



11e2 Whitehaven to Workington

(Technical report by Jacobs)

Policy area: 11e2 Whitehaven to Workington

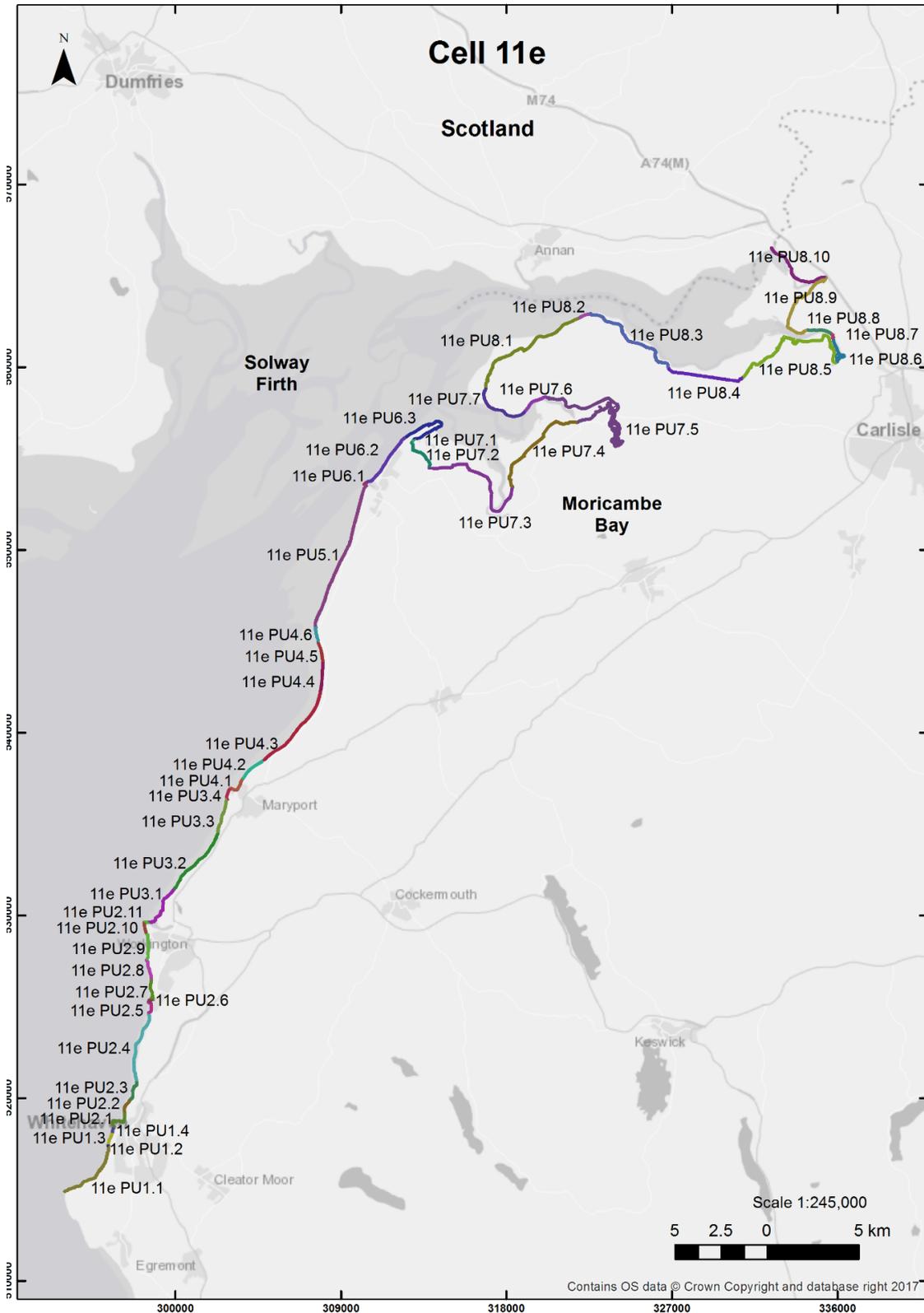


Figure 1 Sub Cell 11e St Bees Head to Scottish Border Location Plan of policy units. Baseline mapping © Ordnance Survey; licence number 100026791.

1 Introduction

1.1 Location and site description

<p>Policy units:</p>	<p>11e2.1 Whitehaven harbour and north beach</p> <p>11e2.2 Bransty to Parton (priority unit)</p> <p>11e2.3 Parton (priority unit)</p> <p>11e2.4 Parton to Harrington Parks (priority unit)</p> <p>11e2.5 Harrington Parks to Harrington Harbour (priority unit)</p> <p>11e2.6 Harrington Harbour</p> <p>11e2.7 Harrington to Steel Works Site (priority unit)</p> <p>11e2.8 Steel Works Site (priority unit)</p> <p>11e2.9 Steel Works to The Howe (priority unit)</p> <p>11e2.10 The Howe to Workington Harbour south breakwater (priority unit)</p> <p>11e2.11 Workington Harbour</p>
<p>Responsibility:</p>	<p>Copeland Borough Council (northern boundary near Copperas Hill)</p> <p>Allerdale Borough Council</p> <p>Network Rail</p> <p>Whitehaven Harbour Commissioners</p> <p>Harrington Harbour and Dock Board</p> <p>Port of Workington (Cumbria County Council)</p>
<p>Location:</p>	<p>This unit (see Figure 1) stretches along the open coastline between Whitehaven Harbour and Workington Harbour and includes the settlements of Whitehaven (including Bransty), Parton, Harrington (including Harrington Harbour) and Workington.</p>
<p>Site overview:</p>	<p>The shoreline is characterised by till cliffs, artificial cliffs cut into dumped spoil and colliery waste deposits and railway embankments which run along the shoreline. The beaches commonly comprise boulder beds and coarse sediments (interspersed with outcropping bedrock) and pockets of sand deposits (found on lower parts of the foreshore such as at Parton Bay (to the north of Whitehaven and Harrington Harbours). At Providence Bay, gravel and sand deposits surround the mouth of the river Lowca Beck. In some locations, there are also hardened slag deposits on the foreshore. There is very little fresh input of sediment to the coast and any that is deposited along the coast tends to be driven northwards, although the harbours, together other promontories and structures, trap some of this sediment resulting in pockets of sediment building up.</p> <p>There are several settlements within this policy area: Whitehaven (including Bransty), Parton, Harrington, Workington (including Salterbeck), with the harbours and marinas representing important centres of commerce and recreation. Key industries supported by the area are: power generation, agriculture, fishing, recreation and tourism.</p> <p>The Cumbrian Coast Line railway runs parallel, immediately adjacent to the coastline throughout the area and is an important connective link between the various towns and villages. It provides an hourly passenger service to Carlisle and Whitehaven and carries weekly volumes of freight to the Port of Workington. The main roads lie further inland.</p>

	There are no land-based sites of designated national or international importance within this policy area, but the coastline has high historical value, and includes scheduled monuments of old quay and lighthouse within Whitehaven Harbour, Whitehaven Old Fort and Parton Roman Fort. Sections of the adopted England Coast Path run in front of the railway line, namely along Parton frontage and between Harrington and Salterbeck. Solway Firth pSPA, covers the nearshore zone and is designated to protect rare, vulnerable and migratory birds.
--	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

1.2 Current SMP policy

The policy details for the whole policy area are shown in Table 1, taken directly from the SMP, (Halcrow, 2011); non priority units have been greyed out.

Due to development of the former Corus site, there may be a requirement to change the boundary of SMP policy units 11e2.8 and 11e2.9.

Table 1 Current SMP Policy for policy area 11e2

Overview: *The towns of Workington and Whitehaven are key regional centres and therefore, continued flood and erosion risk management to these towns forms the basis of the long term SMP vision for this area. Assuming the railway is going to remain operational then the long term plan will be to maintain it in its current position and continue to afford defence to it. However, if the railway does not remain, then the long term plan would be to not continue to maintain those defences. However, even walking away would not enable a 'naturally' functioning coast as the debris from existing structures would take decades to disperse. Some localised defences may be permissible e.g. at Harrington Parks, however, neither long term approach will be compromised by a short term (present day) policy to continue maintaining existing defences. Localised policies at Harrington Parks, The Howe and south of Workington Harbour will provide some sediment input, from cliff erosion, to local beaches and adjacent frontages. The SMP policies manage risks to existing commercial, residential and community assets thus achieving the social objectives, whilst the environmental objectives can be addressed by allowing the areas of natural coast, and disused industrial areas, to erode to facilitate localised natural roll back of the shoreline and provide sediment to neighbouring frontages, unless the erosion poses a contamination risk.*

Location		Policy and Approach (from 2010)		
		0-20 years	20-50 years	50-100 years
11e2.1	Whitehaven Harbour and north beach	Hold the line – By maintaining harbour walls and gates assumes harbour remains operational, maintain or extend rock revetment to railway.	Hold the line – By maintaining or upgrading harbour defences, harbour gates and rock revetment assumes harbour remains operational.	Hold the line – By maintaining or upgrading harbour defences, harbour gates and rock revetment assumes harbour remains operational.
11e2.2	Bransty to Parton	Hold the line - By maintaining or upgrading railway defences.	Hold the line - By maintaining or upgrading railway defences.	Hold the line - By maintaining or upgrading railway defences.
11e2.3	Parton	Hold the line - By maintaining or upgrading railway defences by maintaining rock revetment.	Hold the line - By maintaining or upgrading railway defences and by maintaining or upgrading rock armour defences, possible addition of local flood wall or embankment.	Hold the line - By maintaining or upgrading railway defences
11e2.4	Parton to Harrington Parks	Hold the line - By maintaining or upgrading railway defences.	Hold the line - By maintaining or upgrading rock armour defences, possible addition of local flood wall or embankment.	Hold the line - By maintaining or upgrading defences.
11e2.5	Harrington Parks to Harrington Harbour	Hold the line – By maintaining defences due to potentially contaminated land.	No active intervention – By ceasing maintenance of defences and allowing defences to fail and returning	No active intervention – No defences, allow natural evolution of shoreline up drift of harbour breakwater.

		Undertake study to confirm policy in longer term.	to more naturally evolving coast, dependent on outcome of study undertaken in the short term.	
11e2.6	Harrington Harbour	Hold the line – By maintaining harbour walls – assumes harbour remains operational.	Hold the line – By maintaining or upgrading harbour walls – assumes harbour remains operational and can afford improvements.	Hold the line – By maintaining or upgrading harbour walls – assumes harbour remains operational and can afford improvements.
11e2.7	Harrington to Steel Works Site	Hold the line – By doing nothing until railway at risk, then construct railway defences.	Hold the line - By maintaining or upgrading defences.	Hold the line - By maintaining or upgrading defences.
11e2.8	Steel Works Site	Hold the line - By maintaining or upgrading seawall and revetment including site developer extension and upgrades to defences.	Hold the line – By maintaining, upgrading or extending seawall and revetments, as necessary to reduce risk to the redeveloped site.	Hold the line – By maintaining, upgrading or extending seawall and revetments. – assumes as necessary to reduce risk to the redeveloped site.
11e2.9	Steel Works to The Howe	No active intervention - Allow continued erosion of shoreline.	No active intervention - Allow return to naturally functioning coast.	No active intervention - Allow return to naturally functioning coast.
11e2.10	The Howe to Workington Harbour south breakwater	Managed realignment – By allowing defences to fail and cliffs to form.	Managed realignment – Allow erosion until assets at risk or contaminated land justifies defences.	Managed realignment – Allow erosion until assets at risk or contaminated land justifies defences.
11e2.11	Workington Harbour	Hold the line – By maintaining harbour flood defence walls – assumes harbour remains operational.	Hold the line – By maintaining upgrading harbour flood defence walls and Isabella Road embankment – assumes harbour remains operational and improvements affordable.	Hold the line – By maintaining upgrading harbour defences – assumes harbour remains operational.

2 Appraisal of priority units

Eight units within this area have been defined as priority units:

- 11e2.2 Bransty to Parton
- 11e2.3 Parton
- 11e2.4 Parton to Harrington Parks
- 11e2.5 Harrington Parks to Harrington Harbour
- 11e2.7 Harrington to Steel Works Site
- 11e2.8 Steel Works Site
- 11e2.9 Steel Works to The Howe
- 11e2.10 The Howe to Workington Harbour south breakwater

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 these priority units. The primary justifications for the policies at the SMP level were:

- **Social:** For policy units 11e2.2, 11e2.3, 11e2.4 and 11e2.7 the key justification for holding the line was managing risk to the railway. Similarly, at 11e2.6 and 11e2.11 maintaining the integrity of Harrington and Workington Harbours was a key driver.
- **Environmental:** There were no adverse impacts on designated conservation sites (adjacent to this area) recognised, but Hold the line policies would manage risks to the scheduled monument of Parton Roman Fort. Potential contamination was a recognised risk, requiring further investigation, particularly at policy unit 11e2.5, the site of the former Harrington Iron Works, followed by the wartime magnesite plant.¹
- **Economic:** The economic viability of long term Hold the line policies along the railway frontages of 11e2.2, 11e2.3, 11e2.4 and 11e2.7 was recognised as being dependent upon benefits from the railway and heritage assets along the coast. At 11e2.7, economic viability was based on value of assets at risk, whilst at 11e2.6 economic viability of the policy required additional non quantified commercial and amenity benefits of harbour use.

2.1.2 Current defences

Based upon the most recent asset inspections (CH2M, 2017) undertaken as part of the North West Regional Monitoring Programme, the condition of the existing defences ranges from Poor (4) to Good (2), with sections of undefended artificial and natural cliff.

Table 2 provides a summary of the condition and estimate residual life for the various defence structures, whilst the following text provides further detail regarding current condition and recent management, based upon information taken from the most recent asset inspection report (CH2M, 2017a) and previous inspection reports by Coastal Engineering UK and Capita Symonds (reported in CH2M, 2017a). No specific design details have been obtained for this frontage.

¹ <http://www.users.globalnet.co.uk/~rwbarnesdefencemagnesit.htm>

Figure 2 shows policy units, together with a summary of defence lengths between Whitehaven and Workington.

Table 2 Existing defence condition and estimated residual life

Unit	Location	EA Asset Ref	Defence Type	Condition	Residual Life (years)
11e2.2	Whitehaven North Beach to Redness Point	011KE90390101C04	Vertical Masonry seawall	Fair (3)	20-50
11e2.2	Redness Point to Parton	011KE90390101C05	Vertical Masonry wall, some sections with added toe protection	Fair (3)	20-50
11e2.2 11e2.3	Parton	011KE90400101C01	Rock revetment	Fair (3)	20-50
11e2.3	Parton	011KE90400101C02	Rock revetment	Fair (3)	20-50
11e2.5	Copperas Hill South	011KE90400301C02	Masonry Wall	Poor (4)	10-20
11e2.5	Copperas Hill	011KE90400301C03	Man-made cliff with timber groynes	Fair (3)	20-50
11e2.5	Bellaport Marina South	011KE90410101C01	Vertical seawall and sloping revetment	Poor (4)	10-20
11e2.5	Bellaport Marina North	011KE90410101C07	Vertical seawall and sloping revetment, gabion baskets and rock protection	Poor (4)	10-20
11e2.6	Harrington Harbour	011KE90410101C03	Vertical quay wall	Fair (3)	20-50
11e2.6	Harrington Harbour	011KE90410101C04	Vertical quay wall	Fair (3)	20-50
11e2.6	Harrington North Pier	011KE90410101C05	Rock breakwater	Good (2)	20-50
11e2.6	Harrington South Pier	011KE90410101C08	Vertical masonry wall	Fair (3)	10-20
11e2.6	Harrington Harbour	011KE90410101C09	Vertical quay wall	Fair (3)	20-50
11e2.7	Harrington Station	011KE90410101C06	Beach	Fair (3)	NA
11e2.7	Salterbeck	011KE90410201C02	Slag embankment	Poor (4)	0-5
11e2.7	Salterbeck North to the Howe	011KE90410301C01	Man-made cliff	Fair (3)	NA
11e2.8	Corus Steelworks 1	011KE90410301C02	Rock armour	Poor (4)	10-20
11e2.8	Corus Steelworks 2	011KE90410301C03	Vertical seawall	Poor (4)	10-20
11e2.8	Corus Steelworks 3	011KE90410301C04	Rock revetment	Fair (3)	10-20
11e2.9	The Howe 1	011KE90410301C06	Rock revetment	Good (2)	10-20
11e2.9	The Howe 2	011KE90410301C08	Rock revetment	Good (2)	10-20
11e2.10	The Howe 3	011KE90410301C10	Rock revetment	Fair (3)	10-20
11e2.11	Workington West South Pier	011KE90410301C11	Rock groyne	Fair (3)	20-50

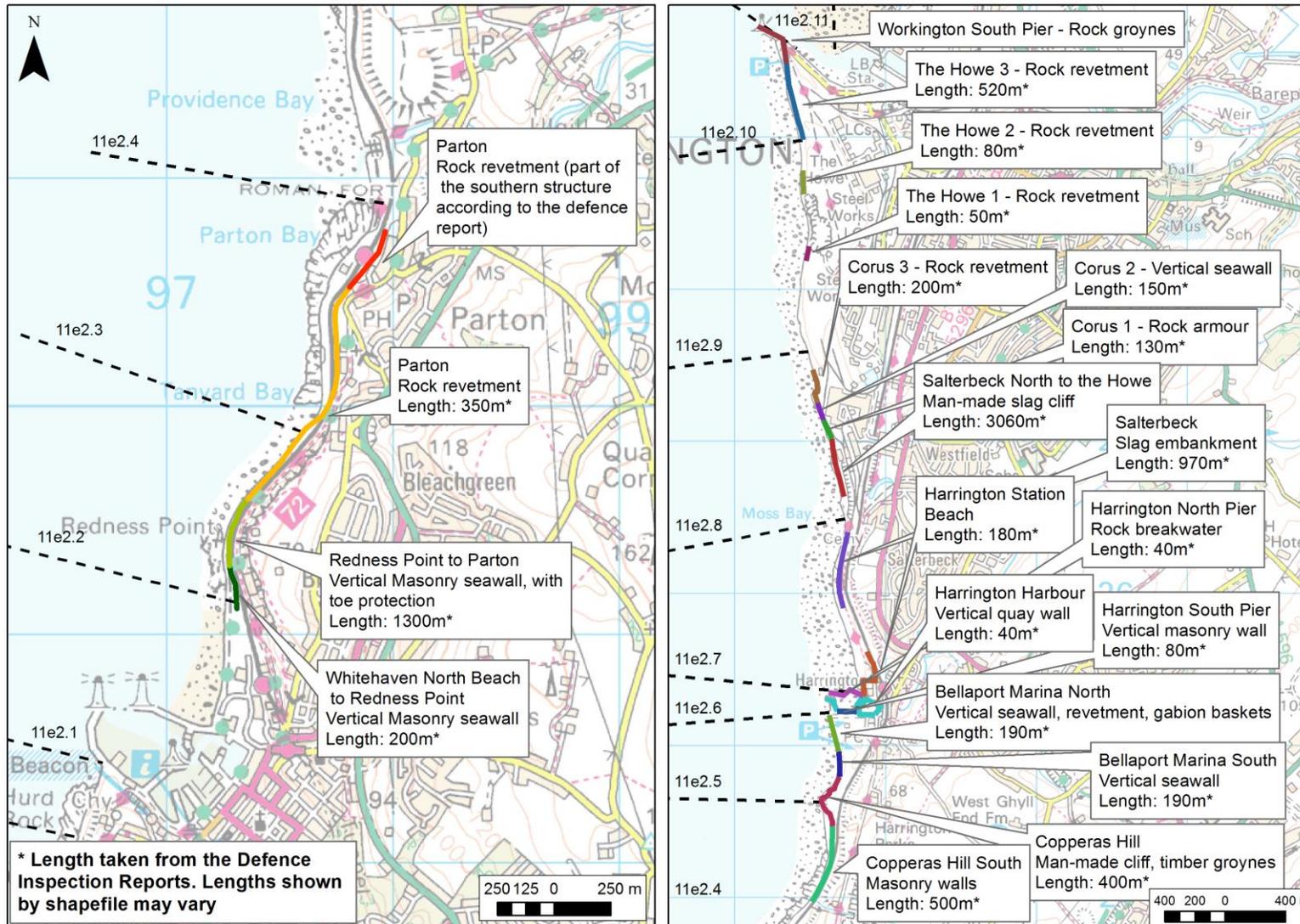


Figure 2 Policy units and summary of defence lengths between Whitehaven and Workington. Note that defences are on the seaward side of the railway. Baseline mapping © Ordnance Survey: licence number 100026791.

Policy unit 11e2.2 (Bransty to Parton)

Whitehaven North Beach to Redness Point: Vertical masonry seawall (200 m) – Network Rail



Figure 3 Vertical seawall between Whitehaven and Redness Point. Photograph taken during CH2M (2017) asset inspection.

Previously there has been observed lowering of the upper beach and movement of informal rocks and boulders, with erosion and slumping of cliff deposits. Minor remedial works were undertaken between 2001 and 2005, and in 2007 an additional concrete apron had been added to the wall at the interface with Redness Point. The grassed bank across the southern end of this frontage suffered erosion due to winter 2013/14 storms, but there had been no noticeable change in the condition of the primary defence wall. There has been no observed change in condition of defences or noticeable erosion of grass bank since, but noticeably less fines on upper beach with greater areas of slag exposed.

Although Network Rail have a management strategy for this frontage, no works appear to have been carried out in relation to this section.

Redness Point to Parton (spans 11e2.2 and 11e2.3): Vertical masonry seawall with toe protection in places (1300 m) – Network Rail



Figure 4 Vertical seawall between Redness Point and Parton. Photograph taken during CH2M (2017) asset inspection.

The primary coastal defence across this frontage is a substantial vertical blockwork wall that interfaces directly with the foreshore. It has been noted that due to the reflective profile of the wall, much of finer sediments have been denuded from the surface of the beach over time, transported away by tidal currents and wave action leaving the coarser boulders and cobbles standing proud on the beach with the remaining finer sediments filling the gaps and voids between the boulders. As these remaining fines are removed the boulders settle further.

A variety of toe constructions had been added over time as levels have dropped. These have provided a function in preventing undermining but generally, due to their impermeable form, have only exacerbated the effects on the beach in front of the defences. By 2007 localised concrete repairs to the toe aprons had been carried out at a couple of locations. By 2010 two sections across the southern half had a new rock armour toe added, but apart from those works there had been no noticeable change in structure condition. Thereafter, whilst there was no noticeable change in structure condition, it was noted that the floor of the northern access tunnel was being undermined, and it is more recently understood that Network Rail have carried out some minor work around the southernmost arch on the north side of Redness Point, where it had been undercut.

Although Network Rail have a management strategy for this frontage, no further works have been carried out since the rock armour toe works in 2010, but it was understood that further work was planned for 2016 and 2017. It is uncertain whether this has been undertaken.

Policy unit 11e2.3 (Parton)

Redness Point to Parton (spans 11e2.2 and 11e2.3): vertical masonry seawall with and without toe protection (1300 m) – Network Rail

See above (11e2.2)

Linear rock revetment (350 m) – Copeland BC

There has been previous erosion at the northern terminal end of the gabion wall which led to localised collapse of the structure at this point. Remedial works to address terminal erosion, comprising addition of further gabion baskets and a concrete apron were carried out at the northern end, but by 2007 localised beach lowering had undermined the apron. Inspection reports in subsequent years have continued to report continuing erosion at the northern end adjacent to the gabion baskets, and by 2012 in the section between the gabions and the slipway some of the rock armour had been dislodged, to the north of the slipway the rock armour and the beach remained stable. The winter storms of 2013 and 2014 reportedly resulted in local overtopping at northern end of armour and damage (undermining and collapse) of terminal gabions. The northern end of gabions was then reinforced with a vertical concrete wall and hardstanding. In 2015, the Environment Agency erected a secondary dwarf wall at southern end to reduce risk of overtopping waters flooding through an arch underneath the railway. There are access issues along this frontage which means that in some area low areas in the rock revetment have not been addressed (Copeland BC, pers comm.).

Policy unit 11e2.4 (Parton to Harrington Parks)

There are no details for most of this unit in annual asset inspection reports. It is understood that Network Rail have recently been undertaking rock revetment works along parts of this frontage.

Parton to Copperas Hill - various defences (approximately 3500-4000 m) – Network Rail (presumed)

The annual inspection reports do not cover the majority of this policy unit, which is presumed to be the responsibility of Network Rail. Oblique aerial photographs show the railway line running beneath the natural cliff and directly at the rear of the foreshore along virtually all this policy unit. In front of the railway line appears to be a mixture of defences, or undefended by eroding scarp edge. At the very southern end, just north of Parton, there is a 500 m length where the railway line is set back behind what might be dunes or tipped spoil.

North of there, oblique photographs shows variable defences, a short length of sloping concrete wall or apron, what might be rock or cobbles perhaps as a former revetment or toe protection to south of this and another short length to north. Further along, in front of the wind turbines, photographs indicate no seawall but some intermittent lengths of rock, but otherwise no protection. Whether the fronting material is natural or tipped slag is unclear, but there is notable erosion and high risk to the railway line being undermined in places. North of here oblique photographs show the whole section protection by either vertical or sloping concrete seawall, with rock revetment or toe protection along much of the length.

It is assumed that Network Rail's frontage management strategy must include this section of coast.

Copperas Hill South: vertical masonry wall with concrete and rock toe protection in places (500 m) – Network Rail

Toe constructions in front of the primary wall have been added in the past at various times due to lowering beach levels. Failure of northern most section of wall occurred in 2006. Most recent rock armour toe was added between 2008 to 2011. In 2014 additional rock toe protection was provided to the section of wall adjacent to the borough boundary. Some localised damage – movement of rock had occurred to the previously placed armour stone at the northern end. Elsewhere the defences remain in similar condition to previously.



Figure 5 Vertical seawall along Copperas Hill. Oblique photograph courtesy of North West Monitoring Programme.

Maintenance and management of defences are the responsibility of Network Rail; their management strategy for the Bransty to Harrington frontage is assumed to include this policy unit.

Policy unit 11e2.5 (Harrington Parks to Harrington Harbour)

Copperas Hill: man-made cliff (400 m) – None

Defence is remains of slag tip, subject to ongoing erosion. There has been no significant change in recent years other than some erosion resulting from storms.

Bellaport Marina South - vertical seawall and sloping revetment (190 m) – Allerdale BC

Since at least 2012 the groynes have been having very little effect on beach retention due to general lack of finer sediments on foreshore and poor condition of these groynes. Overtopping of defences was noted during the 2014 winter storms which exacerbated erosion of bank behind. Damage occurred to the upper gabion mattresses at the interface with the adjacent section of frontage. This has since been temporarily sealed with mass concrete. In 2016 a section of gabions at the slipway collapsed, exposing slag behind. Some mortaring up of cracks between upper and lower vertical wall section at the southern end has since been carried out. The current defence management approach is to maintain defences on an as required basis. There appears to be little obvious benefit from maintaining existing groynes.

Bellaport Marina North: vertical seawall, sloping revetment (190 m) – Allerdale BC



Figure 6 Vertical seawall and sloping revetment along Bellaport Marina North. Photograph taken during CH2M (2017) asset inspection.

Groynes are having little effect on beach retention due to general lack of finer sediments on foreshore, and previous inspections had also noted that these groynes were missing timbers. In 2014, overtopping of lower concrete defences occurred during the winter storms and caused damage to the upper gabion mattresses in several places. To address this, some apron slab overlay works have been carried out, but no remedial works to upper gabions has been undertaken.

There was further damage to the upper gabion mattresses in 2015 at the interface with the adjacent section of frontage. Elsewhere some of the sections of gabion mattresses have been partially removed, presumably by wave action. The current defence management approach is to maintain defences on an as required basis. There appears to be little obvious benefit from maintaining existing groynes.

Policy unit 11e2.7: Harrington to Steel Works Site

Harrington Station: none (180 m) – Allerdale BC (transferring to Network Rail?)

Past defence management approach has been to dispose of dredging arisings from adjacent harbour along toe of cliff to supplement natural material and slow erosion of the backing cliffs; this was last carried out in 2014 although by 2016 all deposited material had been eroded.

Salterbeck: man-made earth embankment (970 m) – Cumbria CC (transferring to Network Rail?)

The slag mounds have been noted in the past to be haphazard with large gaps. There is ongoing erosion of the embankment face and crest, with damage noted following the 2014 storms. The inspection in 2014 identified that the old embankment at old bridge was likely to be breached within the next five years. Despite the embankment remaining at risk of breaching in short term, no current management of the shoreline is undertaken.

Policy unit 11e2.8: Steel Works Site

This is a slag cliff frontage (which extends beyond this frontage along 11e2.9 also), interspersed with individual lengths of defences, which are detailed below. Over time there has generally been little

change to the cliffs, apart from a section north of ex steel works protection, where a whole section of cliff sheared off and was deposited along the toe between 2014 and 2015.

Corus Steelworks 1: rock revetment (130 m) – previously Corus



The toe piling wall is dilapidated; retaining a mixture of armour rock and broken concrete in generally poor condition.

Figure 7 Dilapidated toe piling work along former CORUS frontage. Photograph taken during CH2M (2017) asset inspection.

Corus Steelworks 2: vertical concrete seawall (150 m) – previously Corus

This is a vertical concrete wall with abraded face in places and numerous cracks and spalls but generally in reasonable condition for its age and exposure conditions.

Remedial works have been carried out previously to repair holes, using sheet piling to form face shutter. Evidence of discarded piles on beach.



Figure 8. Vertical seawall along former CORUS frontage. Photograph taken during CH2M (2017) asset inspection.

Corus Steelworks 3: rock revetment (200 m) – previously Corus

This rock armour revetment varies in condition along the frontage. There has been some displacement and movement of armour stone.

[Policy unit 11e2.9: Steel Works to The Howe](#)

Salterbeck North to The Howe (extends along 11e2.8 also): man-made slag cliff (3060 m) – Allerdale BC

This is a slag cliff frontage (which also extends southwards beyond this frontage along 11e2.8). There has generally been little change to slag cliffs.

The Howe 1: rock revetment (50 m) – Cumbria CC

This is a rock armour revetment in variable condition. The structure was noted as having a 5 m wide gap in the centre, due to a collapsed tunnel, back in 2010. There is no information to suggest that this has been repaired. Later reports note the rock armour along this section is retained by steel rail cribwork. No defence management understood to be carried out at present.

The Howe 2: rock revetment (80 m) – Cumbria CC

This is recorded to be an ‘intermittent section of variable condition rock armour revetment’, with no noted deterioration in condition. No defence management understood to be carried out at present.



Figure 9 Howe 2: Rock revetment. Photograph taken during CH2M (2017) asset inspection.

Policy unit 11e2.10: The Howe to Workington Harbour

The Howe 3: rock revetment (520 m) – Cumbria CC



Figure 10 Howe 3: Rock revetment. Photograph taken during CH2M (2017) asset inspection.

Length of rock armour revetment providing protection to local access paths and open space land.

Previously there has been overtopping of the armour stone during the 2014 winter storms, which caused erosion and washout of the bank behind along most of the length. Some armour blocks have become displaced and moved.

2.1.3 Shoreline change

Analysis reports are produced to report on analysis of beach level data collected as part of the North West Monitoring Programme: two reports cover this frontage: Copeland report, covering up to Copperas Hill, and Allerdale report covering north of Copperas Hill. The most recent reports include analysis of data up to October 2016 (CH2M, 2017a, 2017b).

Whitehaven Harbour to Redness Point (11e2.1 and part of 11e2.2)

Recent monitoring data for the period between 2006 to 2016 show that the greatest changes tend to occur within the centre of the bay. Beach levels at the toe of the rock revetment can vary by up a metre, but seaward of this compacted slag deposits are exposed and there is little change in beach level; this may indicate that this surface is not conducive to retaining beach material and tends to be swept clean by waves. Further seawards, below mean sea level, this slag foreshore grades into a sandy foreshore, which has fluctuated in level over time. Along this section of beach, the data indicates a slight increase in levels towards the centre of the bay, but dropping levels to the south.

Previous surveys suggest that the dark colour of sand along the upper beach may indicate a transfer of sand from south of the harbour, or that the previous shoreline had been supplemented with mine waste in the past (CEUK, 2016a, b). Along the armoured frontage there has been no change in backshore position, but to the north of the slipway (11e2.2) there has been erosion of the backshore, with consists of a grassed bank, with around 5 m erosion between October 2013 and May 2014, and a further 3 m between September 2015 and April 2016. Here the railway lies close to the shoreline, with protection provided by a vertical masonry seawall.

Fluctuating beach levels at the toe of the defences has been cause for concern during asset surveys since 2001 (summarised in CH2M, 2017a), particularly along the central section of beach (around the

slipway) and at times beach levels near the central slipway have meant that there has been a step off the end of the slipway onto the beach. It has been noted in these reports that when the upper beach is denuded of material, the toe armour is left sitting directly onto of the compacted slag deposits meaning that the toe armour is more vulnerable to movement, which “could destabilise the surrounding armour”.

Further north, towards Redness Point, bedrock is exposed and there has been little or no change in beach level.



Figure 11 Whitehaven North Beach, looking south, showing the immobile compacted slag deposits, which form the upper beach (above mean sea level), backed by rock revetment and railway embankment. Photograph taken during CH2M (2017) asset inspection.

Redness Point to Copperas Hill (11e2.2, 11e2.3 and part of 11e2.4)

Data for this frontage exists from 2006 onwards, but the frontage north of Lowca Beck has not been surveyed since 2014. Much of the foreshore and beach is at a low level compared to some previous surveys, although the beach level change is relatively limited due to lack of mobile sediment and exposed rocky shore platform in places.

Redness Point – Along this section the railway line lies at the back of the beach, along the toe of the cliffs. The beach comprises boulder beds and coarse sediments. Asset inspections prior to 2006 (back to 2001) indicate that around the Point there has previously been some erosion and beach movement, resulting in the need for remedial works to defences here. Recent data (October 2016) indicates that current beach levels are generally lower than recorded previously. It should be recognised, however, that any change in the position of a boulder, or change in the profile line surveyed can suggest large changes in level, when changes in overall beach level are of low magnitude (CEUK, 2016a), due the scarcity of new sediment inputs.

Redness Point to Parton Bay - The railway continues along the back of the beach along this section. The beach comprises cobbles, boulders and rock outcrops, with a mobile covering of sand and shingle. It has been suggested that the reflective profile of the defences has resulted in scour of finer sediment from the fronting beaches, leaving behind the coarser boulders and cobbles, which are then subject to settling. There was foreshore lowering in the winter of 2013 and 2014 which caused damage to a section of concrete apron along the toe of defences, but generally changes are of low magnitude (less than 0.2 m) along this frontage, with no notable trend of erosion or steepening. There does not appear to be more sediment retention. Even updrift of the artificial promontory at Parton, material appears to be only temporarily trapped, before being removed and moved northwards.

Parton Bay - a rocky shore platform is sometimes visible in the lower foreshore, whilst the upper beach is composed of a wide range of materials from boulder down to coarse sand. At the southern end of the Bay, in front of the artificial promontory, there has been little change in beach level of time. Further north, and at particularly near Lowca Beck, changes in beach level across the upper beach (above mean sea level) have been more significant, with levels varying by up to 1.5 m over time. Either side of the Lowca Beck are grassed banks: to the south around 6 m recession occurred during the winter of 2013 and 2014, since then there has been minimal change (but also no recovery). Beach levels at this location have fluctuated by around 0.5 m. These changes have affected the stability of gabions present along the southern extent of this area. Along the northern side of Lowca Beck, there has also been erosion, with around 20 m retreat of the bank at the mouth of the Beck since 2014. Further north, although the beach level has fluctuated over time, it is not possible to detect any net trend of erosion or accretion.



Figure 12 The central slipway, which lies to the south of Lowca Beck. Here there has been recession of a grass bank to address this, gabions were placed, but these are currently in a dilapidated state. Photograph taken during CH2M (2017) asset inspection.



- Beach levels here have fluctuated, but no discernible trend evident.
- Emergency rock placed
- Recession of around 20 m has been between 2014 - 2016
- There was around 6 m recession in winter 2013/14
- Asset inspection (latest inspection: 2016) indicates that gabion baskets have collapsed due to previous damage caused 2013/14

Figure 13 Recent changes in the vicinity of Lowca Beck.

Lowca Point to the district boundary at Copperas Hill - Beach profiles in this management unit have not been surveyed since autumn 2014. Here there is limited mobile beach cover and bedrock is exposed along much of the stretch. The bedrock exposures form small natural promontories along the frontage, between which crenulated embayments have developed. It is the central parts of these embayments which seem to be the most vulnerable and where works have been needed to protect the railway embankment.



Figure 14 South of Copperas Hill, looking south. At the time of visit no beach was present at the toe of defences towards the south. The beach is composed of sand and shingle which has built up against the promontory of Copperas Hill. Photograph taken during CH2M (2017) asset inspection.

Copperas Hill to Workington (11e2.4 part and 11e2.5 to 11e2.11)

Copperas Hill to Harrington Harbour – Beach profiles in this management unit have not been surveyed since autumn 2014, but previous reporting concluded that between 2010 and 2014 there was no significant change in beach cross sectional area (<1% in total) at profiles where comparative data was available (CEUK, 2016b).

Copperas Hill is composed of artificial cliffs formed of industrial slag waste. These cliffs are reportedly eroding where undefended, although there is no monitoring data to confirm this. A triangle of land is present to the south of Harrington Harbour. Originally this may have been comprised of sediment that had built upon against the harbour, since its constructed in the 1760s, but in the late 19th to early 20th century industrial slag waste, a by-product of the iron works, which was located south of the harbour, was tipped on the shoreline to the south of the harbour, probably building up the land level here and extending the shoreline seawards.



Figure 15 Looking north toward Harrington Harbour from Copperas Hill. Little or no beach material appears to be retained by the groynes. Photograph taken during CH2M (2017) asset inspection.

Asset inspection data from 2010 suggests that beach levels have varied across the frontage over this time, and the presence of groynes suggest that erosion has been a historical issue. These groynes are believed to be having very little effect on beach retention, which has been attributed to the lack of finer sediments on the foreshore, but at present the groynes are also missing timber planking and the most recent photographs show there is no beach at high tide. Overtopping of defences is reportedly an issue along this frontage (CEUK, 2014).

Within Harrington Harbour itself, there have reportedly been issues of siltation (CEUK, 2014), presumably due to fine sediment being washed into the area from both offshore and from frontages to the south.

Harrington to Salterbeck – Beach profiles in this management unit have not been surveyed since autumn 2014, but previous reporting concluded that between 2010 and 2014 there was no significant change in beach cross sectional area (<1% in total) at profiles where comparative data was available (CEUK, 2016b). Immediately north of Harrington Harbour, there has previously been erosion of the cliffs, which contain landfill material. Dredgings from Harrington Harbour have been placed along this frontage, which may have helped slow erosion although reportedly this material is rapidly removed (CEUK, 2016b). The most recent asset inspection (August, 2017; CH2M, 2017b) indicated that beach levels were notably higher than previously, with no erosion of the cliffs evident, however there is no monitoring data available to confirm this. A report by Harrington Harbour Master (March 2018; Allerdale Borough Council, 2018) reported that the recent winter storms have caused erosion to the area north of Harrington Harbour. It is understood from this report that emergency works are planned to deposit rock and shale to the area which has washed away, but it is not known whether these works have been undertaken.

Salterbeck to Workington Harbour – The railway line runs along the back of the beach to Salterbeck, where it cuts inland. From here, the cliffs are mainly cut into industrial slag waste, which resulted in the shore position advancing up to 200 m seaward during the 19th and 20th centuries (CEUK, 2016b). The area of The Howe is a complex mix of natural cliffs and artificial cliffs and the slag itself is of variable resistance and therefore erosion rates may vary (CEUK, 2013). There has reportedly been erosion of the beach and undefended cliffs along this frontage, although there is no recent monitoring data to confirm this.



Figure 16 Spoil cliffs and beach between Salterbeck and Workington. Photograph taken during CH2M (2017) asset inspection.

Along the northern part of the Howe, overtopping during storm events has also been an issue, resulting in erosion of the bank currently protected by armour stone.

Predictions of future erosion from NCERM suggest the following bands of change:

	By year 20	By year 50	By year 100
11e2.1 Whitehaven Harbour and north beach	-	-	-
11e2.2 Bransty to Parton	0 to 6 m	10 to 20 m	20 to 40 m
11e2.3 Parton	0 to 6 m	10 to 20 m	20 to 40 m
11e2.4 Parton to Harrington Parks	0 to 6 m	8 to 20 m	20 to 40 m
11e2.5 Harrington Parks to Harrington Harbour	0 to 6 m	8 to 20 m	20 to 40 m
11e2.6 Harrington Harbour	-	-	-
11e2.7 Harrington to Steel Works Site	0 to 6 m	3 to 20 m	20 to 40 m
11e2.8 Steel Works Site	0 to 7 m	10 to 20 m	20 to 40 m
11e2.9 Steel Works to The Howe	0 to 8 m	8 to 20 m	20 to 40 m

11e2.10 The Howe to Workington Harbour	-	-	-
11e2.11 Workington Harbour	-	-	-

These values are based on very little information on how spoil areas typically erode. It has been observed along this coast that there is a complex mix of natural cliffs and artificial cliffs and the slag itself is of variable resistance. This means that locally erosion rates may vary, making predicting future behaviour difficult.

Along the adjacent coastline, there have been detailed studies into the rate of erosion along the Whitehaven South Beach frontage. These found that following a number of years of low rates of erosion, the rate has recently increased and currently the average annual rate is estimated to be between 2 and 3.5 m per year, but with periods of very low erosion followed by periods when significant change takes place. These rates are significantly higher than the NCERM estimates for this frontage and may not be directly applicable, but the data do demonstrate the level of variability in terms of resistance of different spoils. Continued coastal monitoring is therefore necessary to appraise erosion rates and assess changes in risk levels.

2.2 Outline of the problem

2.2.1 Background

The Cumbrian Coast railway runs along the back of the beach along much of this frontage, and is therefore at risk from erosion and wave overtopping in places. Although the beaches are not particularly dynamic, compared to other parts of the country, there are locations where the beach level has dropped over time increasing the vulnerability of the railway. Even where this is not the case, the low lying nature of the railway means it is vulnerable to storm events, when the combined effect of high tides and surge conditions means the beaches no longer offer sufficient protection and waves are able to reach the backshore. There is little to no sediment being added to the coastal system, therefore a finite volume of sediment is moved around the frontage between the partial barriers created by the harbours and other structures.

North of Salterbeck, the railway line moves inland and the area to seaward has previously been used for industrial uses, including Steel Works and quarrying.

There are also areas where erosion of the backing cliffs is a concern, due to increasing risk to hinterland assets.

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

2.2.2 Issues, constraints and opportunities

Between Redness Point, Whitehaven, and Salterbeck, the railway has been constructed along the back of the beach and is backed by cliffs. There are currently various stretches of defences along this coastline, which protect the railway line along this frontage. However, this asset is vulnerable to any beach lowering, which increases the risk of undermining and wave overtopping. Wave overtopping is already an issue along this stretch, with resultant impacts on train operations. There is little opportunity to realign the railway close to its current location; realignment further inland would incur significant disruption and costs but could be a long term solution. The current SMP policy option of Hold the line assumes that the railway will continue to operate along this line for decades to come.

There are also areas where erosion of the backing cliffs is a concern. Some of these cliffs are artificial and composed of dumped spoil deposits and evidence from Whitehaven South Beach suggests that erosion of such material can be rapid, with little of the material being retained to form protective beaches as the cliffs erode. Issues associated with this include the erosion of potentially contaminated sites, namely a former landfill site at 11e2.9; and that since the SMP2 there has been development of the former CORUS site (11e2.8 and 11e2.9), such that assets at potential risk have changed.

The harbours and marinas of Whitehaven (at the southern end of this frontage), Harrington and Workington remain key assets to the area. Historically there has been built up of sediment, tipped slag and mine waste along the southern side of these structures, but subsequently any erosion of these area now raises issues regarding stability of harbour structures, as they become increasingly exposed. Issues have also been raised regarding siltation within Workington Harbour, which may relate to shoreline erosion to south and subsequently movement of fines around the harbour breakwaters and into the harbour.

Currently there are no statutory land based environmental designations and there are also limited opportunities for environmental improvements within this area. Solway Firth pSPA, covers the nearshore zone and is designated to protect rare, vulnerable and migratory birds; any works that extend beyond the beach will need to consider impacts on this designation. As there are possible water quality issues related to release of sediments from industrial spoil cliffs and former landfill any improved protection of these could be beneficial.

2.2.3 Strategy considerations and general approach

Key considerations

Since the strategy was produced further monitoring data has been collated. There has also been changes in land use along the frontage. The strategy has considered the following:

- changes in risk along the frontage, both due to natural conditions and changes in land use
- current defence conditions and level of risk
- future management options.

It is understood that Network Rail prepared a frontage management strategy for the Bransty to Harrington frontage in 2010, which prioritised the need for further modifications to existing or the provision of new defences where the risk to railway infrastructure requires on going management. That management strategy has not been made available and so has not been reviewed. Therefore, although some assessment of potential strategy options is provided here, these should be reviewed in conjunction with the NR frontage management strategy when considering preferred way forward.

Strategy approach

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

- Privately owned or funded defences – these are locations where the SMP policy may allow Hold the line subject to private funding and investment. The strategy will investigate the performance or impact of the defences and make recommendations on measures to ensure a strategic solution along the frontage. It is unlikely that these locations will attract significant FDGiA funding – here the focus will be on considering varying costs of approaches, environmental impacts on the wider coast and making recommendations accordingly.
- Proposed future developments – these are locations where the SMP policy may still be appropriate for current hinterland assets but where future developments are proposed. Here the strategy will consider possible measures taking account of a possible change to policy. Future or proposed developments cannot be included in economic assessments to justify FDGiA - here the focus will be on considering varying costs of approaches, environmental impacts on the wider coast and making recommendations accordingly.

2.3 Options development and appraisal

The main options 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.

No potential for habitat creation sites has been identified for any of the above frontages.

Table 3 Long list options considered for priority units in 11e2 Whitehaven to Workington

Priority Unit	Hold the line								Managed realignment			
	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
11e2.2 Bransty to Parton	✓	✓		✓	✓	✓	✓		✓			
11e2.3 Parton	✓	✓		✓	✓	✓	✓		✓			
11e2.4 Parton to Harrington Parks	✓	✓		✓	✓	✓	✓	✓	✓			
11e2.5 Harrington Parks to Harrington Harbour	✓	✓		✓	✓	✓	✓	✓	✓			
11e2.7 Harrington to Steel Works	✓	✓		✓	✓	✓	✓	✓	✓			
11e2.8 Steel Works Site	✓	✓		✓	✓	✓	✓	✓	✓			
11e2.9 Steel Works to The Howe					✓	✓	✓	✓	✓			
11e2.10 The Howe to Workington	✓	✓		✓	✓	✓	✓	✓	✓			

The second stage has been to appraise the short listed options. The sections below 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 is provided in a [Strategic Environmental Assessment: Environmental Report](#) which systematically appraises the potential environmental consequences of the proposed strategy and recommend any actions needed to mitigate and monitor identified adverse effects.

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

2.4 11e2.2: Bransty to Parton

Throughout 11e2.2 the railway line lies directly at the back of the beach, along the base of the natural cliffs and supported by vertical masonry seawalls, without which the railway would not be viable. There is now little in the way of any foreshore and works to prevent undermining of these

walls have been necessary in the past. From observation, there would also appear to be some potential for wave overtopping of the defences, which could not only affect operation of the railway but also cause damage behind the seawall presenting another safety risk. This frontage has been highlighted by Network Rail as a priority due to the flood risk from wave overtopping and risks of cliff falls the line has a speed restriction. It is understood that there is a proposal for cliff reprofiling at Bransty to reduce cliff fall risk to the railway and supply rock for a small reclamation at North Beach in 11e2.1.

2.4.1 11e2.2 - Initial screening of options

The policy here is to continue to Hold the line through epochs 2 and 3, based on the assumption that the railway will continue to operate along this line for decades to come.

Table 4 below summarises the rationale for taking long options forward to the short list stage.

Table 4 Screening of long list options for 11e2.2

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option would not manage erosion and overtopping risks to the railway assets. It has been assessed for comparative purposes only.
Do minimum	Reactive patch and repair of defences only.	Baseline only	This option would not manage long term erosion and overtopping risks to the railway assets. However, this may become the default option if funding is no longer available.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing standard of protection.	Yes	Patch repairs if carried out well and are timely could be effective in maintaining the integrity of the structure for several more years and as such is a viable option to be considered.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works, to improve longevity of existing defences.	Yes	Options to modify and adapt existing defences may offer a suitable approach to future management of assets along this coastline, although consideration needs to be given to the expected performance and design life to be attained, therefore gabions would be unlikely to be suitable. It is a viable option to be considered.
Hold the line: Improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Options to modify and adapt existing defences, through raising them, strengthening them or providing toe protection, may offer a suitable approach to future management of assets along this coastline, although consideration needs to be given to the expected performance and design life to be attained. It is a viable option to be considered.
Hold the line: Improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwaters.	No	There is already a very exposed section of coast and there is a scarcity of sediment on the beaches, so for control structures to have a benefit they would need to be carried out in conjunction with significant recharge. Therefore, this is likely to be very expensive to implement and has not been considered further.
Hold the line: Improve through constructing new revetments or seawalls	New shore parallel defences replacing or extending existing defences	Yes	Although options such as proprietary systems, OSA or concrete slopes would be inappropriate along most parts of this frontage, rock armour, concrete armour units, or riprap, would be potentially suited to conditions and requirements here. Construction of a new seawall may also be appropriate, although high cost. Therefore, this option has been taken forward for further consideration.
Hold the line: Improve through beach recharge	Addition of new material to beaches.	No	There is already a very exposed section of coast and is therefore not going to be conducive to beach

			development. This option has therefore not been considered further.
Managed realignment: Construct erosion slowing defences	Low tech measures such as gabion baskets to reduce erosion rates.	No	Given the direct exposure to waves with little or no buffer, it is unlikely that low tech solutions are going to be suitable for long term Hold the line. This option has therefore not been considered further.

2.4.2 11e2.2 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	<p>At present, the existing seawalls appear to be reasonably sound and have not required much maintenance, although in part perhaps due to previous interventions along the toe as beach levels have dropped. However, indications are that there has been loss of the mobile sediments on the foreshore, and some erosion of exposed areas, and the addition of a toe apron indicates potential for undermining and some of the lower masonry may be less stable. The defences are vulnerable to future storm events, when higher water levels combined with extreme wave conditions could cause damage to sections of the wall through both overtopping and outwashing of backfill, and undermining and scour at the toe.</p> <p>Without investment, any damage will be left to deteriorate further, ultimately leading to failure of defences, particularly along the more exposed sections of the frontage. In the longer term there would be reactivation of the cliffs behind.</p>
Environmental	<p>This option would result in a high risk of loss of the section of Cumbria Coast Railway line that runs adjacent to the coastline. This has a number of associated impacts, including increased isolation of small communities along the coastline as this railway is a key transport link between these communities and the wider area.</p> <p>Additionally, this railway is a named feature of the West Cumbria Coastal Plain National Character Area (NCA) and development of its role as an access to the coast and to other recreational areas such as Hadrian's Wall is a stated objective within the NCA profile. Therefore, there will be subsequent impacts on the characteristic landscape features.</p> <p>The adopted route of the England Coast Path follows the base of the cliffs, behind the railway line, along a track known as The Wagon Road; this also forms part of the National Cycle Network. Any increase in overtopping along this frontage prior to defence failure could mean that access would need to be restricted during certain times of year or conditions. Once the defence along this section fails, the track would be at risk from erosion.</p> <p>Impacts of do nothing on the WFD objectives of relevant waterbodies must be considered as there may be changes to the hydromorphology of the frontage. Additionally, there is a current proposal to extend the Solway Firth SPA south to Whitehaven. This proposed site must be treated as though it has been designated of this option on its designated features must be assessed under the Habitats and Species Conservations Regulations 2017 to protect Natura sites.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are associated with forced closure and ultimately loss of the railway infrastructure. Damages related to the disruption and closure of the railway have not been calculated at this stage.

Do minimum (Option 2)

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.	
Technical	<p>As works would be low cost and reactive only, as for Do nothing the future lifespan of the existing defences would depend upon future conditions, for example storm frequency and magnitude. Where repairs are not carried out in a timely manner, then further problems can arise which can then accelerate time to failure.</p> <p>This does not provide a long term solution, particularly along this stretch where previous interventions suggest there has been undermining in the past. This option would revert to Do nothing once the defences fail.</p>

Environmental	Once defences fail, the impacts would be as for the Do nothing option. See Option 1 for description of potential impacts.
Costs	There are no Present Value Capital Works, since works are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £20 k.
Damages	The key damages are associated with forced closure and ultimately loss of the railway infrastructure. It is unlikely, under this option, that works would significantly delay failure beyond that estimated for Do nothing (Option 1). Damages related to the disruption and closure of the railway have not been calculated at this stage.

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

Measures to maintain the existing standard of protection.	
This is would be a continuation of current activities involving patch repairs to the defences, based upon regular inspections and as part of a scheduled programme of works.	
Technical	In many cases, patch repairs if carried out well and are timely, can be effective in maintaining the integrity of the structure for several more years. However, where these are not carried out then further problems can arise which can then necessitate far more substantial and expensive interventions later on. Works to prevent undermining and scour at the toe, together with a proactive approach to patch and repair of the masonry wall, may help to maintain the stability of this seawall for another 10 to 20 years. Beyond this, the situation may revert to Do nothing if repair works become too expensive or extensive.
Environmental	In the short term, current situation would be maintained, however, once the defences fail following the end of residual life, impacts will be as in option 1.
Costs	The Present Value Capital Works are estimated to be £540 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £870 k.
Benefits	The key damages are associated with forced closure and ultimately loss of the railway infrastructure – this may be delayed by 10 to 20 years, compared to Do nothing. Benefits related to reduced disruption and avoidance of closure of the railway and have not been calculated at this stage.

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

This would involve more low cost measures to maintain, but not improve, the existing standard of protection. It could involve rock gabions or similar sacrificial defence options.	
Technical	<p>Rock gabions might offer a temporary solution to quickly fix problems and delay failures by a few more years, but are not considered a sustainable solution due to their short design life: during severe events gabions are likely to become damaged and therefore require repair or replacement, there is also a risk that prior to repair works damage could be caused to the defence behind by subsequent storms. There would also be a need to remove the failed mesh before a longer term solution could be installed. Similarly, geobags are unlikely to be a viable option to consider along this coastline.</p> <p>Ad hoc rock placement along the toe of the defence could be used to address the immediate issues of undermining, which is understood to be the key failure mechanism along this frontage, but equally, this is unlikely to be suitable as a long term solution and eventually the situation would revert to Do nothing. There would be no additional works undertaken to address overtopping risk; therefore, this would remain of vulnerability of the existing defences.</p>
Environmental	<p>In the short term, the situation would remain similar to present. However, as there is no accounting for climatic changes in the future, the Cumbria Coast Railway and the England Coast Path may be at risk of inundation and damage from sea level rise and more severe weather events.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of undertaking any works along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Impacts of this option on the WFD objectives of the relevant waterbodies would need to be considered through further assessment. The origins and nature of the sacrificial material must be considered as it will be transported through coastal processes to adjacent frontages and beyond, which may lead to wider impacts.</p> <p>In the longer term, defences will eventually fail and the impacts will be the same as the Do nothing (Option 1).</p>

Costs	The Present Value Capital Works are estimated to be £810 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,880 k.
Benefits	The railway would remain protected to a degree from both erosion and overtopping for a time, allowing continued operation. However, the risk of overtopping will increase over time, with implications for hinterland properties. Eventually it may become uneconomic to continue replacing or repairing rock and the situation may revert to Do nothing from the medium term. Benefits related to reduced disruption and avoidance of closure of the railway and have not been calculated at this stage.

Hold the line: improve existing defences (Option 5)

This would involve more substantial measures to maintain the existing standard of protection through improving the resilience of the existing defences. A sound toe structure is needed (i.e. rock armour with suitable filter layer, rather than gabions) to ensure that the wall cannot be undermined by further lowering of the foreshore. Where overtopping is an issue, perhaps as a result of sea level rise, then it may be necessary to also raise this wall.	
Technical	<p>This should address the issues of undermining, which is understood to be the key failure mechanism along this frontage. Such works are unlikely to affect adjacent frontages.</p> <p>The overtopping risk would be minimised through increasing the crest level, if required. However, such works will require further investigations into the defence structure to assess the ability of the current wall to take the addition load (weight of wall and additional wave loading).</p>
Environmental	<p>This option would improve the protection to the railway line (and England Coast Path which runs landward of the railway), which is a critical asset along this frontage.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing rock armour along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Impacts of this option on the WFD objectives of the relevant waterbodies but be considered through further assessment. Raising the level of the sea wall may reduce the views out to sea and therefore impact on the visual amenity of the area.</p>
Costs	The Present Value Capital Works are estimated to be £1,780 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,890 k.
Benefits	The railway would remain protected from both erosion and overtopping, allowing continued operation. Benefits related to reduced disruption and avoidance of closure of the railway and have not been calculated at this stage.

Hold the line: improve through constructing new revetments or seawalls (Options 6ab)

This may involve constructing (a) a seawall along this length OR (b) constructing a seaward berm of rock, backfilled either with locally sourced material or with other rock	
Technical	<p>(a) The new seawall would be designed to withstand the higher sea levels, wave forces, and foreshore lowering that might be expected and provide a long term solution to current issues of undermining and overtopping.</p> <p>(b) A (potentially cheaper) alternative would be to move the interface between sea and defence further seaward, and at the same time avoid having to raise the wall or add further scour protection. This could be achieved by constructing a seaward berm of rock, backfilled either with locally sourced material or with other rock (thus effectively creating a berm breakwater). This could be carried out with minimal disturbance to the operation of the railway. It is not anticipated that this would significantly affect alongshore transport, due to the exposed nature of this shoreline and the scarcity of sediment within the system.</p>
Environmental	<p>Option (a) would look slightly different from what is there today, but would be a similar footprint, whilst option (b) would be a larger footprint. There would therefore be some minor impacts on landscape character. Construction of new defences in areas where there have not been any previous, may alter the landscape of the frontage, impacting on the views out to sea and the visual amenity of the area.</p> <p>It is possible that the structure could incept some material which may impact on adjacent frontages.</p> <p>Both options (a) and (b) would maintain protection to the railway and provide adequate defence against future overtopping that might be a result of any sea level rise. There would also be improved protection to the England Coast Path, which runs landwards of the railway.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing rock armour along the toe of the defences would need careful consideration under the Habitats and Species</p>

	Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites.
	Impacts of both of this options on the WFD objectives of the relevant waterbodies but be considered through further assessment.
Costs	<p>a) The Present Value Capital Works are estimated to be £5,000 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £8,100 k.</p> <p>b) The Present Value Capital Works are estimated to be £1,160 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,900 k.</p>
Benefits	Both options would continue to protect the railway and future proof the infrastructure against potential increases in sea level rise, changes in wave climate or storminess. Benefits related to reduced disruption and avoidance of closure of the railway and have not been calculated at this stage.

2.4.3 11e2.2 - Discussion of options

Table 5 summaries the cost calculations for the various options presented above: note that the economic benefits relate primarily to the railway but have not been calculated at this stage.

There is a need to better understand the level of risks to the railway and operations for continued safety and avoidance of unacceptable risk. An Asset Management Plan should be developed for this frontage, including stability assessments, overtopping potential, identification of trigger levels, monitoring and responses. In developing that, comparison and review of Network Rails 2010 frontage management strategy is required.

Assuming a long term need to Hold the line for this policy unit, modifying the existing structure (toe protection, raising, repairing) may be adequate for some years but it is considered likely that before epoch 3 is reached there will be a need to construct a new defence. That might take the form of a replacement seawall, or alternatively a seaward rock berm may offer a much more cost effective and less disruptive option.

Given the exposed location of the railway along this frontage, realignment could be considered in the future. If this is a possibility beyond the next 10 to 20 years, then a more suitable approach would be to continue to carry out remedial works on the current defences. In addition to proactive maintenance and timely patch and repairs to the masonry, it is also possible that additional toe protection may be required, which would most probably take the form of rock armour.

Table 5 Policy unit 11e 2.2 Summary of economics

Policy Unit	Option		Design Life	Capital Works year applied	Whole Life Cost (cash 2018)	Present Value (PV)			
						Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
						£m	£m	£m	£m
11e2.2	Option 1	Do nothing	20	-	0.00	0.00	0.00	0.00	0.00
11e2.2	Option 2	Do minimum	25	-	0.02	0.00	0.01	0.01	0.02
11e2.2	Option 3	Hold the line: Maintain through proactive maintenance	30	0	0.65	0.54	0.01	0.55	0.87
11e2.2	Option 4	Hold the line: Maintain through reinforcing existing structures	50	20	2.75	0.81	0.37	1.18	1.88
11e2.2	Option 5	Hold the line: Improve existing defences	100	20	3.23	1.78	0.03	1.81	2.89
11e2.2	Option 6a	Hold the line: Improve through constructing new seawall	100	20	10.29	5.00	0.06	5.06	8.10
11e2.2	Option 6b	Hold the line: Improve through constructing new berm of rock	100	20	2.44	1.16	0.02	1.19	1.90

2.5 11e2.3: Parton

Throughout most of 11e2.3 the railway line lies directly at the back of the beach, along the base of the natural cliffs and supported by vertical masonry seawalls, without which the railway would not be viable. There appears to be low ground behind the railway line at Parton, but it is uncertain

whether overtopping of defences has ever resulted in flooding to these. However, failure to hold the railway line would result in these becoming vulnerable. Asset inspections report a legacy of problems with erosion but identified remedial works have not necessarily been carried out, despite year on year recommendations to do so. Network Rail is understood to have sought a Marine Licence for rock armour defences along promontory and to deal with issues of outflanking in 2017 and 2018.

Annual coastal defence inspections have highlighted low areas in the rock revetment. These have not been addressed due to access difficulties. There has been previous discussion with Network Rail regarding access across the railway line, but this is an ongoing issue.

2.5.1 11e2.3 - Initial screening of options

The policy here is to continue to Hold the line to the long term, based on the assumption that the railway will continue to operate along this line for decades to come.

Table 6 below summarises the rationale for taking long options forward to the short list stage.

Table 6 Screening of long list options for 11e2.3

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option would not manage erosion and overtopping risks to the railway assets or the village of Parton. It has been assessed for comparative purposes only.
Do minimum	Reactive patch and repair of defences only.	Baseline only	This option would not manage long term erosion and overtopping risks to the railway assets or the village of Parton. However, this may become the default option if funding is no longer available.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing standard of protection.	Yes	Patch repairs if carried out well and are timely could be effective in maintaining the integrity of the structure for several more years and as such is a viable option to be considered.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works, gabions to improve longevity of existing defences.	Yes	Options to modify and adapt existing defences may offer a suitable short term approach to future management of assets along this coastline, although consideration needs to be given to the expected performance and design life to be attained. It is a viable option to be considered.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Options to modify and adapt existing defences, through raising them, strengthening them or providing toe protection, may offer a suitable approach to future management of assets along this coastline, although consideration needs to be given to the expected performance and design life to be attained. It is a viable option to be considered.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwaters.	No	There is already a very exposed section of coast and there is a scarcity of sediment on the beaches, so for control structures to have a benefit they would need to be carried out in conjunction with significant recharge. Therefore, this is likely be very expensive to implement and has not be considered further.
Hold the line: improve through constructing new revetments or seawalls	New shore parallel defences replacing or extending existing defences	Yes	Although options such as proprietary systems, OSA or concrete slopes would be inappropriate along most parts of this frontage, rock armour, concrete armour units, or riprap, would be potentially suited to conditions and requirements here. Construction of a new seawall may also be appropriate, although high cost. Therefore, this option has been taken forward for further consideration.

Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought that this area is conducive to beach development. Beach profile data indicates that even where material has built up it has subsequently been rapidly removed. Therefore, any recharge would require several control structures to aid retention of recharge material, and so would also be a relatively expensive approach.
Managed realignment: construct erosion slowing defences	Low tech measures such as gabion baskets to reduce erosion rates.	No	Given the direct exposure to waves with little or no buffer, it is unlikely that low tech solutions are going to be suitable for long term Hold the line. This option has therefore not been considered further.

2.5.2 11e2.3 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	<p>Over the past few years there has been an ongoing problem with erosion and damage to defences along much of this stretch, particularly along the central part of the bay, near Lowca Beck, where beach levels can vary by up to 1.5 m over time. At the northern and southern extremities of this frontage, beach levels have remained stable, but the railway defences remain vulnerable to storm events. Although the seawall and rock armour appear to be reasonably sound, it is clear from inspection reports that beach levels have fallen along this policy unit in the past, leaving the defences vulnerable to undermining. During storms, higher water levels combined with extreme wave conditions can cause damage to sections of the wall through both overtopping and outwashing of backfill, and undermining and scour at the toe.</p> <p>Without investment, any damage will be left to deteriorate further, ultimately leading to failure of defences, particularly along the more exposed sections of the frontage.</p>
Environmental	<p>This option would likely lead to the eventual failure of the existing defences. Subsequently, a number of residential properties would be at risk of coastal erosion and flooding and there would therefore be consequences for the community of Parton.</p> <p>The Cumbria Coast Railway and Parton Station may be rendered inoperable, meaning that Parton will lose a major transport route, increasing its isolation from the surrounding area. Additionally, there is a Roman Fort in Parton, to the east of Foundry Road which is also part of the Frontiers of the Roman Empire World Heritage Site. While there are no direct impacts risk of coastal erosion or flooding to this historic asset, the failure of the defences, flood damage and coastal erosion may impact on the setting of the monument, reducing its heritage value. There is also potential for undiscovered archaeology within the region which may be uncovered, damaged or destroyed by any coastal erosion or flood events.</p> <p>The adopted route of the England Coast Path runs seaward of the railway line along much of the frontage and also forms part of the National Cycle Trail, along the Former Wagon way. Sections of the England Coast Path would be at increasingly risk of erosion and flooding, although it is already recognised in the proposals that some sections would need to roll back as a direct result of coastal processes.</p> <p>Do nothing may allow for natural coastal processes to become reinstated, potentially enhancing the habitats within the pSPA which must be assessed under the Habitats and Species Conservation Regulations (201&), however impacts on the WFD objectives of the relevant waterbodies must be taken into consideration through further assessment.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are associated with forced closure and ultimately loss of the railway infrastructure, and risk to properties and business located inland of the railway line. The property related damages are £40 k. Damages related to the disruption and closure of the railway have not been calculated at this stage.

Do minimum (Option 2)

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.	
Technical	As works would be low cost and reactive only, as for Do nothing the future lifespan of the existing defences would depend upon future conditions, for example storm frequency and magnitude. Where repairs are not carried out in a timely manner, then further problems may arise, accelerating time to failure.

	This does not provide a long term solution, particularly along this stretch where previous interventions suggest there has been undermining in the past.
Environmental	This Option would only result in a delay in the onset of defence failure. Once defences fail, the impacts would be as for the Do nothing option: see Option 1 for details.
Costs	There are no Present Value Capital Works, since works are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £480 k.
Damages	The key damages are associated with forced closure and ultimately loss of the railway infrastructure, and risk to properties and business located inland of the railway line. It is unlikely, under this option, that works would significantly delay failure beyond that estimated for Do nothing (Option 1). Damages related to the disruption and closure of the railway have not been calculated at this stage.

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

Measures to maintain the existing standard of protection.	
This is would be a continuation of current activities involving patch repairs to the defences, based upon regular inspections and as part of a scheduled programme of works.	
Technical	<p>In many cases, patch repairs if carried out well and are timely, can be effective in maintaining the integrity of the structure for several more years. However, where these are not carried out then further problems can arise which can then necessitate far more substantial and expensive interventions later.</p> <p>Works to prevent undermining and scour at the toe, together with a proactive approach to patch and repair of the masonry wall, may help to maintain the stability of this seawall for another 10 to 20 years. Beyond this, the situation may revert to Do nothing if repair works become too expensive or extensive. Given the direct exposure to waves with little or no buffer, it is also unlikely that such low tech solutions are going to be suitable for long term Hold the line which, irrespective of any plans for the railway, is required to ensure the risk of flooding to Parton is managed.</p>
Environmental	<p>This option would allow the current situation to be maintained at least in the short term with no significant impacts. Overtopping flood risk to low lying areas will increase in frequency over time as standard of protection reduces. This may impact several properties and have a negative impact on the community of Parton.</p> <p>The Cumbria Coast Railway will remain at risk from overtopping (and frequency of flooding is likely to increase), with a requirement for speed restrictions.</p> <p>Works will take place along the existing structure, so there is no anticipated impact on landscape quality or qualifying features of Solway Firth pSPA although this must be confirmed through further assessment under the Habitats and Species Conservation Act 2017.</p> <p>In the longer term it is unlikely that such activities will remain feasible and the situation may revert to Do nothing: with impacts as detailed for Option 1.</p>
Costs	The Present Value Capital Works are estimated to be £600 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,450 k.
Benefits	The key damages are associated with forced closure and ultimately loss of the railway infrastructure – this may be delayed by 10 to 20 years, compared to Do nothing. Beyond this there would be increasing risk to hinterland properties, with indirect impacts on the overall community. Benefits related to reduced disruption and avoidance of closure of the railway and have not been calculated at this stage.

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

This would involve more low cost measures to maintain, but not improve, the existing standard of protection. It could involve rock gabions or similar sacrificial defence options.	
Technical	<p>Rock gabions might offer a temporary solution to quickly fix problems and delay failures by a few more years, but are not considered a sustainable solution due to their short design life: during severe events gabions are likely to become damaged and therefore require repair or replacement, there is also a risk that prior to repair works damage could be caused to the defence behind by subsequent storms. There would also be a need to remove the failed mesh before a longer term solution could be installed. Similarly, geobags are unlikely to be a viable option to consider along this coastline.</p> <p>Ad hoc rock armour placement could address the immediate issues of undermining, which is understood to be the key failure mechanism along this frontage, but is unlikely to be suitable as a long term solution. As for Option 3, such works may help to maintain the stability of this seawall for another 10 to 20 years. Beyond this, the situation may revert to Do nothing. Given the direct exposure to waves with little or no buffer, it is also</p>

	<p>unlikely these solutions are going to be suitable for long term Hold the line which, irrespective of any plans for the railway, is required to ensure the risk of flooding to Parton is managed.</p> <p>There would be no additional works undertaken to address overtopping risk; therefore, this would remain of vulnerability of the existing defences.</p>
Environmental	<p>In terms of hinterland assets, the likely impacts are largely the same as Option 3, with works only providing a short term solution.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing rock armour along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites.</p>
Costs	<p>The Present Value Capital Works are estimated to be £590 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,660 k.</p>
Benefits	<p>The railway would remain protected from both erosion and overtopping for a short amount of time only, allowing continued operation. However, the risk of overtopping may increase over time, with implications for hinterland properties. Eventually it may become uneconomic to continue replacing or repairing gabions and the situation is expected to revert to Do nothing within 10 to 20 years. Benefits related to reduced disruption and avoidance of closure of the railway and have not been calculated at this stage.</p>

Hold the line: improve existing defences (Option 5)

	<p>This would involve more substantial measures to maintain the existing standard of protection through improving the resilience of the existing defences. A sound toe structure is needed (i.e. rock armour rather than gabions) to ensure that the wall cannot be undermined by further lowering of the foreshore. Where overtopping is an issue, perhaps as a result of sea level rise, then it may be necessary to also raise this wall.</p>
Technical	<p>This should address the issues of undermining, which is understood to be the key failure mechanism along this frontage. Such works are unlikely to affect adjacent frontages.</p> <p>The overtopping risk would be minimised through increasing the crest level, if required. However, such works will require further investigations into the defence structure to assess the ability of the current wall to take the addition load (weight of wall and additional wave loading).</p>
Environmental	<p>There would be continued protection of the railway infrastructure. This option would also reduce risk to properties at Parton and benefit the local and wider community through preventing severance by ensuring that the railway and the station can remain operational (although this will also depend on approaches adopted along adjacent stretches of railway). The setting of the scheduled monument of the Roman Fort at Parton, would be protected, allowing it to maintain its heritage value.</p> <p>The defences would also provide improved protection to the adopted route of the England Coast Path which runs landward of the railway line for much of this frontage and also forms part of the National Cycle Trail (see previous comments). Any defence works would need to consider the route as it passes in front of the railway line at Parton. There may be a possibility to incorporate the path into any design.</p> <p>Investigations into feasibility of raising the seawall should take into consideration whether the new height of the wall would impact on the views of the local properties and from for passengers travelling on the railway, noting that the views from the West Coast railway line are part of its heritage value.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing a rock revetment along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Impacts on the WFD objectives of relevant waterbodies must also be determined through further assessment</p> <p>This option does not account for the long term overtopping risk of climatic factors, which leaves many assets along the coastline still at risk of flooding in the future.</p>
Costs	<p>The Present Value Capital Works are estimated to be £900 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,970 k.</p>
Benefits	<p>The railway would remain protected from both erosion and overtopping, allowing continued operation. There would also be protection to properties within Parton. Benefits related to reduced disruption and avoidance of closure of the railway and have not been calculated at this stage.</p>

Hold the line: improve through constructing new revetments or seawalls (Options 6ab)

	<p>This may involve constructing (a) a new seawall along this length OR (b) constructing a seaward berm of rock, backfilled either with locally sourced material or with other rock</p>
--	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Technical	<p>(a) The new seawall would replace the existing structure, and be designed to withstand the higher sea levels, wave forces, and foreshore lowering that might be expected and provide a long term solution to current issues of undermining and overtopping.</p> <p>(b) A (potentially cheaper) alternative would be to move the interface between sea and defence further seaward, and at the same time avoid having to raise the wall or add further scour protection. This could be achieved by constructing a seaward berm of rock, backfilled either with locally sourced material or with other rock (thus effectively creating a berm breakwater). This could be carried out with minimal disturbance to the operation of the railway. It is not anticipated that this would significantly affect alongshore transport, due to the exposed nature of this shoreline and the scarcity of sediment within the system.</p>
Environmental	<p>Option (a) would look slightly different from what is there today, but would be a similar footprint, whilst option (b) would be a larger footprint. There would therefore be some minor impacts on landscape character.</p> <p>Both options (a) and (b) would maintain protection to the railway and provide adequate defence against future overtopping that might be a result of any sea level rise. There would also be improved long term protection to commercial and residential properties in Parton, bringing communitywide benefits. There would also be improved protection to the England Coast Path, which runs landwards of the railway. Any defence works would need to consider the route as it passes in front of the railway line at Parton: there may be a possibility to incorporate the path into the design.</p> <p>Construction of any new defence may alter the available views out to sea or alter the character of the frontage. Both of these may impact on the visual amenity of the site.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing rock armour along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Potential impacts on the WFD objectives of the relevant waterbodies must also be considered.</p>
Costs	<p>a) The Present Value Capital Works are estimated to be £4,530 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £7,350 k.</p> <p>b) The Present Value Capital Works are estimated to be £1,110 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,010 k.</p>
Benefits	<p>Both options would continue to protect the railway and futureproof the infrastructure against potential increases in sea level rise, changes in wave climate or storminess. There would also be improved long term protection to commercial and residential properties in Parton. Benefits related to reduced disruption and avoidance of closure of the railway and have not been calculated at this stage.</p>

2.5.3 11e2.3 - Discussion of options

Table 7 summaries the cost and benefit calculations for the various options presented above.

There is a need to better understand the level of risks to the railway and operations for continued safety and avoidance of unacceptable risk. An Asset Management Plan should be developed for this frontage, including stability assessments, overtopping potential, identification of trigger levels, monitoring and responses. In developing that, comparison and review of Network Rail's 2010 frontage management strategy is required.

A Flood Risk Assessment for Parton is also required to establish levels of risk and therefore requirements for that Plan.

Modifying the existing structure (toe protection, raising, repairing) may be adequate for some years but it is considered likely that before epoch 3 is reached there will be a need to construct a new defence. That might take the form of a replacement seawall, rock revetment or alternatively a seaward rock berm.

Should there be relocation of the railway along the southern section of frontage, but flood protection to people and property at Parton is justified, then the frontline defences can be secured against erosion (e.g. with rock revetment), and a smaller flood wall built at the rear of the defences to address overtopping water.

Table 7 Policy unit 11e 2.3 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 Do minimum		0.00	0.48	0.04	0.08
Option 3 Hold the line: maintain through proactive maintenance		0.60	1.45	0.04	0.03
Option 4 Hold the line: maintain through reinforcing existing defences		0.59	1.66	0.04	0.02
Option 5 Hold the line: improve existing defences		0.90	1.97	0.04	0.02
Option 6 Hold the line: improve through constructing new revetments or seawalls	a	4.53	7.35	0.04	0.01
	b	1.11	2.01	0.04	0.02
<i>*Present Value cost (PVC) inclusive of 60% optimisation bias</i>					
<i>++ Excludes benefits related to the railway</i>					

2.6 11e2.4: Parton to Harrington Parks

Throughout almost all of 11e.4, the railway line lies directly at the back of the beach, along the base of the natural cliffs. Defence is of variable type, with lengths of vertical and sloping seawalls, lengths of rock revetment or possibly randomly tipped rock, whilst other stretches have no defences at all and are actively eroding.

Details on most of these defence lengths, and their condition, are not known as annual inspections do not include this frontage due to the limited access.

There would appear to be some potential for some very localised flooding via Lowca Beck under the railway line at the southern extremity of this policy unit, but no further details are available.

All defence lengths here are assumed to be the responsibility of Network Rail, although in the central section there would be an immediate erosion risk to several wind turbines if these defences were not maintained and were to fail.

Copeland Borough Council own the land behind the railway line and have reported drainage issues within the higher land, particularly between Lowca Beck and Micklam Point. Landslips appear to have affected piped drainage systems along this stretch, which in turn may induce further cliff failures. Although this is not a coastal defence issue, management of the railway will need to include continued monitoring of landslip activity to assess the potential threat to operation.

Additional rock armour protection has recently been installed towards the northern end of this frontage, by Network Rail.

2.6.1 11e2.4 - Initial screening of options

The policy here is to continue to Hold the line through epochs 2 and 3, primarily on the assumption that the railway will continue to operate along this line for decades to come.

Table 8 below summarises the rationale for taking long options forward to the short list stage.

Table 8 Screening of long list options for 11e2.4

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to	Baseline only	This option would not manage erosion and overtopping risks to the railway assets. It has been assessed for comparative purposes only.

	deteriorate and fail.		
Do minimum	Reactive patch and repair of defences only.	Baseline only	This option would not manage long term erosion and overtopping risks to the railway assets. However, this may become the default option if funding is no longer available.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing standard of protection.	Yes	Patch repairs if carried out well and are timely could be effective in maintaining the integrity of the structure for several more years and as such is a viable option to be considered.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works, gabions to improve longevity of existing defences.	Yes	Options to modify and adapt existing defences may offer a suitable short term approach to future management of assets along this coastline, although consideration needs to be given to the expected performance and design life to be attained. It is a viable option to be considered.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Options to modify and adapt existing defences, through raising them, strengthening them or providing toe protection, may offer a suitable approach to future management of assets along this coastline, although consideration needs to be given to the expected performance and design life to be attained. It is a viable option to be considered.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwaters.	No	There is already a very exposed section of coast and there is a scarcity of sediment on the beaches, so for control structures to have a benefit they would need to be carried out in conjunction with significant recharge. This is likely be very expensive to implement and has not been considered further.
Hold the line: improve through constructing new revetments or seawalls	New shore parallel defences replacing and extending existing defences	Yes	There is evidence that seawalls are currently suffering from scour and undermining, so may not be the most appropriate option here. However, a rock revetment throughout the frontage may be an effective way to secure the future of the railway. Therefore, this option has been taken forward for further consideration.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought that this area is conducive to beach development. Therefore, any attempt to provide a beach would require significant recharge and several control structures to aid retention of recharge material. This is likely be very expensive to implement and has not been considered further.
Hold the line: improve through introducing cliff or slope stabilisation measure	This may include toe protection works, drainage or netting.	No	Undercutting appears to be the key risk of failure; therefore, provision of toe protection is likely to be the most effective way of managing this risk. Where this is in front of existing defences, it is considered as part of "Hold the line: improve existing defences"; where new defences are required, this is considered under "Hold the line: improve through constructing new revetments or seawalls". This has therefore not been taken forward as a separate option.
Managed realignment: construct erosion-slowing defences	Low tech measures such as gabion baskets to reduce erosion rates.	No	Given the direct exposure to waves with little or no buffer, it is unlikely that low tech solutions are going to be suitable for long term Hold the line. This option has therefore not been considered further.

2.6.2 11e2.4 - Development and appraisal of short listed options

Do nothing (Option 1)

<p>This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.</p>	
<p>Technical</p>	<p>There is limited mobile beach cover and bedrock is exposed along much of the frontage. Around Copperas Hill, the bedrock exposures form small natural promontories along the frontage, between which crenulated embayments have developed. It is the central parts of these embayments which seem to be the most vulnerable to erosion. There is a variety of discontinuous defences along this policy unit, which appear to have been reactive responses to issues. Beach profile data is not available since 2014, but previous reports suggests that net change in beach levels is of low magnitude along the frontage. Along many sections there is, however, no beach present at high tide, so defences and undefended sections are exposed to direct wave action at least some of the tidal cycle. The defences also remain vulnerable to storm damage, with both overtopping and undermining of defences issues along the frontage.</p> <p>Without investment, any damage caused during storms will be left to deteriorate further, ultimately leading to failure of defences, particularly along the more exposed sections of the frontage. This will eventually lead to reactivation of the backing slopes and cliffs.</p>
<p>Environmental</p>	<p>This option would result in a high risk of loss of the section of Cumbrian Coast Railway line that runs adjacent to the coastline. This has a number of associated impacts, including increased isolation of small communities along the coastline as this railway is a key transport link between these communities and the wider area.</p> <p>Additionally, this railway is a named feature of the West Cumbria Coastal Plain National Character Area (NCA) and development of its role as an access to the coast and to other recreational areas such as Hadrian's Wall is a stated objective within the NCA profile. Therefore, there will be subsequent impacts on the characteristic landscape features.</p> <p>At the southern end of this unit, the railway embankment currently provides protection to some properties (both residential and commercial) in Parton, therefore loss or damage to this embankment will lead to coastal erosion and flooding.</p> <p>In the longer term, reactivation of the slopes and cliffs behind the existing railway will increase risk of erosion of cliff top land, including Lowca Wind Farm. It is also understood that there is proposed development of land at Micklam Farm, although the details of this are not known; this site is set back from the coastal edge, but could otherwise be affected in the long term if cliffs became reactivated.</p> <p>Apart from a short stretch along Parton, the England Coast Path is set back from the top of the cliff and moves inland of Lowca Wind Farm; it is therefore at no immediate risk.</p> <p>Impacts on the WFD objectives of relevant waterbodies must also be determined through further assessment</p>
<p>Cost</p>	<p>There are no costs associated with the Do nothing option.</p>
<p>Damages</p>	<p>The key damages are associated with forced closure and ultimately loss of the railway infrastructure, and risk to properties and business located inland of the railway line. The property related damages are £40 k. Damages related to the disruption and closure of the railway have not been calculated at this stage.</p>

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.</p>	
<p>Technical</p>	<p>Works would be low cost and reactive only, to address identified erosion issues rather than a 'policy unit wide' solution to those issues. The future lifespan of the existing defences will depend upon future conditions, for example storm frequency and magnitude. Where repairs are not carried out in a timely manner, then further problems may arise, accelerating time to failure.</p> <p>This does not provide a long term solution, particularly along this stretch where previous interventions suggest there has been undermining in the past.</p>
<p>Environmental</p>	<p>This Option would only result in a delay in the onset of defence failure. Once defences fail, the impacts would be as for the Do nothing option: see Option 1 for details.</p>

Costs	There are no Present Value Capital Works, since works are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £10 k.
Damages	The key damages are associated with forced closure and ultimately loss of the railway infrastructure, and risk to properties and business located inland of the railway line. It is unlikely, under this option, that works would significantly delay failure beyond that estimated for Do nothing (Option 1). Damages related to the disruption and closure of the railway have not been calculated at this stage.

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

Measures to maintain the existing standard of protection. This is would be a continuation of current activities involving patch repairs to the defences, based upon regular inspections and as part of a scheduled programme of works.	
Technical	<p>Patch repairs, if carried out well and are timely, can be effective in maintaining the integrity of the structure for several more years. However, where these are not carried out then further problems can arise which can then necessitate far more substantial and expensive interventions later. Works to prevent undermining and scour at the toe, together with a proactive approach to patch and repair of the masonry wall, may help to maintain the stability of this seawall for another few years.</p> <p>Beyond this, the situation may revert to Do nothing if repair works become too expensive or extensive. Given the direct exposure to waves with little or no buffer, it is also unlikely that low tech solutions are going to be suitable for long term Hold the line.</p>
Environmental	<p>In the short term there would be little change to the current situation, although overtopping flood risk to the Cumbrian Coast Railway will increase in frequency over time as standard of protection reduces, with a requirement for speed restrictions.</p> <p>In the longer term it is unlikely that such activities will remain feasible and the situation may revert to Do nothing: with impacts as detailed for Option 1.</p>
Costs	The Present Value Capital Works are estimated to be £250 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £410 k.
Benefits	The key damages are associated with forced closure and ultimately loss of the railway infrastructure – this may be delayed by 10 years, compared to Do nothing. Benefits related to the avoidance or reduction in disruption and closure of the railway have not been calculated at this stage.

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

This would involve more low cost measures to maintain, but not improve, the existing standard of protection. It could involve rock gabions or similar sacrificial defence options.	
Technical	<p>Gabions are not considered a sustainable solution due to their short design life: during severe events gabions are likely to become damaged and therefore require repair or replacement, there is also a risk that prior to repair works damage could be caused to the defence behind by subsequent storms. There would also be a need to remove the failed mesh before a longer term solution could be installed. Similarly, geobags are unlikely to be a viable option to consider along this coastline.</p> <p>Ad hoc rock armour placement could address the immediate issues of undermining, which is understood to be the key failure mechanism along this frontage, but is unlikely to be suitable as a long term solution. Even where there has been recent placement of rock along the northern part of the frontage, asset inspections indicate that this rock has been prone to damage and movement, suggesting the nature of such works may be inadequate.</p> <p>There would also be no additional works undertaken to address overtopping risk; therefore, this would remain a risk.</p>
Environmental	<p>The likely impacts are largely the same as Option 3, with works only providing a short term solution.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing rock armour along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites.</p> <p>Impacts on the WFD objectives of relevant waterbodies must also be determined through further assessment</p>
Costs	The Present Value Capital Works are estimated to be £2,010 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £3,310 k.

Benefits	The railway would remain protected from both erosion and overtopping for a short amount of time only, allowing continued operation. However, the risk of overtopping may increase over time, with implications for operations. Eventually it may become uneconomic to continue replacing or repairing gabions and the situation is expected to revert to Do nothing within 10 to 20 years. Benefits related to the avoidance or reduction in disruption and closure of the railway have not been calculated at this stage.
-----------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Hold the line: Improve existing defences (Option 5)

This would involve more substantial measures to maintain the existing standard of protection through improving the resilience of the existing defences. A sound toe structure is needed (i.e. rock armour rather than gabions) to ensure that the wall cannot be undermined by further lowering of the foreshore. Where overtopping is an issue, perhaps as a result of sea level rise, then it may be necessary to also raise this wall.	
Technical	This should address the issues of undermining, which is understood to be the key failure mechanism along this frontage. However, defences along this frontage are currently discontinuous so that simply improving existing defences may not address the risk to the railway as a whole.
Environmental	<p>Locally, such works would improve protection to the railway from overtopping and erosion, but there would remain weak links in the system, such that continued operation of the railway would remain at risk.</p> <p>This option would reduce risk to properties at Parton, but railway linkages may be lost which would be detrimental to the community.</p> <p>Investigations into feasibility of raising the seawall should take into consideration whether the new height of the wall would impact on the views of the local properties and from for passengers travelling on the railway, noting that the views from the Cumbrian Coast railway line are part of its heritage value.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing a rock revetment along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Impacts on the WFD objectives of relevant waterbodies must also be determined through further assessment.</p>
Costs	The Present Value Capital Works are estimated to be £3,350 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £5,460 k.
Benefits	The railway would remain protected from both erosion and overtopping, allowing continued operation. There would also be protection to properties within Parton. Benefits related to the avoidance or reduction in disruption and closure of the railway have not been calculated at this stage.

Hold the line: improve through constructing new revetments or seawalls (Option 6)

Given the extent of defences that are needed to enable the railway to continue along 11e2.4, there may be merit in constructing a rock revetment throughout.	
Technical	<p>The new structure would be designed to withstand the higher sea levels, wave forces, and foreshore lowering that might be expected and provide a long term solution to current issues of undermining and overtopping.</p> <p>Rather than the ad hoc responsive approach to date, there would be advantage in undertaking this sooner, proactively also protecting the deposits currently seaward of the railway line and thus adding a buffer of protection which may then also allow a lower defence structure to be constructed as overtopping onto the line will be less. There is also advantage in addressing the whole frontage at once given the accessibility of the area and thus potentially high mobilisation costs to undertake work and deliver materials.</p>
Environmental	<p>This option would maintain protection to the railway and provide adequate defence against future overtopping that might be a result of any sea level rise. There would also be improved long term protection to commercial and residential properties in Parton, bringing communitywide benefits. Long term protection would also be afforded to Lowca Wind Farm, potentially enabling future investment in the site.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing a rock revetment along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Impacts on the WFD objectives of relevant waterbodies must also be determined through further assessment</p>

Costs	The Present Value Capital Works are estimated to be £11,610 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £19,850 k.
Benefits	This option would continue to protect the railway and futureproof the infrastructure against potential increases in sea level rise, changes in wave climate or storminess. There would also be improved long term protection to commercial and residential properties in Parton. Benefits related to the avoidance or reduction in disruption and closure of the railway have not been calculated at this stage.

2.6.3 11e2.4 - Discussion of options

Table 9 summaries the cost and benefit calculations for the various options presented above.

There is a pressing need to better understand the level of risks to the railway and operations for continued safety and avoidance of unacceptable risk, as sudden erosion or overtopping during storms could result in catastrophic failure. An Asset Management Plan should be developed for this frontage, including stability assessments, overtopping potential, identification of trigger levels, monitoring and responses. In developing that, comparison and review of Network Rail's 2010 frontage management strategy is required.

To Hold the line to maintain the railway in the long term, the most suitable approach is to provide a formal rock revetment. It is recommended that this is done well in advance of the risk to the railway becoming critical, which it possibly already is in places.

Table 9 Policy unit 11e 2.4 Summary of economics

Option	Present Value Capital Works £m	Present Value Total cost (PVC)* £m	PV Benefit (Damage Avoided) £m ⁺⁺	Benefit Cost Ratio
Option 1 Do nothing	0.00	0.00	0.00	-
Option 2 Do minimum	0.00	0.01	0.04	4
Option 3 Hold the line: maintain through proactive maintenance	0.25	0.41	0.04	0.09
Option 4 Hold the line: maintain through reinforcing existing defences	2.01	3.31	0.04	0.01
Option 5 Hold the line: Improve existing defences	3.35	5.46	0.04	0.07
Option 6 Hold the line: improve through constructing new revetments or seawalls	11.61	19.85	0.04	<0.01
<i>*Present Value cost (PVC) inclusive of 60% optimism bias</i>				
<i>++ Excludes railway benefits</i>				

2.7 11e2.5: Harrington Parks to Harrington Harbour

Throughout 11e2.5, the railway and other built assets are set back from the coastal edge, with the area at risk from erosion now a green recreational space. However, this is predominantly 'made ground' created by slag deposits and other tipped spoil and includes the site of the former iron works and then the magnesite plant, demolished in the 1960s (see Figure 17).

The southern half of this is actively eroding; the northern half is partially protected by sections of wall in various states of disrepair. Attempts to hold a beach along the northern section of frontage have failed, likely due to both the deterioration of those structures and a lack of suitable beach building materials being transported along the foreshore. Overtopping of defences is reportedly an issue along this stretch. (CEUK, 2014).



Figure 17 The changing landscape south of Harrington Harbour - the 1950s map on the left shows the site of the Magnesite plant, whilst the aerial image shows today's coastal frontage (aerial © North West Regional Monitoring Programme).

2.7.1 11e2.5 - Initial screening of options

A key issue with respect to the future strategy here is the outcome of the investigation required by the SMP to confirm the appropriateness of the No active intervention policy for epochs 2 and 3, which would depend on the potential for contamination due to erosion of this former industrial site. The approach therefore at this stage is to offer possible approaches based upon alternative outcomes. For example, should it be concluded that there are no contamination issues from the landfill then the most appropriate management approach would be to now cease any interventions. However, if there is a need to continue protecting these same assets for several more decades then it will be necessary to provide more permanent protection.

A further issue to consider would be if erosion directly to the south of Harrington Harbour could result in outflanking and additional risk to the harbour. Whilst possible, this would be better addressed, if it occurs, by developing the harbour arm to provide that protection. Furthermore, a combination of that type of structure and the retreat of the shoreline would offer more opportunity for sediment accretion and more natural beach development, thereby enhancing defence at this location while also potentially improving amenity value.

This area has also been identified as part of a wider area for potential regeneration of Harrington. A feasibility study was undertaken in 2006 (Halcrow, 2006) to consider options. As part of this plan, this area would be protected as a leisure space, with any development of it focused on promoting leisure and recreational activities. This area was recognised as providing a significant asset unique to Harrington and a key element in the overall regeneration of the area.

Table 10 below summarises the rationale for taking long options forward to the short list stage.

Table 10 Screening of long list options for 11e2.5

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	There are limited assets at immediate risk, with key exceptions being car parking and amenity open land. However, this option would result in uncontrolled erosion, which may not be acceptable

			due to potential contamination risks. It has been assessed for comparative purposes only.
Do minimum	Reactive patch and repair of defences only.	Yes	This would be a continuation of current management and could be appropriate given the move to a No active intervention policy.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing standard of protection.	Yes	Patch repairs if carried out well and are timely could be effective in maintaining the integrity of the structure for several more years and as such is a viable option to be considered, but would not be a long term solution.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works, gabions to improve longevity of existing defences.	Yes	Options to modify and adapt existing defences may offer a suitable approach to short term management of assets along this coastline, although consideration needs to be given to the expected performance and design life to be attained. It is a viable option to be considered.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	The seawall is already in poor condition in places, but it may be appropriate to modify the existing walls, covering the poor and deteriorated structures with new and better protection, e.g. rock armour. The costs would need to be balanced against the move to a policy of No active intervention.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwaters.	No	Existing defences have not been effective in retaining beaches, which may be due to either poor condition of defences or scarcity of sediment (or both). For control structures to have a benefit they would need to be carried out in conjunction with significant recharge. This is likely be very expensive to implement and has not been considered further.
Hold the line: improve through constructing new revetments or seawalls	New shore parallel defences replacing or extending existing defences	Yes	Replacing like for like (i.e. new seawalls) is not recommended. The most appropriate option would be to modify the existing walls, covering the poor and deteriorated structures with new and better protection and construct new rock revetments along the presently unprotected 400 m length of this frontage.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought that this area is conducive to beach development. Therefore, any attempt to provide a beach on the present alignment would require significant recharge and several control structures to aid retention of recharge material. This is likely be very expensive to implement and has not been considered further.
Hold the line: improve through introducing cliff or slope stabilisation measure	This may include toe protection works, drainage or netting.	No	Undercutting of cliffs appears to be the key risk of failure, therefore provision of toe protection is likely to be the most effective way of managing this risk. Low cost measures such as ad hoc rock toe works are considered as part of the option "Hold the line: maintain through reinforcing existing defences ". Given the move to a policy of No active intervention, larger scale cliff stabilisation works are not considered appropriate. This has therefore not been taken forward as a separate option.
Managed realignment:	Low tech measures such as gabion baskets to reduce erosion rates.	No	Given the direct exposure to waves with little or no buffer, it is unlikely that low tech solutions are

construct erosion slowing defences		going to be suitable along this coast. This option has therefore not been considered further.
------------------------------------	--	-----------------------------------------------------------------------------------------------

2.7.2 11e2.5 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	<p>The seawall south of Harrington Harbour is already in poor condition in places, and there is no defence elsewhere. Without maintenance, any damage caused during storms will be left to deteriorate further, ultimately leading to failure of the seawall. Overtopping of defences will remain an issue in places and erosion of undefended cliffs will continue.</p> <p>Failure of defences would result in uncontrolled erosion of the landfill site, with potential contamination risk. There is a need to establish the extent of and type of material that is contained in the landfill or former industrial site, which could result in a need to intervene.</p>
Environmental	<p>Failure of defence may result in reactivation in the spoil cliffs along this frontage, with resultant erosion of landfill; the key issue is the potential release of contaminants which could impact on water quality and also for any beach users.</p> <p>Erosion along this frontage may also have implications for a number of outfalls along the frontage, which may need to be modified or relocated as the coast retreats.</p> <p>There will be lost of cliff top amenity land, as well as the car park at the northern end of the frontage, which lies just seaward of the existing defences. There is an alternative car park further inland, but access to the coast would be affected by erosion of the cliffs. The England Coast Path is set back along the top of the cliffs along this stretch so is not at immediate risk.</p> <p>As the cliffs retreat there may be consequences for the stability of the southern pier of Harrington Harbour, as it will become increasingly exposed to waves resulting in impacts to the operation of the harbour.</p> <p>Impacts on the WFD objectives of relevant waterbodies must also be determined through further assessment.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are associated with contamination risk and loss of car parking at Harrington Harbour. There would also be increased risks to the southern breakwater of Harrington Harbour. Damages related to the avoidance or reduction in risk to contaminated land and disruption and closure of the railway have not been calculated at this stage.

Do minimum (Option 2)

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.	
Technical	Works would be low cost and reactive only. These would be unlikely to be sufficient to prevent failure of defences, given their poor condition at present. The outcome would therefore be as for Do nothing.
Environmental	Given defences are already in a poor condition, impacts would be as for the Do nothing option: see Option 1 for details.
Costs	There are no Present Value Capital Works, since works are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £140 k.
Damages	As for Do nothing (Option 1), the key damages are associated with contamination risk and loss of amenity land and car parking at Harrington Harbour. There would also be increased risks to the southern breakwater of Harrington Harbour. Damages related to the risk to contaminated land and disruption and closure of the railway have not been calculated at this stage.

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

Measures to maintain the existing standard of protection. This is would be a continuation of current activities maintaining defences on an as required basis, making ad hoc repairs in places but not in others.	
Technical	<p>Patch repairs, if carried out well and are timely, may be effective in maintaining the integrity of the structure for a few more years. Although this approach accords with policy, there is that need to establish the extent of and type of material that is contained in the landfill, which could result in a need to intervene.</p> <p>Options to patch and repair the seawalls are not going to provide a long term solution.</p>
Environmental	<p>It is unlikely that such works would be sufficient to delay failure of defence for very long, therefore impacts are considered to be the same as the Do nothing option: see Option 1 for details.</p> <p>Works will take place along the existing structure, so there is no anticipated impact on landscape quality or qualifying features of Solway Firth pSPA.</p>
Costs	<p>The Present Value Capital Works are estimated to be £450 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £970 k.</p>
Benefits	<p>The key damages are associated with contamination risk and loss of car parking at Harrington Harbour – this may be delayed by 10 years, compared to Do nothing. There would also be increased risks to the southern breakwater of Harrington Harbour. Benefits related to the avoidance or reduction in risk to contaminated land and disruption and closure of the railway have not been calculated at this stage.</p>

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

This would involve more low cost measures to maintain, but not improve, the existing standard of protection. It could involve rock gabions or similar sacrificial defence options.	
Technical	<p>Rock gabions might offer a short term solution to quickly fix problems and delay failures by a few more years; but should not be considered as a long term solution. During severe events gabions are likely to become damaged and therefore require repair or replacement, there is also a risk that prior to repair works damage could be caused to the defence behind by subsequent storms.</p> <p>There would be no additional works undertaken to address overtopping risk; therefore, this would remain a risk to existing defences.</p>
Environmental	<p>It is unlikely that such works would be sufficient to delay failure of defence beyond 10 years, therefore impacts are considered to be the same as the Do nothing option: see Option 1 for details.</p> <p>Works will take place along the existing structure, so there is no anticipated impact on landscape quality or qualifying features of Solway Firth pSPA.</p>
Costs	<p>The Present Value Capital Works are estimated to be £200 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £630 k.</p>
Benefits	<p>The key damages are associated with contamination risk and loss of car parking at Harrington Harbour – this may be delayed by 10 years, compared to Do nothing. There would also be increased risks to the southern breakwater of Harrington Harbour. Benefits related to the avoidance or reduction in risk to contaminated land and disruption and closure of the railway have not been calculated at this stage.</p>

Hold the line: improve existing defences (Option 5)

An appropriate option would be to modify the existing walls, covering the poor and deteriorated structures with new and better protection, e.g. rock armour, combined with constructing new rock revetments along the presently unprotected 400 m length of this frontage (see Option 6).	
Technical	<p>Together with Option 6, this would address the issues of undermining, which is understood to be the key failure mechanism along this frontage and potentially provide long term protection to the frontage. It would also reduce the risk of outflanking at Harrington Harbour and damage to the southern harbour breakwater. Investment would need to be balanced against the long term policy of No active intervention.</p>
Environmental	<p>Such works would minimise risk of contaminants become released and thereby reduce impact on water bodies. There would also be protection of cliff top amenity land and the beach front car parking. A key benefit is that this could be undertaken in conjunction with works to protect Harrington Harbour, assuming the intention remains to Hold the line here.</p>

	There would be an increase in footprint; as the nearshore zone lies within the Solway Firth pSPA, the impacts of constructing rock armour along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Impacts on the WFD objectives of relevant waterbodies must also be determined through further assessment. Construction of new defence may impact on the visual amenity of the frontage, particularly where frontages have previously been undefended.
Costs	The Present Value Capital Works are estimated to be £770 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,340 k.
Benefits	The amenity land and car parking would remain protected from both erosion and overtopping, reducing the risk of pollution from the landfill site. In conjunction with options for Harrington Harbour, there would be wider benefits. Benefits related to the avoidance or reduction in risk to contaminated land and disruption and closure of the railway have not been calculated at this stage.

Hold the line: improve through constructing new revetments or seawalls (Options 6)

This would be undertaken in combination with Option 5, with rock revetments extended to include the currently unprotected 400 m of frontage.	
Technical	<p>Together with Option 5, this would address the issues of undermining, which is understood to be the key failure mechanism along this frontage and potentially provide long term protection to the frontage. It would also reduce the risk of outflanking at Harrington Harbour and damage to the southern harbour breakwater.</p> <p>The new structure would be designed to withstand the higher sea levels, wave forces, and foreshore lowering that might be expected and provide a longer term solution to current issues of undermining and overtopping.</p> <p>Investment would need to be balanced against the long term policy of No active intervention.</p>
Environmental	<p>Together with Option 5, such works would minimise risk of contaminants become released and thereby reduce impact on water bodies. There would also be protection of cliff top amenity land and the beach front car parking. A key benefit is that this could be undertaken in conjunction with works to protect Harrington Harbour, assuming the intention remains to Hold the line here.</p> <p>Construction of new defences in previously undefended sections may impact on the visual amenity of the frontage.</p>
Costs	The Present Value Capital Works are estimated to be £810 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,410 k.
Benefits	The amenity land and car parking would remain protected from both erosion and overtopping, reducing the risk of pollution from the landfill site. In conjunction with options for Harrington Harbour, there would be wider benefits. Benefits related to the avoidance or reduction in risk to contaminated land and disruption and closure of the railway have not been calculated at this stage.

2.7.3 11e2.5 - Discussion of options

Table 11 provides a summary of costs for the various options considered above: note that benefits relate primarily to the contamination risk and the railway, but these have not been calculated at this stage due to insufficient information.

It is essential that the contamination risk assessment identified by the SMP is carried out as soon as possible as the policy for the next epoch is dependent upon this. Without this, the most cost effective approach to defence management in 11e2.5 cannot be established.

To Hold the line over the long term to prevent erosion of the contaminated site, if there are no other options for its removal, then the most suitable approach is to provide a formal rock revetment both along the currently undefended length and over the existing structures.

Although there may be no built assets currently at risk, continued erosion could change that in the future. Although defending the line now would continue to offer a buffer to any built assets, there is not a good base of defence structures to build upon and there is no financial justification for building new defences at the present time.

Assuming that the contamination risk is low, the recommended approach here is to continue to monitor erosion to establish if other assets (for example the railway line and Harrington Harbour) might become at risk and revisit policy to intervene if necessary in the medium or long term. Options here will also be dependent upon plans for Harrington Harbour and wider regeneration plans for Harrington – there may be opportunities to consider Harrington regeneration area as a whole when justifying defences along this frontage. There also needs to be further investigations into the vulnerability of the south pier of Harrington Harbour, which may be used to justify future works along this frontage.

Table 11 Policy unit 11e 2.5 Summary of economics

Policy Unit	Option		Design Life	Capital Works year applied	Whole Life Cost (cash 2018)	Present Value (PV)			
						Capital Works	Maintenance and Operation Works	Total cost (PVC)	Total cost with Optimism Bias (PV(OB)c)
						Year	Year	£m	£m
11e2.5	Option 1	Do Nothing	10	-	0.00	0.00	0.00	0.00	0.00
11e2.5	Option 2	Do minimum	10	-	0.11	0.00	0.09	0.09	0.14
11e2.5	Option 3	Hold the line: maintain through proactive maintenance	20	5	0.75	0.45	0.15	0.61	0.97
11e2.5	Option 4	Hold the line: maintain through reinforcing existing defences	20	5	0.51	0.20	0.19	0.39	0.63
11e2.5	Option 5	Hold the line: improve existing defences	100	20	1.90	0.77	0.07	0.84	1.34
11e2.5	Option 6	Hold the line: Improve through constructing new revetments/ seawalls	100	20	2.00	0.81	0.07	0.88	1.41
11e2.5	Option 7	Additional Option - Option 5+6	100	20	3.89	1.59	0.14	1.72	2.76

2.8 11e2.7: Harrington to Steel Works Site

There are no formal defences along this frontage. The railway runs along the frontage, but is slightly set back from the coastal edge and fronted by an artificial bank of tipped spoil material (slag), which is currently subject to erosion. There is also some protection provided by the embankment of a former industrial railway (referred to as the 'mineral railway' on historical Ordnance Survey maps), but this is badly eroded particularly around its midpoint. There are a few properties behind the shoreline at the southern end of this frontage, but these are protected by the northern harbour breakwater.

Dredgings from Harrington Harbour have previously been placed along the beaches to the north to slow erosion, but these have been subsequently eroded. This was last carried out in 2014.

This area has also been identified as part of a wider area for potential regeneration of Harrington. A feasibility study was undertaken in 2006 (Halcrow, 2006) to consider options. As part of this plan, there were proposals to develop the area north of the harbour, including a new promenade and residential properties between the shoreline and the railway line.

2.8.1 11e2.7 - Initial screening of options

The policy here is to Hold the line, but only once necessary, i.e. only once there is a risk to the railway line. It is estimated that the embankment of tipped material is likely to be breached in the next five years, which would increase exposure of current railway infrastructure. Responsibility once this is breached will rest with Network Rail in maintaining protection to their infrastructure.

Table 12 below summarises the rationale for taking long options forward to the short list stage.

Table 12 Screening of long list options for 11e2.7

Long list options	Description	Short listed?	Rationale
Do nothing	No works undertaken	Baseline only	There are limited assets at immediate risk but continued erosion is likely to mean that the railway is at risk within the next five years. It has been assessed for comparative purposes only.

Do minimum	Reactive patch and repair of defences only.	No	There are no defences currently present, “Managed realignment: construct erosion slowing defences” may be considered as an alternative Do Minimum option, for comparative purposes.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing standard of protection.	No	There are no formal defences currently present, so this has not been considered further.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works, gabions to improve longevity of existing defences.	No	There are no formal defences currently present, so this has not been considered further.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	No	There are no formal defences currently present, so this has not been 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	This stretch of coastline is fairly exposed and there is limited sediment in the system. For control structures to have a benefit they would need to be carried out in conjunction with significant recharge. This is likely be very expensive to implement and has not been considered further.
Hold the line: improve through constructing new revetments seawalls	New shore parallel defences replacing or extending existing defences	Yes	Inflexible options such as seawalls are not recommended, but rock revetment may be an appropriate approach along this coast.
Hold the line: improve through beach recharge	Addition of new material to beaches.	Yes	Whilst it is not thought that this area is conducive to beach development, use of dredgings from Harrington Harbour may provide temporary protection to the backing cliffs.
Hold the line: improve through introducing cliff slope stabilisation measures	This may include toe protection works, drainage or netting.	No	Undercutting of the spoil embankment appears to be the key risk to the railway. Due to exposure conditions, low tech solutions are unlikely to be sufficient to continue holding the line, instead they may be considered as a measure to slow erosion as part of “Managed realignment: construct erosion slowing defences”. This has therefore not been taken forward as a separate option.
Managed realignment: construct erosion slowing defences	Low tech measures such as gabion baskets or loose tipped rock, to reduce erosion rates.	Yes	Low tech solutions may be appropriate in areas where there is no imminent risk to the railway. This option has therefore been considered further.

2.8.2 11e2.7 - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option no new works would be undertaken.	
Technical	Currently the railway is protected by a low embankment comprised of industrial spoil. Erosion of this means that a section of railway is at risk within the next five years. This would result in damage and possible loss of the railway. Beyond this these are cliffs, known as Walkers Brow, which could become reactivated in the longer term.

Environmental	<p>Most assets are set along the cliff line and most of the properties are set back from the coastal edge, apart from along the southern part of Salterbeck and a cemetery to the north. Depending on future erosion rates, these could be at risk in the long term (50 to 100 years). There are also a number of residential properties along Shore Road, Salterbeck, which could be at risk earlier than this and commercial buildings immediately north of Harrington Harbour.</p> <p>The key asset at risk is the Cumbrian Coast Railway, which lies along the back of the beach. A section of this could be lost or damaged within the next 5 years, forcing possible closure from this time. This would have wider implications for adjacent frontages, as the railway is a critical link between coastal towns and villages.</p> <p>The England Coast Path lies in front of the railway along much of this stretch; this is therefore at high risk of erosion under this scenario.</p> <p>Impacts of this option on the pSPA would have to be assessed under the Habitats and Species Conservation Regulations (2017) and impacts on the WFD objectives of relevant waterbodies must be considered.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are associated with forced closure and ultimately loss of the railway infrastructure. Damages related to the risk of disruption and closure of the railway have not been calculated at this stage.

Hold the line: improve through constructing new revetments seawalls (Option 2)

Although no current defence management is undertaken, intervention is going to be required before too long. Inflexible options such as seawalls are not recommended, being both expensive and prone to damage as seen elsewhere in the area; therefore, the most appropriate form of protection is a rock revetment.	
Technical	<p>The new structure would be designed to withstand the higher sea levels, wave forces, and foreshore lowering that might be expected and provide a longer term solution to current issues of undermining and overtopping.</p> <p>There could be merit in installing this sooner rather than later, along the present edge of the landfill embankment, as this may require a less expensive construction than one that directly abuts the railway.</p>
Environmental	<p>This option would provide a long term protection to the railway infrastructure. It would also reduce the long term risk of erosion to Salterbeck and benefit the local and wider community through preventing severance by ensuring that the railway and the station can remain operational (although this will also depend on approaches adopted along adjacent stretches of railway).</p> <p>Design of defences would need to consider the adopted route of the England Coast Path which runs seaward of the railway line for much of this frontage, and incorporate provision of a route into any design.</p> <p>As this would be a new structure there would be implications for the landscape character and visual amenity</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing a new rock revetment would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites.</p>
Costs	The Present Value Capital Works are estimated to be £3,750 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £6,430 k.
Benefits	This option would continue to protect the railway and futureproof the infrastructure against potential increases in sea level rise, changes in wave climate or storminess. Benefits related to the avoidance of or delay to risk of disruption and closure of the railway have not been calculated at this stage.

Hold the line: improve through beach recharge (Option 3)

This would only apply to the area to the north of Harrington Harbour and would not be appropriate along the more exposed frontage. It would involve the continued use of dredgings from Harrington Harbour to provide protection to backing cliffs.	
Technical	This option allows for an initial recharge of 600m length of beach. Alone, this would only provide temporary protection to cliffs along this section and would need to be implemented in combination with Option 2 to ensure protection to the entire railway infrastructure.
Environmental	Origins and nature of material considered for use in beach recharge must be undertaken. There is a risk of possible release of fine sediment to water environment, with implications for water quality within this

	<p>frontage, potentially moving into adjacent frontages. Impacts on the WFD objectives of these waterbodies must be considered.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of recharging the beach would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for effects on the integrity of the Natura 2000 sites.</p> <p>Assuming this was undertaken with Option 2, this option would provide a long term protection to the railway infrastructure. It would also reduce the long term risk of erosion to Salterbeck and benefit the local and wider community through preventing severance by ensuring that the railway and the station can remain operational (although this will also depend on approaches adopted along adjacent stretches of railway).</p> <p>There would be implications for the landscape character, visual amenity and the potential for recreational value of the beach following recharge.</p>
Costs	The Present Value Capital Works cost is £1,410k for this option. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,260 k. It is assumed dredged material from the harbour for maintenance are free supply.
Benefits	Damages and benefits related to the avoidance of or delay to risk of disruption and closure of the railway have not been calculated at this stage.

Managed realignment: construct erosion slowing defences (Option 4)

This would only apply to the areas where risk to railway is currently low and would not be appropriate along the more exposed frontage.	
Technical	<p>This option would only provide temporary and short term protection to cliffs along section where the railway is not at imminent risk and would need to be implemented in combination with Option 2 to ensure protection to the entire railway infrastructure. Gabions or even loose tipped rock could be considered, but would be sacrificial and would be unlikely to have lifetimes of beyond 10 years.</p> <p>These are not recommended as longer term solutions, and should be accompanied by suitable assessment of potential erosion risk to determine any operational limitations that may need to be put in place by Network Rail, reflecting the lesser performance characteristics of these measures.</p>
Environmental	<p>This option would slow erosion and protect railway for a time. There is a risk that during sever events gabions would become damaged and may split, which could be a health and safety hazard to beach users. The origins and nature of the sacrificial material must be considered as it is expected to enter the sedimentary system, potentially moving into adjacent frontages.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing a rock revetment along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. Impacts on the WFD objectives of the relevant waterbodies must also be considered.</p>
Costs	<p>a) Construction of rock gabions: The Present Value Capital Works are estimated to be £570 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £920 k.</p> <p>b) Placement of loose tipped rock: The Present Value Capital Works are estimated to be £3,220 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £5,150 k.</p>
Benefits	Benefits related to the avoidance of or delay to risk of disruption and closure of the railway have not been calculated at this stage.

2.8.3 11e2.7 – Discussion of options

Table 13 provides a summary of costs for the various options considered above: note that benefits relate primarily to the railway but these have not been calculated at this stage.

To Hold the line to prevent erosion of the artificial shoreline of mine waste (slag), the most suitable approach is to provide a formal rock revetment. It is proposed that this is done well in advance of the risk to the railway becoming critical, as a lower cost construction may be possible utilising the existing tipped fill and providing some a buffer between the shoreline and the railway which may reduce future risks. This approach should be preceded by more detailed risk assessment (required immediately) to determine the point at which erosion may result in instability of the railway line, to inform both safe operations of the line and enabling proactive construction of defences accordingly.

If relocation of railway is a possibility in the future, then construction of full defences may not be warranted. In this case, low tech erosion slowing measures may be appropriate but should be introduced immediately to avoid reaching a position where these can no longer provide an effective solution.

Development of a risk assessment to identify unsafe operational conditions for the railway is recommended, considering the size and frequency of storm conditions and the resulting erosion and overtopping that can arise during those, which will include potential instability of these defences.

Long term options here will also be dependent upon regeneration plans for Harrington, which could include development of North Beach, which would require construction of more formal defences. There may be opportunities to consider Harrington regeneration area as a whole when justifying defences along this frontage.

Table 13 Policy unit 11e 2.7 Summary of economics

Policy Unit	Option	Option	Design Life	Capital Works year applied	Whole Life Cost (cash 2018)	Present Value (PV)			
						Capital Works	Maintenance and Operation Works	Total cost (PVC)	Total cost with Optimism Bias (PV(OB)c)
			Year	Year	£m	£m	£m	£m	£m
11e2.7	Option 1	Do Nothing	0	-	0.00	0.00	0.00	0.00	0.00
11e2.7	Option 2	Hold the line: Improve through constructing new revetments/seawalls	100	-	5.49	3.75	0.27	4.02	6.43
11e2.7	Option 3	Hold the line: Improve through beach recharge	100	5	1.68	1.41	0.00	1.41	2.26
11e2.7	Option 4a	Managed Realignment: construct erosion-slowing defences	10	5	0.68	0.57	0.00	0.57	0.92
11e2.7	Option 4b	Managed Realignment: construct erosion-slowing defences	10	5	3.83	3.22	0.00	3.22	5.15
11e2.7	Option 5	Additional Costed Option: Option 2 and Option 3	100	5	13.22	5.16	1.39	6.55	10.49

2.9 11e2.8 and 11e2.9 (part): Steel Works Site and Steel Works to The Howe

This frontage consists of eroding slag deposit, with just a short length of defence (comprising 3 sections) part way along. This site was previously a quarry, but since the SMP2 was produced, there has been partial development of the former CORUS site with housing (Phase 1) and plans to expand that development (Phase 2) in place; therefore, assets at potential risk have changed and will increase further in the future – with the possible need to change the policy boundary between 11e2.8 and 11e2.9. It is noted in the developer's coastal retreat assessment implies that this site needs to be protected for 150 years.

The present defences are not in a condition that can be considered suitable for providing the long term protection that will now be required to prevent erosion of this area. Photographs also indicate these are a significant health and safety hazards in places with exposed steel from the seawall and sheet piles included.

2.9.1 11e2.8 and 11e2.9 (part) - Initial screening of options

This potential for site development was recognised by the SMP in setting a Hold the line Policy which was to be implemented by 'maintaining, upgrading or extending seawalls and revetments, as necessary to reduce risk to the redeveloped site'.

Although the developers commissioned a brief study to assess whether the Phase 1 works would be at risk, concluding that they are not at least in the foreseeable future (assuming quarrying operations have not weakened this material), the further plans indicate development into areas that could require the existing defences to be replaced and erosion protection to be extended. That may also extend into the southernmost section of 11e2.9. Conversely, based upon the present extent of

the development plans, it may be that it is not actually necessary to Hold the line along some the more southerly length of 11e2.8 unless the railway line, currently set back here, became vulnerable.

Table 14 below summarises the rationale for taking long options forward to the short list stage.

Table 14 Screening of long list options for 11e2.8 southern section of 11e2.9

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	Given the development of the site, failure of defence and resultant cliff erosion would not be acceptable. It has been assessed for comparative purposes only.
Do minimum	Reactive patch and repair of defences only.	No	Defences are already in a poor condition meaning that they are likely to fail in the short term. Therefore, this option is the equivalent of Do nothing and as such as not be assessed further as a separate option.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing standard of protection.	No	Efforts to patch and repair the existing defences, which are in a poor condition, or not present, are not going to be suitable to provide the necessary protection along this frontage.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works, gabions to improve longevity of existing defences.	No	Options to modify and adapt existing defences are not going to be suitable to provide the necessary protection along this frontage.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	No	Options to modify and adapt existing defences are not going to be suitable to provide the necessary protection along this frontage.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwaters.	No	It is not thought that this area is conducive to beach development. Beach solutions will be technically difficult and expensive so have not been considered further.
Hold the line: improve through constructing new revetments seawalls	New shore parallel defences replacing or extending existing defences	Yes	New seawalls along the erodible edge of the slag deposits could be effective but would also be expensive to construct and will suffer the same issues of scouring and potential undermining of the toe seen along other sections of this shoreline, so also not recommended. A better option is likely to be a rock armour revetment, but properly designed and constructed with geotextile, suitable toe, and to a height to address overtopping, not random tipped stone seen elsewhere locally which will ultimately fail.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought that this area is conducive to beach development. Beach solutions will be technically difficult and expensive so have not been considered further.
Hold the line: improve through introducing cliff slope stabilisation measure	This may include toe protection works, drainage or netting.	Yes	There may be some benefit in reprofiling and stabilising cliffs along this frontage, but additional works along the cliff toe are still likely to be required to ensure adequate protection to this frontage.
Managed realignment: construct erosion slowing defences	Low tech measures such as gabion baskets to reduce erosion rates.	No	It is unlikely that low tech solutions are going to be suitable along this coast. This option has therefore not been considered further.

2.9.2 11e2.8 and 11e2.9 (part) - Development and appraisal of short listed options

Do nothing (Option 1)

This is considered as a baseline against which other options can be appraised. Under this option all maintenance and management of the defences would cease and defences would be allowed to fail.	
Technical	There are only short lengths of defences along this frontage, which are generally in poor condition. Although over time changes to the slag cliffs have been of low magnitude, the cliffs are prone to erosion during storms. Under this scenario there would be a risk of cliff erosion, with resultant risk to cliff top assets.
Environmental	<p>This option would not reduce flood or coastal erosion risk to the frontage. Although there are not currently any residential properties or services within this frontage, the site of the decommissioned steel works is about to undergo development. This option would risk the viability of this project by leading to damage or loss of land from erosion and residual flood risk to the properties constructed.</p> <p>As this site is a decommissioned steel works site, there is risk of contaminated ground being released through erosion. Additionally, to the north of the site, seaward of the Derwent Howe Industrial Estate, there is a historic and an authorised landfill site. Further ground investigations would be required to establish the content of these sites and the extent of any contamination in the site. This option would lead to continued erosion and flooding of these sites, potentially leading to damage and breach of the sites.</p> <p>The nearshore environment within this frontage forms a part of the Solway Firth pSPA and there are examples of maritime cliffs and slopes (BAP habitats) within the frontage. NAI would allow these environments to develop naturally, though the benefits of this may not outweigh the contamination risk outlined above. Extent and severity of any impacts would have to be assessed under the Habitats and Species Conservation Regulations (2017). Implementation of NAI must not impact on the WFD objectives of the relevant waterbodies.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are associated with risk to cliff top properties within the old CORUS site. However, new or proposed properties cannot be taken into consideration in the national economics. Damages on UU Assets (gravity sewer in case of flooding and sewer to sea outfall in case of erosion) have not been monetised at this stage.

Hold the line: improve through constructing new revetments seawalls (Option 2)

This is likely to involve a rock armour revetment, properly designed and constructed with geotextile, suitable toe, and to a height to address overtopping.	
Technical	<p>The new structure would be designed to withstand the higher sea levels, wave forces, and foreshore lowering that might be expected and provide a long term solution to current issues of undermining and overtopping.</p> <p>Rather than the ad hoc responsive approach to date, there would be advantage in undertaking this sooner, proactively also protecting the deposits currently seaward of the railway line and thus adding a buffer of protection which may then also allow a lower defence structure to be constructed as overtopping onto the line will be less. There is also advantage in addressing the whole frontage at once given the accessibility of the area and thus potentially high mobilisation costs to undertake work and deliver materials.</p> <p>It may be possible to remove and reuse rock currently along unit 11e2.9.</p>
Environmental	<p>This option would ensure long term protection to CORUS site, but involves the construction of new defences along previously unprotected frontage and extending into an area where policy was NAI in medium long term. This would defend the landfill sites from potential damage.</p> <p>These are linear defences so are unlikely to have a wider impact on coastal transport. However, the nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing a rock revetment along the toe of the defences would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites. It is anticipated, however, that the long term impacts from such works on qualifying features can be scoped out at an early stage of the HRA. etc.</p> <p>Through reducing erosion of spoil deposits there may be potential benefits in terms of water quality along this frontage. However, the cliffs and slopes present along the frontage are a BAP habitat and constraining natural erosion rates may impact on their value. Potential impacts on WFD objectives of relevant water bodies must be taken into consideration.</p>

Costs	The Present Value Capital Works are estimated to be £3,510 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £6,020 k.
Damages	This option provides long term protection to the proposed development along the CORUS site. However, proposed new properties cannot be taken into account in the defence appraisal national economics.

Hold the line: improve through introducing cliff slope stabilisation measures (Option 3)

In combination with a rock armour revetment (Option 2): the height of the revetment could be limited, allowing some erosion of the upper cliff behind, which might then be trimmed and stabilised.	
Technical	To provide long term protection, this would need to be carried out in combination with Option 2, so the benefits would be similar. However, it will require a wider set back zone between the edge of any public space in front of the new development and frontage.
Environmental	<p>Potential impacts are largely similar to option 2, however with the allowance for some erosion of the cliffs and slopes. Some of these listed as BAP habitats and so allowing some natural erosion would likely help their natural value, particularly in relation to the pSPA present in the nearshore. Full assessment of potential impacts on the pSPA is required under the Habitats and Species Conservation Regulations (2017).</p> <p>By allowing some erosion of the cliffs, there remains some risk to the integrity of the landfill sites and so the risk of contamination of the surrounding environment. Potential impacts on WFD objectives of relevant water bodies must be taken into consideration.</p>
Costs	The Present Value Capital Works are estimated to be £1,040 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,680 k.
Damages	In combination with Option 2, this option provides long term protection to the proposed development along the CORUS site. However, proposed new properties cannot be taken into account in the defence appraisal national economics.

2.9.3 11e2.8 and 11e2.9 (part) - Discussion of options

Table 15 provides a summary of costs for the various options considered above: note that benefits relate primarily to future housing development of the site and have not been calculated at this stage. Following national appraisal guidance proposed future assets cannot be included in the national economic assessment although they may be very important for attracting local or regional funding.

The most suitable technical approach is to construct a formal rock revetment along the undefended lengths of this policy unit where there is a risk to assets, and to replace the existing defences, which are inadequate, with a similar design. Given the development has a 150 year life, these will need to be designed to withstand any further erosion over the remainder of a similar period. Furthermore, amongst the existing structures are some noticeable health and safety hazards. As such, mitigation measures are required to prevent public accessing those areas until those are removed, which in themselves may affect the current integrity of those structures and risks to the areas immediately above.

Risk assessments for the new development should be produced to assess both the extent of new defences, and risks posed by the failure of the existing structures. This should extend into 11e2.9, as necessary. There may also need to be an investigation into the risk of contamination from erosion of the former quarry works.

To inform further management of the frontage, an Asset Management Plan should be developed for this frontage, including stability assessments, overtopping potential, identification of trigger levels, monitoring and responses.

Table 15 Policy unit 11e 2.8 Summary of economics

Policy Unit	Option		Design Life	Capital Works year applied	Whole Life Cost (cash 2018)	Present Value (PV)			
						Capital Works	Maintenance and Operation Works	Total cost (PVe)	Total cost with Optimism Bias (PV(OB)c)
						£m	£m	£m	£m
11e2.8	Option 1	Do Nothing	10	-	0.00	0.00	0.00	0.00	0.00
11e2.8	Option 2	Hold the line: improve - construct new revetments/seawalls	100	-	6.04	3.51	0.25	3.76	6.02
11e2.8	Option 3	Improve through introducing cliff/slope stabilisation measures	100	10	1.53	1.04	0.02	1.05	1.68

2.10 11e2.9 (part): Steel Works to The Howe

This frontage consists of a largely undefended cliff of former slag deposits (known as Derwent Howe slag bank), which extends into unit 11e2.10. Throughout 11e2.9 there are no cliff top assets at risk. Along the southern extent of this unit is the development of the former CORUS site; this is addressed within 11e2.8 above.

Derwent Howe slag bank was operated as a quarry from the early 1990s up until planning permission expired in late 2016. It is owned by the County Council, with extraction undertaken by a local operator. As well as slag extraction, the site was used for the deposit of inert waste materials and recycling of wastes. It is understood that there were plans in place to develop a scheme to cap and landscape the site, but the status of these plans is uncertain. The slag bank has been identified as a Mineral Safeguarding Area for secondary aggregates in the Cumbria Minerals and Waste Local Plan, adopted 2017 (Cumbria County Council, 2017).

There are just two short lengths of defences partway along; these are of little consequence in terms of defence of this policy unit.

2.10.1 11e2.9 (part) - Initial screening of options

Along 11e2.9, the SMP2 policy is for No active intervention policy from the short term, but the SMP justification text makes no mention of potential contamination issues. However, the potential risk of contamination has been raised and, further to investigations, there may be a need for implementation along this frontage and certainly in the short term, whilst possible impacts are identified.

The other factor that has changed since the SMP is the development of the site to the south. Depending upon erosion rates, there is a possibility that defences to protect that development may have to extend a short distance north into 11e2.9; this is considered in 11e2.8 and should be considered as extending the boundary of that policy unit, rather than amending policy for this unit.

The options below (see Table 16) therefore consider possible approaches, should there be a need to defend due to contamination issues.

Table 16 Screening of long list options for 11e2.9

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Yes	This is the current SMP policy and has therefore be considered further.
Do minimum	Reactive patch and repair of defences only.	No	The two short stretches of defence are of little consequence, therefore do minimum would effectively be the same as Do nothing, and as such has not been 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	Attempting to provide a beach will require significant recharge and control structures, and would therefore be expensive. Given there are no assets at direct risk, this has not been considered further.
Hold the line: improve through constructing new revetments seawalls	New shore parallel defences replacing or extending existing defences	Yes	Should the potential contamination risk be deemed significant enough to warrant a longer term solution, then more substantial options would need to be implemented. Seawalls will be at high risk of scour and undermining, so is not considered appropriate along this frontage. It is unlikely that there will be a more cost-effective solution than constructing a rock revetment throughout although less 'formal' defences such as a riprap slope may offer another alternative.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	Attempting to provide a beach will require significant recharge and control structures, and therefore expensive. Given there are no assets at direct risk, this has not been considered further.
Hold the line: improve through introducing cliff slope stabilisation measure	This may include toe protection works, drainage or netting.	No	Toe protection works have been considered as part of 'constructing new revetments or seawalls' above. Undermining is understood to be the key driver of erosion therefore neither netting nor drainage works are likely to be effective here.
Managed realignment: construct erosion slowing defences	Low tech measures such as gabion baskets to reduce erosion rates.	Yes	Low tech solutions, such as gabions or rock at the cliff base to reduce erosion of the cliff toe, may limit erosion in the short term but will not stop it altogether and ultimately only work for a limited period of time. If remediation was considered to be an appropriate response to address the contamination, then such measures may be appropriate along this frontage, recognising that beyond the short term erosion would recommence.

2.10.2 11e2.9 (part) - Development and appraisal of short listed options

Do nothing (Option 1)

This is appropriate given the current SMP policy of No active intervention. Under this option no new works would be undertaken.	
Technical	<p>Under this approach, there would be continued erosion of slag deposits – with rates tending to vary due to the variable composition of the slag. Locally the rock revetment would continue to provide some protection, but there could be occasionally overtopping of the rock during storms, which would result in erosion of the bank behind. Armour blocks may also become displaced or removed, with the effectiveness of the defence likely to reduce over time.</p> <p>There is also a risk that the rock will eventually become outflanked due to continued erosion of the slag banks on either side. Erosion of the bank may also expose further tunnels, which could result in larger areas of the site becoming undermined and potentially accelerating erosion of the slag. Rates of erosion are difficult to estimate given the heterogenous nature of the slag deposits, but experience from further south at Whitehaven indicates that rates could be up to 3 m/year could occur should softer deposits become exposed.</p>

Environmental	<p>Quarrying activities at the site ceased in 2016, following expiration of the licence; the site is, however, defined as a Mineral Safeguarding Area for secondary aggregates. Further erosion of the site may have an impact on the deliverability of any future extraction.</p> <p>There are potential contamination issues from erosion of the spoil and the site was also previously used for deposit of waste materials, although the licence was for only inert materials: this could impact on adjacent water bodies.</p> <p>There are no land based designated sites in the vicinity, but the wider site has previously been identified as providing scope for significant wildlife habitat enhancement. There are also a number of archaeological remains on the site and in the vicinity, and subsequent mitigation and interpretation could be required.</p> <p>The England Coast Path runs along the back of the quarry, so could be at risk fairly soon, if the fronting ridge of material becomes eroded; elsewhere it is about 90 m back from the current edge. Buildings are more than 250 m inland of the coastal edge, so are unlikely to be at risk except in the long term (>50 years) even under the highest rates.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are associated with impact on quarrying activities and coastal path. There are no costs associated with the damages. Damages on UU Assets (gravity sewer in case of flooding and sewer to sea outfall in case of erosion) have not been calculated at this stage.

Hold the line: improve through constructing new revetments seawalls (Option 2)

This approach will only be required if the contamination risk is considered significant enough to warrant intervention. Two options have been considered: (a) rock revetment and (b) riprap slope	
Technical	<p>(a) The new structure would be designed to withstand the higher sea levels, wave forces, and foreshore lowering that might be expected and provide a long term solution to current issues of undermining and overtopping.</p> <p>(b) A riprap slope is a less formal defence option, involving a range of rock sizes, which is designed to be dynamically stable. This could be designed to provide a similar level of protection as the more formal, rock revetment and would provide a long term solution to current issues of undermining and overtopping. Being more mobile, it may be more vulnerable to storm damage and require more frequent maintenance to reform slopes.</p>
Environmental	<p>Option (a) would involve a new structure involving large boulders, but linear so limited impact on longshore drift is anticipated. This would protect the quarry area and minimise the risk of future erosion and therefore release of contaminants. As this would be a new structure there would be implications for the landscape character, although this is not specifically designated in this area.</p> <p>Option (b) would involve a less formal structure which is expected to naturally reprofile. It would look more natural but may involve a slightly larger footprint. The structure would be more mobile, but this means there is a potential for outwashing of smaller rocks possible during storms.</p> <p>Both options would support the Marine Safeguarding Area designation, by minimising the risk of further erosion.</p> <p>The nearshore zone lies within the Solway Firth pSPA, therefore the impacts of constructing a new rock revetment, under either a or b, would need careful consideration under the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects on the integrity of the Natura 2000 sites.</p>
Costs	<p>a) The Present Value Capital Works are estimated to be £3,610 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £6,220 k.</p> <p>b) The Present Value Capital Works are estimated to be £1,820 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £4,000 k.</p>
Benefits	Both options would continue protect the quarry and minimise contamination risk. The economic benefits of delay to or avoidance of contamination risks have not been calculated at this stage.

Managed realignment: construct erosion slowing defences (Option 3)

This would only apply if remedial works were planned in the short term to address the contamination risk. It would not provide a long term solution as erosion would be slowed but not stopped. Gabions would provide only a very short term solution; therefore rock placed along the toe may be a more sustainable solution. Rock could be relocated as required.	
Technical	This would only provide temporary protection to cliffs along this section, to allow time for any remedial works to address the potential contamination risk. Whilst gabions are relatively cheap and easy to construct

	they are not particularly suitable in this location, which is exposed to wave action, because they are too flexible and can be easily destroyed during storms. Toe armour would help reduce undermining of the toe, but, being lower than the measures considered under Option 2, would not prevent upper cliff erosion during surges and storm events. The rate of cliff retreat would be less than would occur naturally and there is also a possibility that following retreat of the upper cliff a more stable slope could form.
Environmental	This option would only provide a short term protection, which may be sufficient to address only potential contamination risk. There would still be erosion of the spoil slopes, but at a reduced rate than would occur naturally. In the long term, without further works, the situation would revert to one similar to Do nothing (see Option 1).
Costs	The Present Value Capital Works are estimated to be £1,050 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,710 k.
Damages	The economic benefits of delay to or avoidance of contamination risks have not been calculated at this stage.

2.10.3 11e2.9 (part) - Discussion of options

Table 17 provides a summary of costs for the various options considered above: note that benefits relate primarily to the landfill and associated contamination risk but these have not been calculated at this stage due to insufficient information.

The risk assessment for the new development of the CORUS site should be produced to determine whether any new or future defences might need to extend into 11e2.9, and consider amending the policy unit boundary as necessary.

Although not identified as an issue here, along with other sites in the area it would be recommended that some investigation into the risk of contamination from erosion of the former quarry works and waste infill are undertaken.

If further investigations indicate that there is no requirement to continue defending on the current line, then there should be no further investment in maintaining the existing revetments, and consideration might be given to the removal of the rock for reuse in works elsewhere.

However, if there are contaminant risks due to erosion of the quarrying site, then a further assessment of potential options and a review of the SMP policy would need to be considered ahead of implementing measures to Hold the line. A decision would need to be made whether it is cheaper to undertake remedial works to remove contamination or construct substantial defences, most probably in the form of a formal rock revetment or rip rap slope, in order to prevent further erosion into the long term.

This area has been defined as a Mineral Safeguarding Area for secondary aggregates in the Cumbria Local Plan. The deliverability of any future extraction may require defence of the frontage, therefore further evaluation may be required.

Table 17 Policy unit 11e2.9 Summary of economics

Policy Unit	Option		Design Life	Capital Works year applied	Whole Life Cost (cash 2018)	Present Value (PV)			
						Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
						£m	£m	£m	£m
11e2.9	Option 1	Do Nothing	10	-	0.00	0.00	0.00	0.00	0.00
11e2.9	Option 2a	Hold the line: improve - construct new revetments/seawalls	100	-	6.28	3.61	0.27	3.89	6.22
11e2.9	Option 2b	Hold the line: improve - construct new revetments/seawalls	100	10	5.52	1.82	0.68	2.50	4.00
11e2.9	Option 3	Managed Realignment: construct erosion-slowing defences	50	5	1.29	1.05	0.02	1.07	1.71

2.11 11e2.10: The Howe to Workington Harbour

This is a largely undeveloped area, believed to be made up of former slag deposits, which is currently protected by a length of rock armour revetment. There is evidence that some disruption to armour stone has occurred, with dislodged stone being moved northwards, with the original bull head rail toe piling missing across majority of frontage. There was also overtopping of the structure during winter 2014 storms, which caused erosion of bank behind. Any built assets are located several hundred metres inland, but any erosion of this area would have implications for the south pier structures of Workington Harbour.

This frontage is part of a larger area that is being proposed for a major regeneration scheme (Port Derwent). Any future development plans will need to take account of erosion risk to the site.

Derwent Howe slag bank lies at the southern extent of this unit (and extends south into unit 11e2.9); this has been identified as a Mineral Safeguarding Area for secondary aggregates in the Cumbria Minerals and Waste Local Plan, adopted 2017 (Cumbria County Council, 2017).

2.11.1 11e2.10 - Initial screening of options

The current SMP policy here for Managed realignment, through allowing existing defences to gradually deteriorate, recognising that currently there are limited assets at risk but that, in the longer term, assets could become at risk and there is also a potential contamination risk.

A key issue with respect to the future strategy here is a need to understand the potential for contamination from erosion of the spoil material, to confirm the appropriateness of the SMP policy in the current epoch as well as in the future. If for example it was concluded that this material should not be allowed to erode, then works incorporating the current defences would be most appropriate, not allowing them to deteriorate; the current implementation of policy is effectively No active intervention at the moment, not Managed realignment.

Therefore, the appropriateness of the SMP policy remains uncertain and the preferred strategy cannot be concluded until such investigations are undertaken.

The approach therefore at this stage has been to offer possible approaches based upon alternative outcomes. For example, should it be concluded that there are no contamination issues from the landfill then the most appropriate management approach would be to not intervene. However, if there is a need to continue protecting these same assets for several more decades then it will be necessary to provide more permanent protection.

Table 18 below summarises the rationale for taking long options forward to the short list stage.

Table 18 Screening of long list options for 11e2.10

Long list options	Description	Short listed?	Rationale
Do nothing	No works undertaken	Baseline only	There are limited assets at immediate risk but erosion would have potential consequences in terms of contaminants being released and also implications for harbour structures.
Do minimum	Reactive patch and repair of defences only.	Yes	Current defences are in a fair condition; therefore, this may be an appropriate solution.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing standard of protection.	Yes	Current defences are in a fair condition; therefore, this may be an appropriate solution.

Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works, gabions to improve longevity of existing defences.	No	Defences currently consist of rock revetment, it is likely that works would either be to maintain the defence (considered in option above) or to improve the defence, potentially by increasing its height or width to reduce overtopping risk (considered in option below). Therefore, this has not be taken forward as a separate option.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	There is potential to enhance improve the current rock revetment to ensure overtopping risk is reduced.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwaters.	No	Construction of new control structures would be expensive and given the limited assets at risk are not considered appropriate at this location.
Hold the line: improve through constructing new revetments seawalls	New shore parallel defences replacing or extending existing defences	No	There is already a rock revetment structures along this frontage. Construction of a new structure would be expensive and given the limited assets at risk is not considered appropriate at this location.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	Material is already retained along this beach by the harbour structures, adding additional material would probably require new structures to be built in order to prevent material being moved around into the harbour. This would be expensive and given the limited assets at risk is not considered appropriate at this location.
Hold the line: improve through introducing cliff slope stabilisation measures	This may include toe protection works, drainage or netting.	No	The current defences already provide cliff stabilisation; therefore, this not been taken forward as a separate option.
Managed realignment: construct erosion slowing defences	Low tech measures such as gabion baskets or loose tipped rock, to reduce erosion rates.	No	The revetment present is in fair condition and could be adapted or relocated to allow some limited erosion. Therefore, this not been taken forward as a separate option.

2.11.2 11e2.10 - Development and appraisal of short listed options

Do nothing (Option 1)

Although the current SMP policy is Managed realignment, it effectively involves this option. Under this option no new works would be undertaken and the existing defences would be allowed to deteriorate and eventually fail.

If there are no concerns over possible contamination, consideration might be given to actively removing that rock for beneficial reuse elsewhere within another policy unit, where protection is required.

Technical

Under this approach, the rock revetment would continue to provide some protection, but there could be overtopping of the rock during storms, which would result in continued erosion of the bank behind. Armour blocks may also become displaced or removed, with the effectiveness of the defence likely to reduce over time. Rates of erosion are difficult to estimate given the heterogenous nature of the slag deposits, but experience from further south at Whitehaven indicates that rates could be up to 3 m/year could occur should softer deposits become exposed.

If erosion occurs directly to the south of Workington Harbour it could result in outflanking and additional risk to the harbour and will certainly expose more of the harbour arm. Unless works are undertaken to address this then there could be issues associated with harbour operations.

Environmental	<p>Derwent Howe slag bank, at the southern end of this unit, is defined as a Mineral Safeguarding Area for secondary aggregates. Further erosion of the site may have an impact on the deliverability of any future extraction.</p> <p>There are potential contamination issues from erosion of the spoil cliffs, with subsequent effect on water quality and beach users.</p> <p>There are no land based designated sites in the vicinity. There are a number of archaeological remains on the site and in the vicinity, and subsequent mitigation or interpretation could be required.</p> <p>The English coastal path is about 60 m back from the current edge along much of the coastal frontage; under low rates it is unlikely to be at risk, but should rates be higher, it could be at risk in medium term. At the harbour arm, the route runs along the beach and the southern edge of the Harbour; here it could be at risk from erosion rerouting would need to be considered.</p> <p>Buildings are more than 250 m back, so unlikely to be at risk except in the long term (>50 years) even under the highest rates. The beach front car park could be lost fairly quickly and there is also an access road to this.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are associated with potential contamination risk. There are also potential damages related to outflanking impacts on the harbour, however these are not quantifiable at this stage. Failure assumed by year 10.

Do minimum (Option 2)

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.	
Technical	<p>Under this approach, the rock revetment would continue to provide some protection, but there could be overtopping of the rock during storms, which would result in continued erosion of the bank behind. Maintenance works could prolong the life of the structure by a few years.</p> <p>Armour blocks will eventually become displaced or removed, with the effectiveness of the defence likely to reduce over time. Rates of erosion are difficult to estimate given the heterogenous nature of the slag deposits, but experience from further south at Whitehaven indicates that rates could be up to 3 m/year could occur should softer deposits become exposed.</p> <p>As for Do nothing, if erosion occurs directly to the south of Workington Harbour it could result in outflanking and additional risk to the harbour and will certainly expose more of the harbour arm. Unless works are undertaken to address this then there could be issues associated with harbour operations.</p>
Environmental	This Option would only result in a delay in the onset of defence failure. Once defences fail, the impacts would be as for the Do nothing option: see Option 1 for details.
Cost	There are no Present Value Capital Works, since works are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £240 k. Based on 15 year design life.
Damages	The key damages are associated with contamination risk. At the current stage contamination risk damages have not been calculated.

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

Measures to maintain the existing standard of protection. This would involve maintaining defences on an as required basis, making ad hoc repairs in places but not in others.	
Technical	<p>Patch repairs, if carried out well and are timely, may be effective in maintaining the integrity of the structure for several more years. It is assumed that under this option any armour block that become displaced or removed would be replaced. Such maintenance should prolong the life of the structure by several years.</p> <p>Under this approach, the rock revetment would continue to provide some protection, but there could be overtopping of the rock during storms, which would result in continued erosion of the bank behind.</p>
Environmental	Dependent upon future conditions, this scenario should ensure that erosion along this frontage is minimised for several years. Eventually, damage caused by repeated overtopping may mean this approach become unsustainable and the situation would revert to Do nothing, but this may be delayed until at least the medium term. In the long term, impacts would be similar to Do nothing (see Option 1 for details).
Costs	The Present Value Capital Works are estimated to be £370 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £850 k, based on 20 year design life.

Damages	The key damages are associated with contamination risk and loss of car parking – this may be delayed by 10 years, compared to Do nothing. There would also be increased risks to the southern breakwater of Workington Harbour. There are no costs associated with the damages.
----------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

2.11.3 11e2.10 - Discussion of options

Table 19 provides a summary of costs for the various options considered above: note that benefits relate primarily to the avoidance of contamination from the landfill but these have not been calculated at this stage as there is insufficient information to do so.

It is essential that the necessary assessment of contamination from the landfill is carried out as soon as possible as the policy for the future of this area is dependent upon this and the most cost effective approach to defence management in 11e2.10 cannot be established without that.

If it is concluded that there is a long term need to Hold the line to prevent erosion of contaminated landfill, and there are no other options for its removal, then the most suitable approach is to maintain the existing rock revetment, which should delay erosion until at least the medium term. Longer term protection could be provided by improving the revetment to reduce overtopping, but this will involve additional costs.

Alternatively, if it is concluded that if there is no requirement to continue defending along the current line, then there should be no further investment in maintaining the existing rock revetment, and indeed some consideration might be given to its removal and reuse. Some works to the harbour arm may however then be required to ensure its stability and limit any erosion and overtopping risks.

Although there may be no built assets currently at risk, continued erosion could change that in the future and intervention may be required in some decades to come, although there is no financial justification for building new defences at the present time. This frontage lies within an area that has been proposed for a major regeneration scheme. Associated development plans will need to ensure that the erosion and flood risk is taken into account – there may also be opportunities to funding future defences that could benefit both the adjacent hinterland and the harbour.

The area at the southern end of this frontage has also been defined as a Mineral Safeguarding Area for secondary aggregates in the Cumbria Local Plan (Derwent Howe slag bank). The deliverability of any future extraction may require future defence of part of this frontage, therefore future evaluation may be required.

The approach here therefore should be to monitor erosion to establish if and when other assets might become at risk, taking account of evolving regeneration plans, and revisit policy to intervene at a point in the future.

Table 19 Policy unit 11e2.10 Summary of economics

Policy Unit	Option		Design Life	Capital Works year applied	Whole Life Cost (cash 2018)	Present Value (PV)			
						Capital Works	Maintenance and Operation Works	Total cost (PVc)	Total cost with Optimism Bias (PV(OB)c)
						Year	Year	£m	£m
11e2.10	Option 1	Do nothing	10	-	0.00	0.00	0.00	0.00	0.00
11e2.10	Option 2	Do minimum	15	-	0.19	0.00	0.15	0.15	0.24
11e2.10	Option 3	Hold the line: Maintain through proactive maintenance	20	5	0.66	0.37	0.16	0.53	0.85

3 Appraisal of non priority units

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

- 11e2.1 Whitehaven Harbour and north beach
- 11e2.6 Harrington Harbour
- 11e2.11 Workington Harbour

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 11e2.1 Whitehaven Harbour and north beach

3.1.1 Existing approach to flood and coastal erosion risk management

The SMP policy for 11e2.1 Whitehaven Harbour and north beach is Hold the line through to the long term (50 to 100 years) by maintaining harbour walls and gates. It was assumed that the harbour remains operational, with maintenance of the harbour structures the responsibility of Whitehaven Harbour Commissioners.

Justification for the policy was that this would maintain the integrity of the port and town and would also manage risks to the Scheduled Monuments of the Quay and Lighthouse.

No assessment of inner harbour structures has been undertaken for this report. The AECOM 2016 report noted that by inspection the West Pier was observed to be in generally good repair with no obvious signs of recent damage. The latest asset inspection (CH2M, 2017a), undertaken as part of the North West Regional Monitoring Programme, appraised the condition of the outer harbour walls to be Fair. Previous inspections (reported in CH2M, 2017a) conclude that there has been no notable change in the condition of harbour piers and breakwaters or changes in conditions within harbour observed over the past few years. Remedial works to repair the deck surfacing of the South Pier and replace the coping stones along its northern face were carried out in Spring 2014 following the winter storms.

Defences along North Shore consist of a linear rock armour revetment. Toe blocks to the armour structure are founded directly on compacted beach deposits and slag, making them vulnerable to movement in the event of beach movement at the toe (CECS, 2001). The beaches along this stretch are subject to cyclical changes, which periodically exposes the defences to undermining and movement, which could destabilise the armour (CEUK, 2016). Although the defences have a residual life of 20 to 50 years, they are currently considered to be in fair condition (CH2M, 2017), with rock armour missing in places and evidence of undermining and toe movement, particularly along the northern stretch of revetment (CH2M, 2017) and adjacent to the slipways.

3.1.2 Strategy considerations

Since the SMP2 was adopted there has been a proposal to extend the current SPA, with a change in name from the Upper Solway Flats and Marshes Special Protection Area SPA to Solway Firth SPA. Other than this there have been no changes in environmental designations. The adopted England Coastal Path runs around the back of the marina and dock.

To the south of Whitehaven (policy unit 11e4.1), the SMP policy is No active intervention. A previous report by AECOM (2016) highlighted concern that this policy is not compatible with a Hold the line policy for Whitehaven Harbour, as ongoing erosion of spoil cliff along Whitehaven South Beach is progressively exposing the inner parapet wall of West Pier, placing it at risk of failure. The preferred option from the AECOM study was to maintain the existing west pier structure, which would be in accordance with the current SMP policy. It is assumed that this would be included as part of implementing the policy of Hold the line along this frontage.

Along the north shore of Whitehaven there are proposals in place for a £300 million scheme, led by property company BEC, in partnership with Copeland Borough Council and Whitehaven Harbour Commissioners, which will involve development and regeneration of Whitehaven harbourside and surrounding area. Plans include construction of a multi storey carpark within 70 m of the current shoreline. There has also been some consideration into extending the current shoreline position seawards, immediately north of the north pier to enable reclamation and redevelopment of the area behind.

3.1.3 Discussion

There is no justification at the current time to change the SMP policy; economic arguments for continuing to Hold the line will be enhanced by future development of the hinterland. Recent asset inspections indicate that there has been movement of the defence toe, in response to changes in beach level. If this situation continues, works to address this should be considered such as the placement of additional rock along the toe to bolster the defence.

It is recommended that development plans for Whitehaven consider potential improvements to the coastal frontage including upgrading the current defence.

Any future plans to advance the current defence will need to consider the following:

- Potential impact on the pSPA – although the consultation document suggest that existing coastal defences are unlikely to have an impact on the designated features, a HRA will be required. Any advance in defence will result in coastal squeeze and loss of intertidal habitat.
- MMO approval (Marine License) – this may be required, depending upon the extent of proposed works.
- The potential impact on adjacent frontages due to changes in longshore drift – although there is unlikely to be an impact on beaches to the south, due to the prevailing drift direction, there may be impacts on shorelines north, where the railway line is already vulnerable.
- The potential impact on Whitehaven Harbour – it is possible that any extended defence could alter tidal flows past the harbour entrance and therefore affect sediment movement and siltation patterns.
- Impact on recreational beaches – there is currently limited beach along the southern part of this frontage, but this widens to the north. Any seaward extension could mean that this beach area could narrow or be lost altogether.
- The SMP policy may need to be formally changed to Advance the Line, requiring an SMP Change Process will need to be initiated. Any proposed changes to SMP policy should include community and stakeholder consultation prior to being submitted for approval by local authority cabinet, submission to the Regional Flood and Coastal Committee (RFCC) and final approval by the Environment Agency.

Such works could also bring positive benefits, including:

- Reduced risk to hinterland assets, including heritage features, which in turn should encourage further investment in the area.
- Potential to develop and improve the coastal frontage, possibly incorporating a new cycleway and enabling a new route for the England Coast Path, improving resilience of slipways and improving the visual landscape.
- Bolstering of North Pier, providing increased protection to Whitehaven Outer Harbour.

On the southern side of Whitehaven Harbour (South Beach), the AECOM project appraisal report for Whitehaven South Beach identified a series of actions that should still be undertaken to continue to look at other justifications for defending South Beach. These may result in a case to be made for introducing new defences now, or in the future, which are unlikely to be detrimental to other areas

of the coast and therefore there are no immediately obvious reasons why they should not be permitted if funding were found. In the meantime, the approach should be to monitor erosion to establish if and when other assets might become at risk and revisit policy to intervene at a point in the future.

Future actions:

- The most recent asset inspection report (CH2M, 2017) recommends a watching brief be kept on toe movement, particularly between the slipways where movement has occurred due to beach losses.
- Liaison between developers and local authority to discuss consideration of future protection of the shoreline and potential funding opportunities.
- Should plans progress regarding potential extension of the current defences seaward, a full investigation will be required to assess impacts and the need to formally change SMP policy.

3.2 11e2.6 Harrington Harbour

3.2.1 Existing approach to flood and coastal erosion risk management

The SMP policy for 11e2.6 Harrington Harbour is Hold the line through to the long term (50 to 100 years) by maintaining harbour walls. It was assumed that the harbour remains operational.

No assessment of inner harbour defences has been undertaken. Outer structures have been assessed as part of the North West Regional Monitoring Programme. The latest asset inspections (CH2M, 2017b) conclude that Harrington South Pier is in Fair condition, with some defects noted in the crest of the masonry wall. The quay walls are also observed to be in Fair to Good condition but the pier between the inner and outer harbour are reportedly in poor condition. Harrington North Pier is reported to be in Good condition, although a previous observation by CEUK (2013) suggested that the armour stone looks oversteep for the exposure conditions and reprofiling was recommended (it is not known whether this has been carried out).

The most recent Harbour Master's report (March 2018; Allerdale Borough Council, 2018) reported that although the recent winter storms did not cause any structural damage to the main pier or harbour quays, there was damage to the gabion baskets on the south shore and those between the pier and the breakwater. Several large rocks were also displaced from the rock armoured breakwater.

3.2.2 Strategy considerations

Since the SMP2 was adopted there has been a proposal to extend the current SPA, with a change in name from the Upper Solway Flats and Marshes Special Protection Area SPA to Solway Firth SPA. Other than this there have been no changes in environmental designations. The adopted England Coastal Path runs around the back of the marina and dock.

There are proposals to promote the economic regeneration of the area of Harrington using the Harbour as the central feature. A feasibility study was undertaken in 2006 (Halcrow, 2006) which set out a phased approach to regeneration, including development of the Outer Harbour involving construction of new and extended North and South breakwaters at the harbour entrance.

3.2.3 Discussion

There is no justification at the current time to change the SMP policy; economic arguments for continuing to Hold the line will be enhanced by any future regeneration of the area.

Any future plans to change the configuration of the breakwaters will need to consider the following:

- Potential impact on downdrift and updrift areas (in particular units 11e2.5 and 11e2.7) – any extension to the breakwaters is likely to intercept the northerly drift, this may have positive

impacts on the beach immediately to the south, but may affect beaches to the north, which are already experiencing erosion

- The potential impact on the outer harbour – calmer conditions may be created within the outer harbour, which may encourage greater siltation that currently experienced. Increased build-up of material to the south, may also create issues due to the formation of a sand bar across the harbour entrance.
- Potential impact on the pSPA – although the consultation document suggest that existing coastal defences are unlikely to have an impact on the designated features, a HRA will be required. Increased dredging requirements could also have consequences on the ecology of the area

Such works could also bring positive benefits, including:

- Reduced risk to the south of the harbour (11e2.5), which would reduce contamination risk resulting from erosion of this frontage.
- Reduced risk to hinterland assets, including heritage features, which in turn should encourage further investment in the area and enable development of recreational and tourism opportunities.
- Improved conditions within the Inner and Outer Harbour, providing an area of calm water for all craft.
- Improvements to the visual amenity and landscape of the area.

Future actions include:

- Continued inspection and maintenance of harbour structures, with repairs and remedial works undertaken by Harrington Harbour and Dock Board as necessary.
- Depending on the policy for 11e2.5, there may need to be further investigations into the vulnerability of the south pier of Harrington Harbour. 11e2.5 frontage currently protects the South Pier inner section from the prevailing conditions. Any erosion of the beach and slag slopes here could therefore place this structure at greater risk of failure.
- Liaison between potential developers and Allerdale Borough Council to develop future regeneration plans and ensure integrated approach to considering coastal erosion and flooding risks along adjacent frontages and identify potential funding opportunities.
- Should plans progress regarding potential extension of breakwaters, a full investigation will be required to assess impacts locally and on adjacent shorelines and nearshore.

3.3 11e2.11 Workington Harbour

3.3.1 Existing approach to flood and coastal erosion risk management

The SMP policy for 11e2.11 Workington Harbour is Hold the line through to the long term (50 to 100 years) by maintaining and upgrading harbour flood defence walls. It was assumed that the harbour remains operational and improvements affordable. Workington Harbour is a Municipal Port owned and operated by Cumbria County Council, who maintain responsibility for maintenance of structures.

No assessment of harbour structures has been undertaken for this report. The latest asset inspection (CH2M, 2017b), undertaken as part of the North West Regional Monitoring Programme, reported that the current condition of the South Pier Breakwater is Fair, although recent erosion of the crest was evident.

The condition of the breakwaters was discussed with the Port Manager, who advised the rubble mound breakwater extension to the South Pier was built by the MoD in the 1940s from 35 tonne concrete blocks. The condition of the breakwater and the beach is monitored by the port, and they

were aware of only of 3 occurrences of damage over the last 20 years, with the latest being in the Oct 2017 storms. It is understood that Allerdale Council and the Port have an arrangement with the company that runs the quarry to the south to occasionally extract surplus beach material rather than allowing it to overtop the breakwater crest and enter the navigation channel. The North Pier and North Beach retaining wall was reinforced with rock armour more than 10 years ago, but this area is becoming vulnerable to undermining again, the failure of this structure could make the port area vulnerable to tidal flooding.

3.3.2 Strategy considerations

The Port of Workington is one of the largest ports in Cumbria and there has been significant investment in the area as part of expansion plans.

The Port of Workington is also identified in the Cumbria Minerals and Waste Local Plan (CCC, 2017) for a waste treatment and management facility and for safeguarding of its wharves and rail sidings.

Since the SMP2 was adopted there has been a proposal to extend the current SPA, with a change in name from the Upper Solway Flats and Marshes Special Protection Area SPA to Solway Firth SPA. Other than this there have been no changes in environmental designations. The adopted England Coastal Path runs along the southern harbour arm and around the back of the harbour, before rejoining the coast half a kilometre north of the harbour.

3.3.3 Discussion

There is no justification to change the SMP policy; economic arguments for continuing to hold the line will be enhanced by any further development of the port and regeneration of this part of Workington.

Future actions include:

- Continued inspection and maintenance of harbour structures, with repairs and remedial works undertaken by Cumbria County Council as necessary. The most recent asset inspection report (CH2M, 2017) recommends repair of the crest of Workington South Pier.
- Depending on the policy for 11e2.10, there may need to be further investigations into the vulnerability of the south pier of Workington Harbour. The Howe currently protects the South Pier inner section from the prevailing conditions. Any erosion of the beach and slag slopes here could therefore place this structure at greater risk of failure.

4 References

Allerdale Borough Council (2018). Harbour Master's Update. Harrington Harbour and Dock Board – 16 March 2018. Available on-line:

<http://democracy.allerdale.gov.uk/documents/119474/Harbourmasters%20report.pdf>

Coastal Engineering UK Ltd (2013). Allerdale Borough Council Annual Coastal Monitoring Inspection – October 2012.

Coastal Engineering UK Ltd (2014). Allerdale and Carlisle Annual Local Monitoring Report 2012

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

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

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

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

CH2M (2017c). Copeland Analytical Report, 2016. Prepared for Copeland Borough Council, as part of the North West Regional Monitoring Programme. December 2017.

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

Cumbria County Council (2017). Cumbria Minerals and Waste Local Plan 2015 to 2030. Formally adopted September 2017.

Halcrow (2006) Harrington Harbour Regeneration Study. Prepared for Allerdale Borough Council. May 2006.

Halcrow (2011). North West England and North Wales Shoreline Management Plan SMP2: main report and supporting appendices. North West & North Wales Coastal Group.

For Comment

Supporting technical data

Review of “Workington Development Site - Coastal Retreat and Wave Overtopping Assessment: Summary Report (RPS, 2017)”

Background

RPS were commissioned by Olnato Ltd to advise on the sea defence at the site of the old Corus steel plant, Workington. In an earlier report (May 2015), RPS concluded that “...*Olnato propose that construction of the new revetment will not be undertaken for a period of six years (or sooner if the County Council is ready to proceed with their works before then) to allow time for the County Council to establish its coastal protection proposals for the adjoining coast. During this period the Stage 1 housing will be developed as the Stage 1 site does not require coastal protection works along the vertical seawall and the most seaward corner of the development is some 75 metres back from the coastline to the north of the sea wall. This is equivalent to some 160 years of coastal retreat plus an allowance of 16 metres for overtopping.*” In response to this, Allerdale Council Planning department requested further information about the derivation of the coastal erosion and overtopping set back line proposed.

As such, the RPS report provides a summary of issues in relation to coastal erosion and overtopping along this frontage.

Assessment of erosion risk

RPS undertook a preliminary assessment of the future coastal retreat rates of the slag banks at the study area, assuming a scenario in which it was assumed that the existing armour had ceased functioning as an effective coastal defence, i.e. Do nothing.

RPS used a simple equation to take account of future sea level rise: $R2 = (R1/S1) \cdot S2$; where: $S1$ =historical sea-level rise rate (m/yr), $S2$ = future sea level rise rate (m/yr), $R1$ = historical retreat rate (m/yr), $R2$ = future retreat rate (m/yr).

They used the undefended slag bank on the southern part of the site to inform the potential historical erosion of unprotected slag material, and calculated change through comparing a historical orthograph, from 1961, with a recent Google image. For this they calculated that the slag bank had retreat around 4.88 m over 42 years, giving a mean historical retreat rate of 0.12 m/year. A historical sea level rise rate of 0.2 mm/year was applied and 0.6 mm/year taken as a future rate.

The analysis projected an average annual rate of cliff retreat of around 0.36 m/year, which was translated to a retreat of 54 m over the next 150 years (for comparison with NCERM and the SMP predictions, this would equate to 36 m by year 100).

Assessment of overtopping

Inshore wave climate data from along the shoreline of Moss Bay derived from the wave transformation model and simulations conducted by RPS for the initial coastal protection study were used to undertake overtopping calculations using techniques contained in the EurOtop Manual. Overtopping risk was appraised for a Do nothing scenario.

The following reason for considering overtopping was given: “*the eroded slag material could become near vertical and subject to impulsive loading conditions. Under these conditions, incident waves can break against the near vertical shoreline and result in a violent up-rushing jet of water which can cause excessive overtopping in the region immediately behind the eroding shoreline.*”

Taking account of future sea level rises, for a 1 in 100 year return period condition, a wave of the following hydraulic parameters was assumed to occur 10 m offshore from the existing shoreline:

Sea surface elevation = 6.24 m, Max Period = 8.76 s, Significant wave height = 3.413 m, Local Water Depth = 0.61 m, Water Level = 5.63 m.

Based on guidance from EurOtop, it was estimated that 95% of the overtopping would travel approximately 16 m landward. The report therefore concludes that *“the building line should be 16 m landward of the eroded HW mark to allow the overtopping waters to be drained away by promenades; roads etc. and prevent overtopping water entering the buildings.”*

Conclusions of the report

The report concludes the following:

- “1. To allow for 150 years of coastal retreat, the building line of the development proposed by Persimmon Homes should be 54 metres back from the high water mark at the current slag bank coastline along the northern part of the site.*
- 2. To account for excessive overtopping from impulsive wave loading, the building line of the development should be moved back an additional 16 metres from the line of the eroded shoreline.*
- 3. Thus if the building line is 75 metres back from the existing high water mark along the northern section of the coastal frontage, the development is expected to have more than 160 years of protection from coastal erosion in this area.”*

Appraisal

Both the Shoreline Management Plan and the National Coastal Erosion Risk Mapping (NCERM) study have considered erosion risk; conclusions from these are summarised below. Neither of these studies considered overtopping risk.

Shoreline management plan (2011):

This does not provide specific data for the Corus frontage, but gives the following estimates for the frontage between Saltom Bay and Workington:

0 - 20 years: Up to 10 m of erosion could occur along the active cliffs, but several metres could occur due to a single event, during this period.

20 – 50 years: Cliffs along this stretch could erode by up to 25 m by year 50, but could be less than 5 m along more resistant frontages. Several metres could occur due to a single landslide event.

50 – 100 years: Cliffs along this stretch could have eroded by up to 50 m by year 100, but could be less than 10 m along more resistant frontages. Several metres could occur due to a single landslide event.

NCERM (updated 2017):

The data set provides three estimates for epoch; these are cumulative distances for each epoch. The highest values estimated for this frontage are:

By 20 years: between 4 and 8 m

By 50 years: 10 and 20 m

By 100 years: between 20 and 40 m

Based on the data above, the estimate provided by the RPS study seems reasonable, although at the lower end of the estimates.

It should also be noted that in the RPS calculations, the assumption regarding future sea level rise is not in line with the most recent Environment Agency guidance on climate change allowances for use in flood risk assessments. RPS should have used the Climate Change advice allowances for planning and flood risk assessments², which indicates rates increasing from 2.5 mm/year to 13 mm/year giving 0.99 m to 2115. Also the source of the quoted rate for historical sea level rise is unknown, and

² (<https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>)

does not accord with data from regional tide gauges published by the National Oceanography Centre, which indicates trends of 1.22 mm/year at Heysham, -4.61mm/year at Workington and 2.07mm/year at Portpatrick³.

There is, however, significant uncertainty associated with predicting change along these cliffs:

- historically this shoreline has experienced little or no sea level rise, with erosion being mainly storm-driven; as such, there is a high level of uncertainty with regard to how these artificial cliffs may respond in the future, should sea level rise accelerate.
- Being mainly storm driven, rates of erosion are highly dependent upon future storm frequency and magnitude. Unfortunately, no beach profile data has been undertaken along this frontage since 2014 and there is therefore poor understanding of how much retreat may occur during a storm event.
- The heterogenous nature of the artificial spoil cliffs means that their resistance varies from location to location, so predicting future behaviour is even more difficult. For example, along the Whitehaven South Beach frontage, recent investigations have found that following a number of years of low rates of erosion, since 2003 the rate has increased; the reason for this increase remain uncertain. Currently the average annual rate is estimated to be between 2 and 3.5 m/year. This is significantly higher than the current estimates for this site and may not be applicable to this particularly, but does demonstrate the level of variability in terms of resistance of different spoils.

Before assuming safety of the site, through defining a setback line based on anticipated rates of erosion, further studies and monitoring would be recommended. These would need to include extensive bore hole data to assess whether the character of the spoil changes through the cross section; improved understanding of how cliffs response to storm events and continued monitoring of beach and cliff conditions.

³ <http://www.psmsl.org/product/trendstrends.txt>