1,900 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £4,350 k.</p>
Benefits	<p>Delay of onset of Do nothing damages, with design life up to 50 years. As Do nothing in long term. The benefits are estimated to be £9,420 k.</p>

2.4.2.4 Hold the line: maintain through reinforcing existing defences (Option 4)

<p>This option assumes that the current defence arrangements would be retained and reinforced or upgraded but without crest raising to adapt to future sea level rise.</p>	
Technical	<p>The defences would be maintained as option 3, but the life of the structures would be extended over the strategy duration by reinforcing with rock armour or concrete revetment overlays as required in the future. This is considered to be equivalent to the current management approach, as rock armour overlays have been constructed in several locations in recent years.</p>
Environmental	<p>This would continue to reduce risk of erosion and flooding to the road and hinterland assets into the long term, but would not address any increase in storm wave overtopping due to sea level rise over the strategy period. Therefore there would be periodic disruption to the road, with a potential need to close the road.</p> <p>Reinforcing the defences with rock armour is likely to require small seaward extension of the toe of the defences, resulting in direct losses of the designated intertidal and related impact on the value the</p>

	<p>biodiversity and designations within the estuary. In addition, as this option allows for holding the line through the long term there may be indirect habitat loss in the long term epoch. This slight increase in footprint may also alter the hydromorphology of the frontage which should be assessed under the WFD.</p> <p>This area falls within the Lake District National Park and World Heritage Site. The natural, rural landscape of the National Park is a significant factor of the Lake District's outstanding universal value. Increasing the size of the hard defences will have negative impacts on the setting of these designations, though there is opportunity to minimise these impacts through incorporating complimentary designs into any new defence.</p>
Cost	The Present Value Capital Works are estimated to be £2,780 k assuming works are undertaken in year 20, and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £5,240 k.
Benefits	Avoidance of long term loss of A5087 route, but increasing disruption in long term due to flooding and road closures due to storm wave overtopping. The benefits are estimated to be £11,370 k.

2.4.2.5 Hold the line: improve existing defences (Option 5)

This option assumes that the current defence alignment will be retained and that the defences will be upgraded through toe reinforcement, rock armouring and crest raising to adapt to future coastal change and sea level rise.	
Technical	<p>The existing defences would be upgraded in the future to adapt to ongoing coastal change and future sea level rise. This would be similar to the works required under Option 4, but with the addition of crest raising or placing additional rock armour overlay to give a rougher more dissipative revetment surface. The future improvements would seek to mitigate deeper water at the defence toe due to sea level rise allowing larger wave attack to the coastal structures and sustain or reduce wave overtopping discharges. It is assumed that a managed adaptive approach would be taken to climate change, so the larger defences would be implemented only when existing defences reach end of their service life and need replacing or the increasing disruption to road traffic justifies intervention to manage the risk of overtopping.</p>
Environmental	<p>This would continue to reduce risk of erosion and flooding to the road and hinterland assets into the long term and higher crest levels would reduce overtopping in the longer term. There is the possibility that the seaward views from properties may be reduced as result of this increased crest level. This area falls within the Lake District National Park and World Heritage Site. The natural, rural landscape of the National Park is a significant factor of the Lake District's outstanding universal value. Increasing the size of the hard defences will have negative impacts on the setting of these designations, though there is opportunity to minimise these impacts through incorporating complimentary designs into any new defence.</p> <p>As this option aims to maintain a hard defence, there is potential for impacts related to habitat loss affecting the habitats on the seaward of the defence. This may result in indirect habitat loss and related impact on the value the Morecambe Bay designations. There may also be direct habitat loss related to the requirement for an increased footprint of the improved defence. The extent of these impacts should be assessed as part of any scheme arising from the Strategy.</p>
Cost	The Present Value Capital Works are estimated to be £6,500 k with works assumed to take place in year 20, and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £11,390 k.
Benefits	Avoid Do nothing damages over the strategy duration. The benefits are estimated to be £15,850 k.

2.4.2.6 Manage realignment: construct defences once set back (Option 6)

This option assumes that set back defences would be required for realigned sections of the road if this could provide a more cost effective approach to maintaining the road. This accords with the medium term SMP policy which allows for potential Managed realignment in the medium term followed by Hold the line in the long term.	
Technical	<p>In locations where it is feasible the road could be set back to a more sustainable alignment, reducing the costs of coastal defence. However, cost savings on coastal defence would need to be offset against the costs of re-routing the road. Due to settlement and isolated properties on the landward side of the road there are limited opportunities for small scale road realignments.</p> <p>The option would only be applicable if the road could be set back behind current properties along virtually the whole length of the policy unit. Setting the road back could require around 4 km of new road construction, requiring construction across the flood plains of Sarah Beck and Deep Meadow Beck. There would also be costs for demolition and removal of sections of defence that are not directly protecting properties. There would also be costs for decommissioning or downgrading the existing road to local access. In the long term, under a large scale realignment, the coastal settlements and isolated</p>

	properties which currently benefit from the defences to the road would be left undefended and at long term risk.
Environmental	<p>This option does not reduce risk of damage to the properties adjacent to the road's current alignment, but would ensure continued provision of a viable road route. Full assessment of impacts of a road realignment would have to be undertaken if this option is taken forward.</p> <p>By creating set back defences it may allow more natural coastal processes to establish. Monitoring should be implemented to ensure that these processes don't cause negative impacts elsewhere. The land on the seaward of the set back defences would provide opportunity for coastal habitats to migrate landward with changes in sea level, thereby avoiding habitat loss impacts on the designated habitats of the Morecambe Bay designations. Though the shift of terrestrial habitats to coastal habitats may result in the loss of important terrestrial habitats. There would likely be direct habitat loss related to the construction of new hard defences. Monitoring should be implemented to manage the extent of habitat change.</p> <p>Altered landscape potentially arising from managed realignment could impact on the setting of the Listed Building present in the area and also impact on the setting of the Lake District World Heritage Site, the nature of which may be positive or negative depending on the nature of any habitat changes. Consultation on managed realignment would therefore be required with Historic England and Lake District National Park WHS.</p>
Cost	The costs would relate to construction of the new road alignment and downgrading or removing the exiting road to provide local property access, decommissioning and removal of defences. Costs need to include for maintaining defences until the realigned road is in place. The Present Value Capital Works are estimated to be £9,930 k with works assumed to take place in year 30, and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £17,710 k.
Benefits	The benefits would relate to the (possibly) maintaining the highway link and there would be lower maintenance costs for the defences. There would be damages related to the increasing risk of flooding and erosion loss of properties adjacent to the existing road. Benefits would include the short term benefits of Option 3 and long term benefits of avoiding loss of the road.

2.4.2.7 Other considerations: potential habitat creation sites (Option 7)

This option would need to be considered alongside Options 4 or 5 if impacts on the designated habitats of Morecambe Bay need to be mitigated or compensated for.	
Technical	<p>Habitat creation may be required to offset potential damage to the designated sites in Morecambe Bay due to direct losses from the increased footprint of larger coastal defences required to mitigate climate change in the long term or to adapt to potential losses due to habitat loss from holding the line in locations where the coastal defences constrain the existing intertidal habitats from migrating landwards due to sea level rise.</p> <p>The flood plain landwards of Roosebeck and Goadsbarrow may present potential longer term opportunities for habitat creation for mitigating the impacts on the Morecambe Bay sites. Presently the area is too high in the tidal frame to create any additional mud or sandflats as it is above mean high water tide level.</p> <p>Due to the presence of the coast road it would not be feasible to breach the defences to allow natural tidal flooding to create habitat and therefore a regulated tidal exchange (RTE) approach allowing controlled flows through a sluice or culvert would be required. There is around 80 hectares of the flood plain adjacent to Sarah Beck that could potentially be at a suitable level for saltmarsh development with future sea level rise, although the restricted flow into the site may significantly reduce this.</p>
Environmental	<p>As described above, this option would only be considered in the medium or long term epoch alongside Hold the line options for the current defences, options 4 or 5, if required, to compensate for intertidal habitat losses from habitat loss or direct losses in the footprint of larger defences. This option could provide an opportunity to deliver an overall net gain in intertidal habitat creation.</p> <p>The impacts of RTE would be similar to some of those identified under Option 6 (Managed realignment). There would be impacts on current agricultural land use and depending on scale, on the landscape setting. A gain in intertidal habitat would result in the loss of non designated freshwater grazing marsh that would likely require replacement elsewhere. Impacts of this option on the WFD objectives should also be considered.</p>
Cost	The Present Value Capital Works are estimated to be £1,530 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,490 k.

Benefits	Avoidance of losses to the designated habitats, which there may be a legal requirement to mitigate. (not quantified)
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2.4.3 11c13.2 - Discussion

Table 4 summaries the cost and benefit calculations for the various options presented above. Without capital schemes, once current defences become redundant in around 20 to 50 years, Options 2 and 3 would not deliver the SMP objectives of maintaining the important road link over the strategy period.

The medium term policy in the SMP suggests consideration of Managed realignment in the medium term, which would require realigning the road to a more sustainable alignment, avoiding the need for larger coastal defences on the front line. Option 6 considers this option and notes that it would require a large scale realignment, potentially requiring up to 4 km of new road construction. Table 4 shows that even in the long term, taking account of any sea level rise, this is unlikely to be economically viable or more cost-effective than upgrading the current coastal defences through reinforcing or improving (Options 4 and 5), both of which are shown to be marginally viable as economic benefits exceed the costs. It is therefore considered that such a large scale intervention would not be justifiable at present and would only be feasible if there were large increases in coastal risks due to climate change.

Option 7 considers potential for habitat creation through a regulated tidal exchange (RTE) approach, this could be considered in the medium to long term alongside Options 4 or 5 if impacts due to footprint of upgraded defences on the designated habitats of Morecambe Bay need to be mitigated or compensated for and it is more cost effective and environmentally acceptable to undertake habitat replacement here than elsewhere in Morecambe Bay. A number of further studies are required to confirm the feasibility of regulated tidal exchange for this purpose and how it could be incorporated in the long term.

- Clarification of the objectives for undertaking a regulated tidal scheme.
- More detailed desk top assessment of sites (e.g. lengths of footpaths with site, potential for contaminated land, consultation with landowners).
- Preliminary design - quantifying the length of any new defences, number and positions of structures.
- Hydrodynamic modelling to determine effects on flood risk and geomorphology as well as the likely inundation of the sites.
- Costs and economics- Quantifying the costs for the works and future maintenance versus existing management activities.

The environmental assessment of the options indicated that Options 6 and 7 would be equally preferred in the long term, meeting most objectives, with proactive maintenance the overall preferred option in the short term.

Table 4 Policy unit 11c13.2 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 (up to 20 years)	0.47	1.38	6.71	4.9
Option 3 Hold the line: Maintain through proactive maintenance (up to 50 years)	1.90	4.35	9.42	2.2
Option 4 Hold the line: maintain through reinforcing existing defences in year 20	2.78	5.24	11.37	2.2
Option 5 Hold the line: improve existing defences in year 20	6.50	11.39	15.85	1.4
Option 6 Manage realignment: construct defences once set back in year 30 (costs and benefits include	9.93	17.71	11.37	0.6

Option 3 before realignment takes place) +				
Option 7 Other considerations: potential habitat creation sites++	1.53	2.49	++	++
<i>*Present Value cost (PVC) inclusive of 60% optimism bias + Costs for land purchase not included. ++Benefits would include intertidal habitat creation. If there are habitat loss impacts from holding the line in the long term intertidal habitat creation may be legally required for mitigation or compensation for impacts on the internationally designated habitats. May need to be considered as part of Option 5.</i>				

2.4.1 11c13.2 - Strategic way forward

In the short term the preferred strategic approach is to Hold the line through Option 3 (proactive maintenance), which could be sufficient for up to 20 years whilst a funding strategy and a longer term solution are developed.

To provide long term protection to the road in its current location, the existing defences would need to be improved through reinforcing with rock armour or concrete overlays (Option 4) and, depending on the rate of sea level rise, it may also be necessary to increase the crest level (Option 5). Although the SMP consider the possibility of realigning the road, the length of new A road required means this is unlikely to be more cost-effective than improving the current defences.

A feasible alternative would be the possibility of a small scale regulated tidal exchange scheme, to provide compensatory habitat; this would require further study, but should be considered as a part of a longer term solution.

A whole catchment approach is required to manage the flood risk. The following activities are recommended in the future:

- Monitoring of coastal process and asset condition.
- Maintenance and repair of existing defences, with identification of works required for poor condition defences.
- Further studies required to investigate the potential for management realignment and RTE schemes, with early consultation with Natural England and Lake District National Park WHS.

Further details on actions and responsibilities are provided in the **Action Plan**.

2.5 11c13.3 Rampside

The Rampside frontage is currently protected from direct wave action by the wide fringing saltmarsh. There are existing coast protection defences along the whole frontage mostly consisting of sloping concrete revetments, which are heavily vegetated but given the limited exposure considered to be in a fair condition. There are no raised flood defences at present.

The SMP policy in the short term is No active intervention with a change in the medium term to Hold the line due to an expectation of a need to introduce raised tidal flood defences to mitigate expected sea level rise. At the time the SMP was developed the Environment Agency Flood Zone 2 risk map showed most of Rampside to be at risk of flooding under extreme events. However, the latest version of the flood risk map shows much lower risk with only a very small area of the village in the present day Flood Zone 2.

The Mott Macdonald (2010) Roa Island Shorelink study has highlighted that the Foulney Embankment is fundamentally important to the stability of the marsh in this area and that the marsh provides a natural coastal defence function to Rampside. Long term option consideration for Rampside therefore needs to take into account options for the embankment.

2.5.1 11c13.3 - Initial screening of options

The table below summarises the rationale for taking long list options forward to the short list stage.

Table 5 Screening of long list options for 11c13.3

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail	Baseline only	This is the current short term SMP policy. It has also been appraised in for the longer term for comparative purposes only.
Do minimum	Reactive patch and repair of existing defences only.	No	In this location this is no different to the Do nothing option, so has not be considered further.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	No	The existing defences will be beyond residual service life by the end of the SMP short term epoch in around 10 years' time so maintenance alone would not be appropriate.
Hold the line: maintain through reinforcing existing defences	Measures such as additional rock armour or new concrete overlay panels	Yes	Allows for upgrading existing defences to Hold the line in the future if coastal risk increases due to sea lever rise or loss of the fronting marsh.
Hold the line: sustain through reinforcing existing defences	Measures such as additional rock armour or new concrete overlay panels	No	In this case this option is not significantly different from "maintain through reinforcing existing defences".
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Allows for consideration of adaptation to sea level rise or loss of the marsh. This could take the form of rock armour works or possibly proprietary revetment system to overlaying existing seawall. However, if the marsh remains, a setback crest wall adjacent to the road in the medium or long term may be suitable to mitigate risk from rising sea levels.
Hold the line: improve existing defences (Foulney Embankment)	Measures to retain and enhance the saltmarsh at Foulney Embankment by refurbishing the embankment.	Yes	The saltmarsh developed extensively during the 1970s and is afforded protection by the Foulney Embankment. This option could include for repairing and reinforcing the embankment and is equivalent to Option 1 in the Mott MacDonald (2010) study.
Hold the line: improve through constructing new revetments or seawalls	New shore parallel defences replacing or extending existing defences	No	Equivalent to "improve existing defences" option.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwaters.	No	The intertidal zone is environmentally designated habitat and new shore control structures are unlikely to be conducive to the designation objectives.
Managed realignment: construct defences once set back	Construct new rock or concrete linear defences at set back locations if or where road realigned.	No	No suitable locations for realigning the defences.
Managed realignment: construct secondary embankment	Construct new set back flood embankments.	No	There is very limited space along most of the frontage for an embankment without encroaching onto the marsh.

Long list options	Description	Short listed?	Rationale
Managed realignment: remove existing defences	Remove existing defences and allow the shoreline to adopt a more natural alignment.	No	This would not protect the road or other assets and would not be in accordance with SMP Policy.
Other considerations: potential habitat creation sites	Consideration of creation of new intertidal habitat by constructing new secondary embankment and regulated tidal exchange beneath the road.	No	No suitable locations for realigning the defences or coastal habitat creation.
Other considerations: adaptive management of assets	Low cost rock toe protection if required to adapt to future foreshore lowering or crest raising to adapt to rising sea levels	No	Not considered as equivalent to “Hold the line: Improve existing defences” in this location.

2.5.2 11c13.3 - Development and appraisal of short listed options

2.5.2.1 Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. This is the current short term SMP policy due to the low coastal risks at presence.	
Technical	The current defences are heavily vegetated, but considered to be in fair condition with residual life of 5 to 10 years. In practice the coastal risk is managed by the saltmarsh and the current semi natural defence arrangements and No active intervention Policy which is equivalent to Do nothing could be suitable into the SMP medium term, depending on future sea level rise and changes to the fronting marsh. The marsh is sheltered by the Foulney Embankment which is already breached in several locations and deteriorating in condition, and so may impact the stability of the stability of the marsh.
Environmental	<p>This option would be in accordance with the current short term SMP policy.</p> <p>This option would not reduce the long term risk of flooding and coastal erosion to the Roa Island Road or its associated infrastructure and could result in breaches to the road, loss of the important transportation link it provides as well and loss of access to and increased risk to properties and communities in the long term. The loss of this road would also put the health of the local population at risk by increasing the response time of any emergency vehicles that would be required to the area.</p> <p>This option may result in long term losses to or limit to the use of the recreational facilities including the National Cycle Route 700 which follows the Roa Island Road, footpath adjacent to the road and informal car parking areas for residents and users of the beaches. Some assets may require relocation.</p> <p>Additionally, there would be an increasing flood risk to listed buildings. There is also potential for loss of freshwater grazing marsh backing the area due to the increasing tidal flood risk. However, this option would allow for a more naturally evolving coastline, which may be of benefit to the designated habitats and species present within Morecambe Bay which are currently constrained by the coastal defences adjacent to Roa Island Road.</p> <p>To the west of the Foulney Embankment is the only known areas of sea grass in Northwest England, which are particularly sensitive to water quality changes.</p>
Cost	There are no costs associated with the No active intervention option.
Damages	Nil in short term. Potential tidal flood risk damages in the long term, or medium term if the marsh is lost. The damages are estimated to be £660 k.

2.5.2.2 Hold the line: maintain through reinforcing existing defences (Option 2)

This option assumes that the current defence arrangements would be maintained and repaired or reinforced when necessary. This would accord with the medium and long term SMP2 policy.	
Technical	The sheltering by the saltmarsh significantly reduces wave action and related risk and so significant intervention is not considered necessary at present. The existing defences are not raised above ground level and so do not provide a flood defence function. In the future if the marsh does not accrete vertically to keep pace with rising sea levels, deeper water at the defence toe may result in larger waves. A suitable response may be to maintain, repair and reinforce existing revetments with concrete overlays or possibly rock armour toe replacement, on a like for like basis. This is likely to be in the form of localised patching of sections where erosion could become an issue rather than wholesale upgrade, e.g. at locations where there is property or the road immediately adjacent to the shore. This option does not include works to the Foulney Embankment, which are considered under Option 4.
Environmental	<p>The defences would be maintained, repaired and renewed when necessary with similar materials to original but this option may not mitigate against the potential for increased overtopping of defences which may result from changing climatic factors in the future. This would be in accordance with the medium term SMP policy.</p> <p>Continuing to Hold the line in the short term is unlikely to affect the existing stability of the Morecambe Bay SPA, Ramsar, SAC and SSSI and will likely allow continued accretion of saltmarshes and mudflats. However, there is potential for loss of intertidal habitat due to habitat loss and uncertainty of sediment supply in the long term. These changes, together with any direct impacts though defence repairs, would likely require further assessment.</p> <p>This option will continue to constrain hydromorphological processes which may affect the WFD objectives of the Morecambe Bay coastal waterbody and so require assessment.</p> <p>Maintaining the defences while the saltmarshes are lost may alter the landscape character and visual amenity of the frontage. This area falls within the Lake District national park and world heritage site. The natural, rural landscape of the National Park is a significant factor of the Lake District's outstanding universal value. Increasing the size of the hard defences will have negative impacts on the setting of these designations, though there is opportunity to minimise these impacts through incorporating complimentary designs into any new defence.</p>
Cost	The Present Value Capital Works are estimated to be £2,510 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £4,070 k. This assumes capital works are undertaken in year 5.
Benefits	Due to the low risks from erosion and tidal flooding the benefits would be very small and unlikely to justify significant works. The benefits are estimated to be £540 k.

2.5.2.3 Hold the line: improve existing defences (Option 3)

This option assumes that the current defences would be improved in the medium or long term in accordance with the SMP policy by constructing a new flood defence to adapt to higher sea levels.	
Technical	<p>Although tidal flood risks are currently low the SMP anticipated that the village could be at significantly greater risk in future due to rising sea levels or larger storm surges and that there could be justification for a raised flood defence adjacent to the road to manage coastal flood risk to properties in the village. This would apply along the two sections where the road is adjacent to the shoreline.</p> <p>The new defence could be in the form of low wall slightly set back from the current defences and so not impacting on the designated sites. The existing revetments would need to be maintained and repaired as in Option 2. This option does not include works to the Foulney Embankment, which are considered under Option 4.</p>
Environmental	<p>This option would likely result in similar impacts as in Option 2, though this option would mitigate for increased overtopping as a result of climatic changes in the future.</p> <p>The raised defences may impact on the landscape and visual amenity of the frontage by impacting on the views of the sea from residential properties.</p>
Cost	The Present Value Capital Works are estimated to be £950 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,550 k. This assumes capital works are undertaken in year 50.
Benefits	The latest flood risk mapping shows a lower risk to the village than at the time the SMP was developed and so it is unlikely that there would be justification for raised defences until the long term epoch unless the fronting marsh was to significantly erode. The benefits are estimated to be £620 k.

2.5.2.4 Hold the line: improve existing defences (Foulney Embankment) (Option 4)

<p>This option involves measures to retain and enhance the saltmarsh between Rampside and the Foulney Embankment by upgrading the Foulney Embankment. It assumes that the failed pitched stone and rock embankment would be replaced in accordance with option 1 in the Roa Island Shorelink Sustainability Study, Mott Macdonald (2010).</p>	
<p>Technical</p>	<p>The embankment is considered to have been fundamental to accretion on Rampside Sands and the subsequent formation of the saltmarsh which provides protection to the hinterland as well as environmental benefits. The works proposed in the Mott Macdonald study option 1 allowed for using the existing embankment remains as a base and constructing a rock bund consisting of two layers of rock armour. The length requiring refurbishment was estimated as 640 m in 2010. There has been further storm damage over the last 8 years and so an allowance for 20% more has been assumed for the strategy, i.e. about 770 m requiring upgrade. The crest level would be the same as the existing rock bund, about 4.8 mOD, and so the tide would flow over the bund on Spring tides as it does at present. This option does not include works to the Rampside frontline defences, so would need to be considered alongside Options 2 or 3.</p>
<p>Environmental</p>	<p>This option would manage long term flood risk to the assets at risk within this frontage.</p> <p>Foulney Island is a bird sanctuary managed by the Cumbria Wildlife Trust and is the only known breeding site for Arctic Tern in the Northwest of England and the embankment itself is a part of the array of international and national conservation designations that cover Morecambe Bay. This option would help to retain and enhance the saltmarsh between Rampside and the Foulness embankment although there is potential for small losses in the footprint of the works. A HRA would be required to assess the impacts of this option on the integrity of the conservation sites. Similarly, a WFD assessment would be required to ensure that the works do not compromise the achievement of WFD water quality targets, particularly with regard to the condition of the shellfish waters located off the coast. To the west of the embankment is the only known areas of sea grass in Northwest England, which are particularly sensitive to water quality changes.</p> <p>As this embankment is a popular walking trail, there may be opportunity to enhance its recreational value by installation of or renewal of information boards related to the designations of the surrounding bay and the bird reserve on Foulney Island.</p> <p>As this options involves modifications to an existing structure it is unlikely to have adverse impacts on the character of the coastline.</p>
<p>Cost</p>	<p>The Mott MacDonald (2010) study estimated capital costs as £2,820 per linear meter which would give a cost of £2.2 million in 2010 prices, equivalent to Present Value Capital Works of £4,680 k. Assuming the works are undertaken in year 50, the Present Value Total Cost with Optimism Bias (PV(OB)c) is £1,780 k. This assumes capital works are undertaken in year 50.</p>
<p>Benefits</p>	<p>Benefits relate to the following coastal flood risk reduction to Rampside village and stabilisation of the important designated habitats in the vicinity. While noting the importance of the embankment to the protection of both Rampside and Roa island Mott MacDonald (2010) did not estimate benefits to Rampside as it was outside their study scope. The benefits for Rampside frontage are estimated to be £620 k. However, this does not include benefits related to 11c13.4, Roa Island</p>

2.5.3 11c13.3 - Discussion

Table 6 summaries the cost and benefit calculations for the various options presented above. This indicates than none of the intervention options considered are economically viable as the present value costs exceed the benefits.

In recognition that the shoreline is sheltered by the fringing saltmarsh, the Foulney Embankment and Roa Island Causeway, the SMP considered that a No active intervention policy was appropriate for this frontage in the short term but identified that raised defences may be justifiable in the medium or long term due to sea level rise. The latest flood risk mapping from the Environment Agency shows lower risk than at the time of the SMP, so it is not presently expected that raised defences would be justified until into the long term (50 to 100 years) epoch.

The SMP assumed that the marsh would remain stable and may accrete in response to sea level rise. However, the Mott MacDonald (2010) study has highlighted that the deterioration of the original rock bund of the Foulney Embankment may cause the marsh to erode in future. Since that study there has been further deterioration to the embankment, allowing greater tidal flows through the breaches and increased pressure on the associated creeks in the marsh, however the overall marsh is currently still expanding towards Roosebeck. It is recommended that the changes are monitored in order that possible future intervention

requirements can be assessed appropriately. The Barrow BC annual inspections should be extended to include the Foulney Embankment and monitoring of changes to the marsh should be undertaken as part of the regional monitoring programme in liaison with Cumbria Wildlife Trust who manage the site.

Table 6 Policy unit 11c13.3 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 Hold the line: maintain through reinforcing existing defences	2.51	4.07	0.54	0.14
Option 3 Hold the line: Improve existing defences in year 50	0.95	1.55	0.62	0.4
Option 4 Hold the line: Improve existing defences (Foulney Embankment) in year 50⁺	1.10	1.78	0.62 ⁺	0.3
+ - Benefits of erosion protection to the saltmarsh and intertidal habitats not included				

2.5.4 11c13.3 - Strategic way forward

In the short to medium term, the shoreline is anticipated to remain sheltered by the fringing saltmarsh, the Foulney Embankment and Roa Island Causeway, therefore no works are likely to be needed apart from very minor repairs. Do nothing is therefore the preferred strategic approach, although risks will need to be monitored.

In the long term there may be a need to improve defences and Option 3, raising existing defences, is likely to be the most cost effective. This could be in the form of low wall slightly set back from the current defences to minimise impacting on designated sites, but will depend upon the future management of Roa Island, Roa Island Causeway and Foulney Embankment.

The following activities are recommended in the future:

- Monitoring of coastal process and asset condition, with asset inspections extended to include Foulney Embankment.
- Minor maintenance of existing defences if required.
- Monitoring of marsh and risk levels to coastal road and properties to enable future intervention to be assessed appropriately.

Further details on actions and responsibilities are provided in the **Action Plan**.

2.6 11c13.4 Roa Island

Since the SMP2 was completed, Barrow in Furness Borough Council have commissioned Mott Macdonald (2010) to undertake a review and update of an earlier ABPmer (2003) Roa Island Shorelink: Sustainability Study, which has been taken into account in this strategy. The 2010 study included a walk over defence condition assessment to assess changes since 2003; review of coastal wave and water level conditions; consideration of current performance of defences and their residual lives; appraisal of options for maintenance and improvement of defences; an environmental baseline assessment; and economic appraisal of options in order to confirm the viability of the SMP Hold the line policy.

Economic analyses of the proposed options indicated that an option comprising the construction of a 0.75 m high flood wall, new revetments locally on the Island and refurbishment of the Foulney Causeway has a benefit cost ratio (BCR) of 2.8. However, in order to generate additional Outcome Measures score the project team also considered an option that included realignment of Foulney Embankment in order to create 15 ha of saltmarsh (see option 4, 11c13.3). The options costs and benefit assessments all considered major capital schemes commencing in year 5. Although the habitat creation option resulted in a higher outcome measure score the BCR reduced to 1.7 due to the additional costs of the realignment.

The report also provided a defence condition inspection undertaken in January and February 2010. The general findings indicate a need for regular condition monitoring to be carried out to assist in managing the short to medium term changes in the asset grade in addition to the evolutionary trends that affect the foreshore material and nearshore bedforms.

The report noticed that *“during the Condition Survey, areas where the facing had been removed (on the eastern flank of the Shorelink causeway) revealed a clay under layer, leading Mott MacDonald to postulate that the Shorelink structure is potentially composed of material excavated from nearby glacial till cliffs, faced with a revetment. Further investigation into the geotechnical nature of the causeway structure would improve understanding of the likely mechanisms of failure. If it is assumed that the causeway is not composed of a solid core material such as rocks or boulders, failure of the structure could occur rapidly once the revetment facing is removed. Geotechnical failures have not been independently addressed to date and these need to be understood more fully in order to evaluate the performance of the Shorelink better”*.

2.6.1 11c13.4 - Initial screening of options

The Roa Island Shorelink Sustainability Study, 2010 Review (Mott MacDonald, 2010) appraised a number of options. The options considered by Mott Macdonald generally cover equivalent options to those elsewhere in the strategy, although they had no explicit inclusion of Do nothing and Do minimum options. These have therefore been taken forward as short listed options:

Mott Macdonald short list options	Equivalent options considered elsewhere by this strategy
Option 1 Rehabilitation and strengthening of the Foulney Embankment	Hold the line: improve existing defences (Foulney Embankment)
Option 2: Habitat creation and realignment of Foulney Embankment (to 4.5mOD)	Other considerations: potential habitat creation sites
Option 3: Raise/Bund the causeway	Hold the line: improve existing defences
Option 4: Construction of flood walls around the Shorelink	Hold the line: improve or construct new revetments or seawalls
Option 5: Construction of rock armour revetment along the eastern and western flanks of the island	Hold the line: maintain through reinforcing existing defences

From a review of the detailed Mott Macdonald review, it is concluded that all options that would be appropriate for consideration as part of this strategy have been included in the short list of options developed by Mott Macdonald.

2.6.2 11c13.4 - Development and appraisal of short listed options

The options considered by Mott MacDonald (2010) are reviewed in Table 8. The study suggested preferred management options for Roa Island, and set out preliminary investigations and works required to allow a preferred option to be selected.

Table 8 includes additional comments and information on costs, based on more recent information provided by Natural England and to take account of further deterioration of the structure since the 2010 study.

Table 7 Review of short list options presented in Mott McDonald (2010)

Mott McDonald short list options (2010)	Description	Cost	Comments
<p>Foulney Embankment: Option 1 – Rehabilitation and strengthen the Foulney Embankment</p>	<p>The rehabilitation and strengthening of the Foulney Embankment would involve using the existing embankment rock bund as the base for the upgraded structure. The upgraded structure would follow the same alignment as the existing Foulney. The crest and toe of the upgraded embankment would be protected from scour and wave attack with rock armour. The crest height of the existing Foulney Embankment is approximately +4.8 mOD, except for where the embankment has failed. Therefore, a crest height of +4.8 mOD was proposed for the upgraded structure which would still allow for the over flow of water at high tide. The upgraded embankment utilises a front slope of 1 in 1.5 to minimise the footprint of the structure.</p>	<p>Cost estimates indicate that the rehabilitation and strengthening of the existing Foulney Embankment would cost approximately £2,820 per m. In 2010 the length of the embankment requiring renovation was approximately 640 m, and so it was expected that this option would cost in the order of £1.8 million.</p> <p>However, it has deteriorated further over the last 8 years and so allowing for about 20% additional length of repairs the cost would be about £2.2 million in 2010 prices.</p>	<p>This option has been considered in 11c13.3 as the Foulney Embankment gives protection to both Rampside and Roa Island.</p> <p>The Mott MacDonald study recommends computer modelling studies to better understand the nearshore wave climate. The Foulney Embankment controls the strong tidal flows and is fundamental to sediment transport and the stability of saltmarshes and tidal flats in the vicinity. It is therefore considered that tidal flow modelling may also be required.</p> <p>This option would restore the embankment to former functionality and avoid potentially significant changes under a Do nothing option.</p>
<p>Foulney Embankment: Option 2 – Habitat creation and realignment of Foulney Embankment (to 4.5 mOD)</p>	<p>In this option, a replacement embankment is proposed to link the landfall of the Shorelink causeway on Roa Island with Foulney.</p> <p>The present Foulney Embankment is already breaching in more than 16 places. Under Option 2, the existing Foulney Embankment would be fully breached in two places following the construction of the replacement embankment, this would allow the steady supply of tidal waters, sediment and seed to enter the newly enclosed area and would encourage the development of saltmarsh. The new embankment would be constructed with land based plant using the ‘end tipping’ method. The core would be constructed using quarry run and then covered with rock underlayer. The front face of the structure would be protected from wave attack with armour stone units placed in two layers. Mean high water springs is +4.45 mOD, therefore a crest height of +4.5 m has been utilised.</p>	<p>Price estimates provided indicate that the construction of a new embankment would cost approximately £4,930 /m. Given that the length of the new embankment is approximately 533 m, it is expected that this option would cost in the order of £2,627,690 in total.</p> <p>However, If Option 2 was implemented, the need to provide flood defence and coastal protection to the eastern side of the Roa Island Shorelink would be reduced.</p>	<p>Under this option 15 ha of tidal mud or sand flat in the bay between Foulney Embankment and Roa Island causeway could be converted to saltmarsh by realigning the landward end of the Foulney Embankment south to Roa Island.</p> <p>Given the importance of the mud and sand flat habitats around Foulney and Roa Island to birds and the especially sensitive habitats highlighted by Natural England in the area including rare eel grass (<i>Zoostera</i>) beds this option would need to be considered very carefully and is unlikely to be viable in the short term.</p>
<p>Roa Island: Option 3 – Raise or Bund the causeway</p>	<p>Two different alternatives have been proposed relating to Option 3.</p>	<p>Cost estimates indicate that the construction of the bund would cost approximately £4,630 /m, while</p>	<p>The aim of the two sub options are to reduce tidal flood risk to the causeway through raised defences as adaptation to sea level rise. Given the current low level of</p>

Mott McDonald short list options (2010)	Description	Cost	Comments
	<p>Option 3a, involves constructing a 1 m high earth bund faced with armour stone on either side of the causeway. Fill would be used to increase the defence level and armour units placed on the outer faces at a 1 in 1.5 slope would dissipate the wave energy and limit overtopping. The sides of the causeway would be steepened to retain the original footprint. However, Option 3a would be subject to a geotechnical stability review.</p> <p>Option 3b, involves raising whole the causeway with fill material by 1 m installation of a new robust facing material in the form of armour stone. The sides of the causeway would be steepened to retain the original footprint. However, this would be subject to a geotechnical stability review. Option 3b would also require the reinstatement of the causeway road at the higher level along any buried services that are potentially located in the road verge.</p> <p>Both options would also require the construction of 1 m flood walls (to c. 7.55 m) at the neck of the island to prevent water ponding at the northern end of the island where the existing ground level is the lowest.</p> <p>In the 2003 ABPmer report two options were considered for the raising of the Shorelink in order to reduce overtopping; firstly, at a level of 0.5 m and secondly to a level of 1 m. These options were discarded owing to the increased expenditure necessary in order to raise the level of the Shorelink over installation of pre cast concrete flood walls. With new sea level rise guidance, the proposal to raise this level by 0.5 m for a 100 year design life is no longer a feasible option and thus has not been re considered in this 2010 review.</p>	<p>raising the causeway would cost approximately £7,300 /m. Given that the length of the new embankment is approximately 800 m, it is expected that Option 3a would cost in the order of £3,704,000 in total and Option 3b would cost in the order of £5,840,000.</p> <p>Along with the cost of constructing the bund or raising the causeway, an additional £229,500 must be included in both options for wing walls at the neck (northern end) of the island.</p>	<p>risk to traffic disruption it is not expected that this work would be required until the medium or long term epochs.</p> <p>The Do nothing scenario for the economic assessment for the Mott MacDonald study assumes that the causeway is the weak link and that once the defences fail and the causeway is breached the assets on the island would all be effectively lost to erosion as the access is cut.</p>
<p>Roa Island: Option 4 – Construction of flood walls around the Shorelink</p>	<p>Option 4 involves the construction of flood walls along the Shorelink. Three potential different flood wall options have been identified and described below</p> <p>Option 4a involves the construction of two 0.75 m flood walls on top of the existing Shorelink along with the construction of 0.9 m flood walls at the neck (northern end) of the island to prevent water ponding at the northern end of the island.</p>	<p>Cost estimates indicate that the construction of the following flood wall options would cost approximately:</p> <p>Option 4a - £1,310/m</p> <p>Option 4b - £1,700/m</p>	<p>The aim of these two sub options are to reduce tidal flood risk to the causeway through raised defences as adaptation to sea level rise. Given the current low level of risk to traffic disruption it is not expected that this work would be required until the medium or long term epochs.</p>

Mott McDonald short list options (2010)	Description	Cost	Comments
	<p>Option 4b (see Figure 10) involves the construction of two 1.2 m flood walls on top of the existing causeway and construction of (same level, so 1.35 m) flood walls at the neck (northern end) of the island to prevent water ponding at the northern end of the island.</p> <p>Option 4c (see Figure 11) involves construction of two 1.2 m mass concrete flood walls on top of the existing causeway and construction of 1.35 m flood walls at the northern end of the island to prevent water ponding at the neck (northern end) of the island.</p>	<p>Option 4c - £1,320/m</p> <p>Facing on the revetment - £1,231/m</p> <p>Considering the average length of the flood walls on either side of the causeway is 935 m, the approximate total cost of the different flood wall options will be as follows:</p> <p>Option 4a - £1,224,850</p> <p>Option 4b - £1,589,500</p> <p>Option 4c - £1,234,200</p> <p>The construction of the flood wall along the Shorelink will need to include the construction of facing in order to provide protection to the existing revetment. The cost of the facing is £500,000 for the east side of the Shorelink owing to the west side recently undergoing maintenance.</p>	
<p>Roa Island Defences: Option 5 – Construction of rock armour revetment along the eastern and western flanks of the island.</p>	<p>Option 5 involves the construction of rock armour revetments along the eastern and western flanks of the Island to replace the aging, failing defences. On the western flank a 120 m long revetment would run from the slipway south to the Watch Tower. On the eastern flank a 222 m long revetment would run from the neck of the island to the slipway at Foulney Street. the revetment would have a crest height of +7.2 mOD to tie into the existing ground level and a front slope of 1 in 2 to dissipate wave energy.</p>	<p>Cost estimates indicate that the construction of the rock armour revetment would cost approximately £2,000 /m. Given that the total length of the both revetments is 342 m, it is expected that Option 5 would cost in the order of £684,000 in total.</p>	<p>This option allows for improving the aging defences along about 340 m of the shoreline. Further, similar works would be required in future for the southern part of the island between the Watchtower and Foulney Street slipway, about 350 m.</p>

2.6.3 11c13.4 - Discussion

The Mott MacDonald (2010) study reviewed overall lifetime costs and benefits for sustaining the defences and confirmed that the SMP policy remained appropriate (see Table 9). Their economic appraisal indicated an overall benefit cost ratio of 1.6 to 2.8 depending on the options considered. The appraisal recognised that there were additional benefits not mentioned in the high level economic review in the SMP which showed a BCR of just below 1, including the RNL station which cost £2.6 million when built in 2000 and would cost significantly more to relocate.

Mott McDonald (2010) highlighted the importance of the Foulney Embankment and considered costs for its refurbishment in the overall benefit cost analysis for Roa Island, which gave a lower bound BCR of 1.6. The appraisal for the adjacent Rampside policy unit in section 2.5 above recognises that there are shared benefits for the embankment, strengthening the case for repairing it.

The strategic environmental assessment indicated that Option 1, rehabilitation of the Foulney Embankment alongside maintaining defences to the island and causeway met the most objectives. Natural England has, during consultation on this strategy, highlighted that there are especially sensitive habitats in the intertidal zone near Roa Island that need careful consideration during development of options to implement the long term Hold the line policy.

A number of further investigations were suggested by Mott Macdonald:

- **Geotechnical Investigation** – composition and stability of the Shorelink Causeway would improve the understanding and likely failure mechanism of the structure.
- **Wave Model** – in order to develop detailed design of any of the proposed management options, an understanding of the wave climate is required. A numerical wave modelling study is required to establish the design conditions.
- **Environmental and Ecology** – Japanese knotweed was identified on the site, this requires further investigation and treatment prior to any works commencing on site.

In addition, due to the environmental sensitivity of the intertidal habitats it is considered that modelling of tidal flows and geomorphological studies would be required to better understand the Do nothing consequences to the coastal processes and intertidal habitats as the Foulney Embankment deteriorates and fails and consider options to manage the embankment in future consultation with the Cumbria Wildlife Trust.

During options stage engagement Natural England suggested that there could be conservation benefits under a Do nothing scenario and potential disconnection between Foulney and the Roa Island Causeway if it reduced predator access to Foulney using the embankment as this has negative effects on the breeding success of the bird colony on Foulney managed by Cumbria Wildlife Trust. However, it is noted the whole foreshore area is intertidal and accessible at most stages of the tide irrespective of the low rock embankment which only has an impact at high tide. Further consultation with Natural England and Cumbria Wildlife Trust is therefore recommended to fully understand their concerns.

Table 8 11c13.4 Summary of economics, taken from Mott McDonald (2010).

Scheme	Design Life	Capital Works year applied	Capital Cost (cash 2018)	Present Value (PV)
				Total cost with Optimism Bias (PV(OB)c)
	Year	Year	£m	£m
Scheme 1 is based on a flood wall 0.75m in height along the causeway and a revetment on the Island (Option 4 and Option 5).	100	5	3.08	3.35
Scheme 2 is based on a flood wall 0.75m in height along the causeway, a revetment on the Island and a new embankment constructed to Foulney Island (Option 4, Option 5 and Option 2).	100	5	5.02	5.46
Scheme 3 is based on a flood wall 0.75m in height along the causeway, a revetment on the Island and an upgrade to the present embankment (Option 4, Option 5 and Option 1).	100	5	5.39	5.87

	Total losses (£k)	PV losses (£k) in year 5	PV losses (£k) in year 10	PV losses (£k) in year 20
Properties	8,639.54	7229.82	6050.12	4236.79
Infrastructure	100	83.68	70.03	49.04
Total	8739.54	7313.50	6120.15	4285.83

Scheme	1	2	3
Total Cash Cost (£k)	2408.85	3924.12	4213.65
Total PV Cost (£k) including OB	2,620.53	4,268.96	4,583.93
Benefit – Cost Ratio	2.79	1.71	1.60

2.6.4 11c13.4 - Strategic way forward

In the short term the preferred strategic approach is to implement the SMP Hold the line. There are various options (options 3 or 4 for the causeway and 5 for defences on the Island) that would maintain the standard of defence into the long term, but further studies are required, particularly regarding defence of the causeway, due to foundation issues, and the impact of the deterioration of the Foulney Embankment resulting in additional exposure and habitat changes.

Therefore in the immediate term, ongoing maintenance of the defences would be required until a decision can be made on the best approach going forward. A whole coast approach is required to manage the flood and coastal risks, as the approach taken here will also depend upon the future management of the Foulney Embankment.

The following activities are recommended in the future:

- Monitoring of coastal process and asset condition, with asset inspections extended to include Foulney Embankment (included in 11c13.3).
- Minor maintenance and repairs to existing defences as required.
- Further studies required to confirm long-term approach to management of Foulney Embankment.

Further details on actions and responsibilities are provided in the **Action Plan**.

3 Appraisal of non priority units

There are two additional units within this area, which have been defined as non priority units:

- 11c13.1 Bardsea to Newbiggin
- 11c13.5 Piel Island

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

3.1 11c13.1 Bardsea to Newbiggin

3.1.1 11c13.1 - Existing approach to flood and coastal erosion risk management

The SMP2 policy for this frontage is No active intervention from the short term. There are limited defences present, and the SMP policy allows the natural processes to continue. However private defences may be permitted subject to consent. There are limited assets at risk therefore the SMP found that shoreline defences cannot be justified on an economic basis. No active intervention will result in naturally functioning sustainable coastline. Erosion of the low cliffs will provide sediment to the upper foreshore on the down drift frontages.

The locations of defences on this frontage is shown in Figure 18 and their condition is described below, based on the latest coastal walkover inspections by CH2M (2018b).

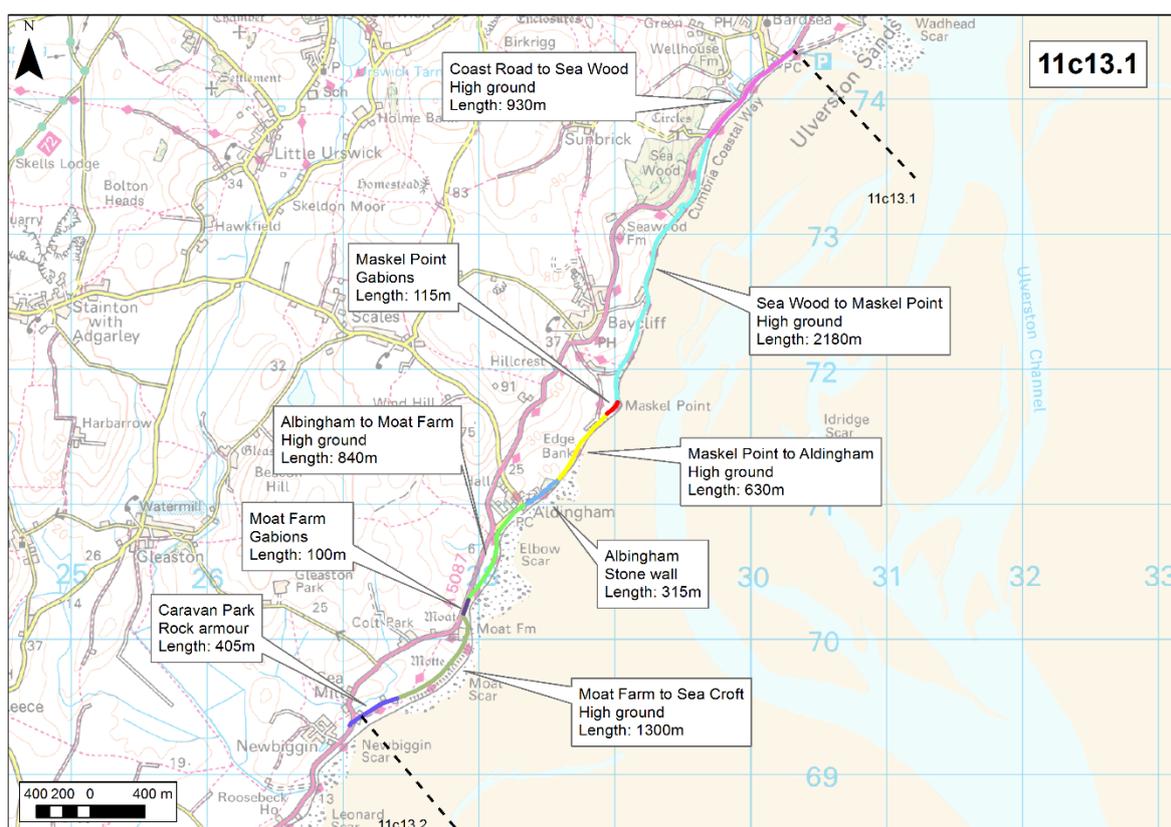


Figure 17 Policy unit location plans and defence overview for 11c13.1 Baseline mapping © Crown copyright and database rights, 2019. Ordnance Survey licence number: 1000019596.

Coast Road to Sea Wood – 930 m – categorised as high ground and in poor condition. The shoreline has a shallow slope, with shingle upper beach providing limited protection to the adjacent road. There has been growth of saltmarsh and in recent years reedbed along the backshore of this frontage.

Sea Wood to Maskel Point – 2176 m – The upper intertidal zone consists of vegetated salt marsh and reed beds. The vegetation will help dissipate wave and tidal action, providing an element of natural protection to the slowly eroding cliffs (Figure 19) (CH2M, 2018b).



Figure 18 Coast Road to Sea Wood and Sea Wood to Maskel Point. Asset photographs taken from CH2M (2018b). 2015 Aerial photograph © North West Regional Monitoring Programme.

Maskel Point – 114 m – private defence consisting of a man-made coastal revetment, cobble or boulders on the slope and gabion situated on the crest. Overall condition of the structure is fair, a residual life of 10 to 20 years. The gabions on the crest have failed, with a substantial loss of stone and failure of wire gabion (see Figure 20).

Maskel Point to Aldingham - 445 m – private natural shoreline comprising of shingle and cobbles. The cliffs are comprised of unconsolidated material and susceptible to erosion (CH2M, 2018b).



Figure 19 Maskel Point and Maskel Point to Aldingham

Aldingham – 314 m – South Lakes District Council owned revetment and private stone vertical wall: overall condition fair with a residual life of 10 to 20 years. The exposed face and crest of both sloped and vertical walls are in a good condition, with only some missing mortar visible. There is a timber groyne which is in poor condition, with nearly all planks missing. evidence of scour at the toe of the vertical wall.

Aldingham to Moat Farm – 840 m – Natural shoreline categorised as eroding high ground with shingle upper beach and timber groynes in poor condition (CH2M, 2018b). There is a culverted outfall discharging to the beach near Ladycroft Cottage that occasionally becomes blocked with beach material, and has caused flooding of the A5087 road on an annual basis.



Figure 20 Aldingham and Aldingham to Moat Farm. Taken from CH2M (2018b).

Moat Farm – 105 m – Cumbria County Council gabion retaining wall to A5087 coast road in good condition, residual life estimate for the defence is 10 to 20 years.

Caravan Park – 405 m – private rock revetment in a poor condition, residual life estimate of 10 to 20 years (Figure 22). Noted that the armour tapers out at the northern end with individually placed rocks providing limited protection. At the southern end of the asset where it joins with the revetment protecting the road there is a good, 2 layer thickness (CH2M, 2018b).



Figure 21 11c13.1 Caravan Park. Taken from CH2M (2018b).

3.1.2 11c13.1 - Strategy considerations

The frontage is characterised by rising land, such that the key risk is from erosion of the boulder clay cliffs. These are interposed by areas of low lying land. Much of the frontage is unprotected, but defences exist in locations and are in a variable condition. Where unprotected the boulder clay cliffs are experiencing noticeable erosion. The hinterland includes large tracts of agricultural land and farmsteads, interspersed with small communities. Both Newbiggin and Aldingham lie close to the coast and are therefore at potential risk from erosion. The A5087 Coast Road runs close to the coast through this policy unit and is a busy alternative route to the A590 between Ulverston and Barrow as well as linking villages and towns on the Furness Peninsula. Defences along the road protect a number of properties and caravan parks in close proximity to the beach. Between Newbiggin and Aldingham there are also United Utility Assets within the road.

Moat Hill, a 12th or 13th century motte and bailey castle, is a scheduled monument on the coast between Newbiggin and Aldingham. The seaward side of the castle and earlier ringwork has been partially destroyed by coastal erosion and is at risk of further coastal erosion in the future. There are also a number of listed properties at Aldingham.

The intertidal zone is nationally and internationally designated due to its importance for coastal habitats and birds, supporting a wide range of habitats and qualifying species. This includes Morecambe Bay and Duddon Estuary SPA, Morecambe Bay SAC, Ramsar and SSSI. The SSSI is currently in favourable condition (latest assessment in 2010) although constraints imposed by defences is noted in the last assessment. Sea Wood SSSI lies between Bardsea and Baycliff and extends to the cliff edge. This is designated for its broadleaved, mixed and yew woodland.

Natural England is working on proposals to improve public access along this coast but as yet the route is undefined.

There are localised combined tidal and fluvial flooding issues, for example where a culvert of Aldingham Beck enters Morecambe Bay at Ladycroft Cottages.

Beach profile monitoring indicates varying behaviour in different parts of this frontage over the past 10 years, mainly related to tidal channel migration and the varying level of shelter provided to different parts of the shoreline by offshore scars, ridges and islands (CH2M, 2018a). Between Bardsea and Aldingham, there has been modest vertical accretion across the upper saltmarsh or sandflats but considerable erosion of the lower sandflats as the tidal channel has moved progressively shorewards over the past 5 years. The greatest change has been observed at Aldingham where the cross shore width of the sandflats at mean sea level reduced from 2700 m to 1000 m between 2007 and 2016.

Further south, the SMP2 (Halcrow, 2011) reported a gradual net landward retreat of mean high water between Aldingham and Rampside over the last 150 years, however, beach profile monitoring in the last decade has indicated a recent change in this trend (CH2M, 2018a).

3.1.3 11c13.1 - Discussion

Given the assets at risk, there is currently no justification for any change in policy therefore, the recommendation would be for the policy to remain, assuming this enables works to be undertaken to maintain short stretches of defences, subject to consent. A study has previously been undertaken into the road flooding problem near Ladycroft cottages and a solution of opening the culvert up has been proposed with estimated costs of around £150 k.

3.1.4 11c13.1 – Strategic way forward

The proposed strategic approach is to implement the SMP policy through a Do nothing approach for majority of frontage, with localised hold the line at existing coastal defence locations to protect existing infrastructure and properties. The need for short term erosion slowing defences at Moat Farm Scheduled Monument should be considered with Historic England in order to allow time for recording.

Future recommended activities include:

- Continued monitoring of shoreline change, as part of the North West Regional Monitoring Programme, to identify any changes in observed trends and any possible increase in risk level. At this stage it is not thought necessary to add any additional profiles.
- Continued inspection and maintenance of the existing structures, with repairs and remedial works undertaken as necessary. Any modification to or replacement of the existing structures would also require consent from Natural England due to the designation of the intertidal zone and a scheme level HRA and AA may need to be undertaken.
- Seek funding for works to open up the Ladycroft cottage culvert to reduce flood risk to the A5087.
- Safe siting of the England Coast Path; Natural England is working on proposals to improve public access to the coast between Silecroft and Silverdale, which includes this section. (see <https://www.gov.uk/government/publications/england-coast-path-in-the-north-west-of-england>).
- Impacts of ongoing erosion on the Scheduled Monument at Moat Farm to be considered by Historic England and appropriate mitigation (such as recording before loss) to be identified and undertaken.

3.2 11c13.5 Piel Island

3.2.1 11c13.5 - Existing approach to flood and coastal erosion risk management

At Piel Island (11c13.5) the SMP policy is No active intervention in all three epochs although the policy allows for localised defences, e.g. to manage risk to the castle ruins, subject to consent. There are existing defences that give some erosion protection to the east side of the island between the slipway and the castle.

The defences at Piel Castle, which is a Scheduled Monument, are managed by Historic England. The original defence was grouted stone with poured concrete repairs. Some sections were replaced with gabions in the late 1980s. The Capita (2016) inspection categorised the overall defence condition as Poor.



Figure 22 Piel Island. 2015 aerial photograph © North West Regional Monitoring Programme.

3.2.2 11c13.5 - Strategy considerations

The intertidal zone is nationally and internationally designated due to its importance for coastal habitats and birds, supporting a wide range of habitats and qualifying species. This includes Morecambe Bay and Duddon Estuary SPA, Morecambe Bay SAC, Ramsar and SSSI, and South Walney and Piel Channel Flats SSSI. These designations extend across the whole of Piel Island which forms part of the SSSI.

Piel Island has a significant heritage value and its amenity and cultural value is of considerable importance in the local area. In addition to the Scheduled Monument of Piel Castle, there is a high potential for buried archaeology due to its long history of human occupation. The other key assets on the island are the passenger ferry jetty, which has recently been rebuilt, the Ship Inn, which is over 300 years old and the terrace of former pilot's cottages.

3.2.3 11c13.5 - Discussion

There is no justification for any change in SMP policy, which allow maintenance of existing private defences, therefore, the recommendation would be for the policy to remain.

3.2.4 11c13.5 – Strategic way forward

The proposed strategic approach is to implement the SMP policy through a Do nothing approach for majority of frontage, with localised hold the line at existing coastal defence locations to reduce erosion risk to the heritage assets, subject to funding.

Future activities include:

- Liaison between Barrow Borough Council and Historic England to review requirement for management of defences to Piel Castle Scheduled Monument.
- Monitoring of risk to historical assets, including buried archaeology, and liaison with Historic England to enable sufficient time for recording and, where appropriate, collection of finds.
- Continued inspection and maintenance of the existing structures, including ferry jetty, with repairs and remedial works undertaken as necessary. Any modification to or replacement of the existing structures would also require consent from Natural England due to the designation of the intertidal zone and a scheme level HRA and AA may need to be undertaken.

Further details on actions and responsibilities are provided in the **Action Plan**.

4 Summary of proposed strategy: 11c13

Preferred strategic approach: Environmental enhancement – allow the northern part of the frontage to function as naturally as possible along, with local measures to reduce erosion risk to roads and property, but maintain existing defences to the A5087 along the southern frontage, recognising this as a more cost effective approach to managing this critical infrastructure.

		Next 10 years	Beyond 10 years
11c13.1	Bardsea to Newbiggin	Allow area to function as naturally as possible, but with maintenance of localised defences to protect infrastructure and properties.	
11c13.2	Newbiggin to Rampside	Maintain defences to A5087 coast road. Repair damage to poor condition defences as required.	Maintain and upgrade defences to A5087 strategic transport link and hinterland assets, including coastal communities.
11c13.3	Rampside	Monitor saltmarsh and deterioration of Foulney Embankment, with minor works undertaken to retain existing defences as required.	Continue to monitor risk of flooding and erosion to Rampside, consider need for works to upgrade existing defences should risks increase.
11c13.4	Roa Island	Maintain and repair existing defences to causeway and Roa Island, whilst longer term solutions are sought.	Maintain defences on the island and causeway. Review need to refurbish Foulney Embankment.
11c13.5	Piel Island	Allow area to function as naturally as possible, whilst allowing for local defences to protect shoreline assets such as Piel Castle to be maintained.	

Key actions and activities (next 10 years):



- Monitor condition of defences.
- Monitor marsh and intertidal change.
- Monitoring of risk to historical assets at Moat Farm Castle and Piel Castle Scheduled monuments.



- Proactive maintenance and repairs to degradation/damage to defence assets if required.



- Studies and landowner consultation for habitat creation needed to mitigate habitat loss in defence footprints as part of strategic habitat compensation plan
- Further studies required to confirm long-term approach to management of Foulney Embankment, after 5-years monitoring.



- Review risks of ongoing erosion on the Scheduled Monument at Moat Farm and consider the need for erosion slowing temporary defences and recording and investigations before loss.



- Seek funding for scheme to open up the Ladycroft cottage culvert to reduce flood risk to the A5087.



- Liaison between stakeholders regarding needs for local defence management.
- Identification of works required for poor condition defences to A5087.

Further details on actions and responsibilities are provided in the **Action Plan**.

5 References

ABPmer (2003) Roa Island Shorelink: Sustainability Study

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