



11d5 Seascale to St. Bees

(Technical report by Jacobs)

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Policy area: 11d5 Seascale to St Bees

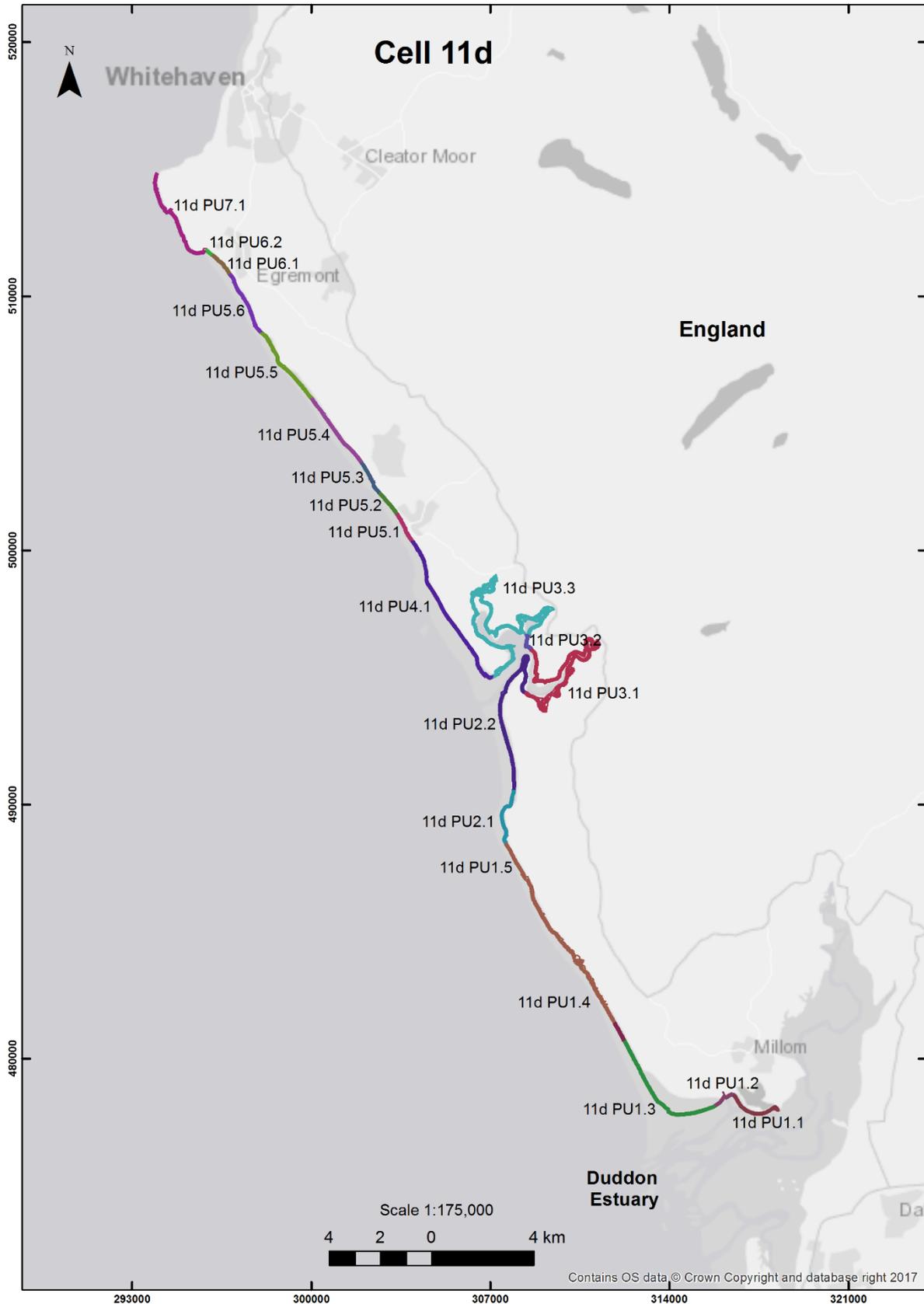


Figure 1 Sub Cell 11d Hodbarrow Point to St Bees Head Location Plan of policy units. Baseline mapping © Crown copyright and database rights, 2019. Ordnance Survey licence number: 1000019596.

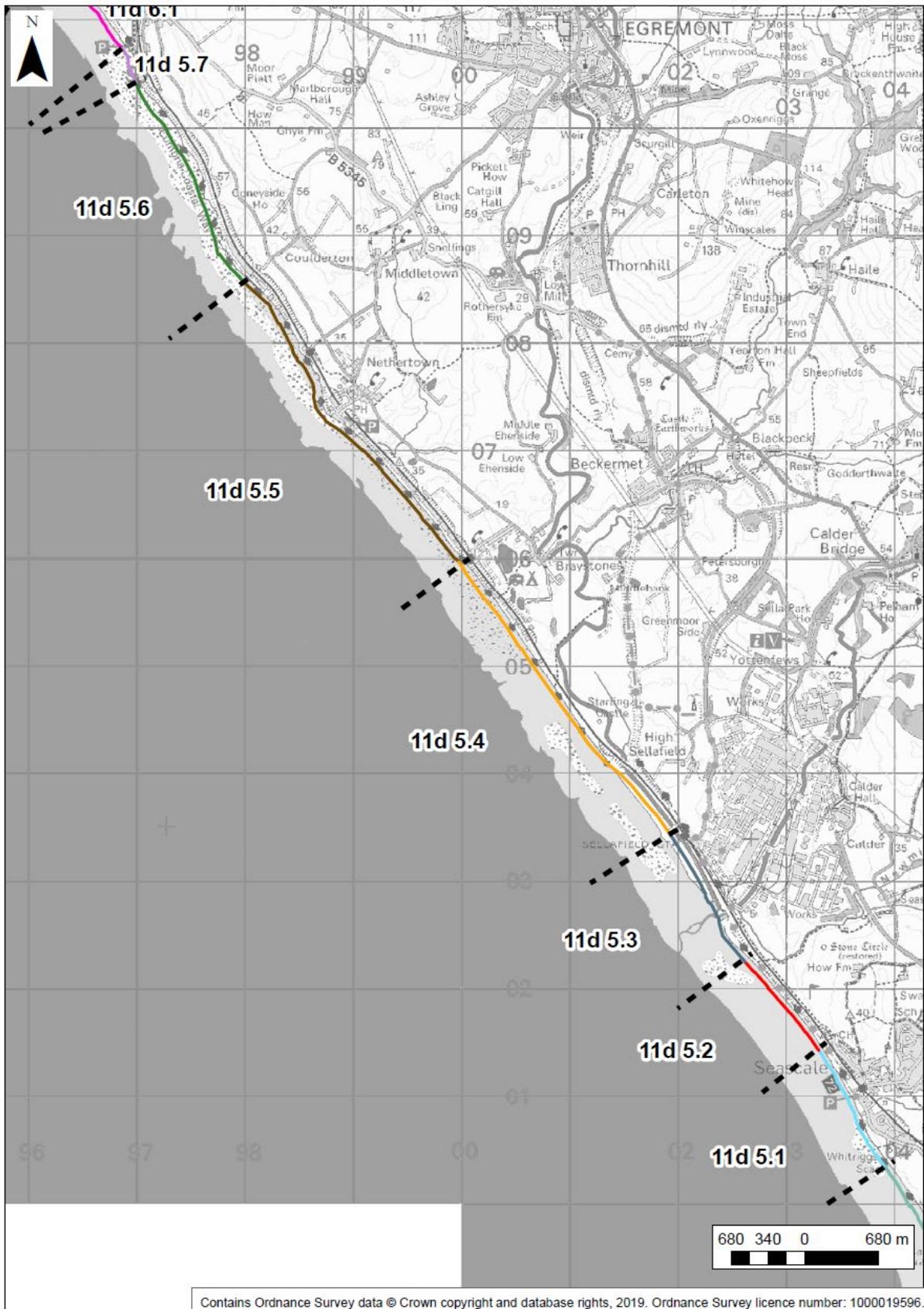


Figure 2 Location of Policy Area 11d5: Seascale to St Bees. Baseline mapping © Crown copyright and database rights, 2019. Ordnance Survey licence number: 1000019596.

1 Introduction

1.1 Location and site description

<p>Policy units:</p>	<p>11d5.1: Seascale (priority unit)</p> <p>11d5.2 Seascale to Sellafield (priority unit)</p> <p>11d5.3 Sellafield (priority unit)</p> <p>11d5.4 Sellafield to Braystones (priority unit)</p> <p>11d5.5 Braystones, Nethertown, Couderton (priority unit)</p> <p>11d5.6 Couderton to Sea Mill (priority unit)</p> <p>11d5.7 Sea Mill to Pow Beck (priority unit)</p>
<p>Responsibility:</p>	<p>Copeland Borough Council</p> <p>Cumbria County Council (Highways)</p> <p>Network Rail</p> <p>Nuclear Decommissioning Authority</p> <p>Private landowners</p>
<p>Location:</p>	<p>The policy area falls within sub cell 11d: Hodbarrow Point to St Bees Head and extends from the village of Seascale to Pow Beck. This frontage encompasses the villages and smaller communities of Seascale, Braystones, Nethertown and Couderton, as well as the Sellafield nuclear site and the adjacent Moorside site, which was previously being considered for a new power station.</p>
<p>Site overview:</p>	<p>The coastline encompasses a diverse range of habitats including mud and sand flats, shingle and pebble beaches and honeycomb worm reefs.</p> <p>Generally, this is a rural setting with the major development at Sellafield being the exception to this.</p> <p>Although Sellafield Nuclear Power Station has entered decommissioning, there are expanding energy industries, together with the tourism sector, which are key employers in the area and add to the development pressure. There have previously been expansion plans adjacent to Sellafield (Moorside Project) which would provide significant opportunities in the area, with potential impacts on the surrounding villages in terms of provisions of housing for increased workforce and transportation routes. However, plans are currently on hold.</p> <p>Tourism and agriculture are likely to remain important contributors to the local economy. Settlements along the coastal strip are linked by the Cumbrian Coast Line and coastal road. The Cumbrian Coast Line railway runs along the top of, or in front of, the till cliffs between Sellafield and St Bees (11d5.4 to 11d5.7) which are prone to failure. Fringing beaches are present along this stretch of coastline and north of Nethertown sandstone bed outcrops dominate the foreshore. There is a variety of formal and informal defences along this stretch giving some protection to both the railway embankment and residential properties.</p> <p>Seaward of the railway line there are several permanent and seasonally occupied beach dwellings which have been constructed on the crest of the gravel beach and rely on the beach for protection from flooding and erosion.</p> <p>There are no statutory land based environmental designations along this frontage, but Drigg Dunes lie to the south of the frontage and these are designated as a Site of Special Scientific Interest (SSSI) and a Special Area of</p>

	<p>Conservation (SAC). The notifications recognise the broad range of maritime habitats represented by the site which support a rich and varied range of flora, invertebrates and amphibian species. The dune heath along the northern end of Drigg is of particular significance as it is the largest example of this rare habitat on the west coast. The site is also part of the Drigg Coast European Marine Site. The intertidal and nearshore are part of the Cumbria Coast Marine Conservation Zone (MCZ), which extends from Saltom Pit to the mouth of the Ravenglass Estuary. It protects intertidal and shallow subtidal habitats and the diverse range of plant and animal communities these habitats support.</p>
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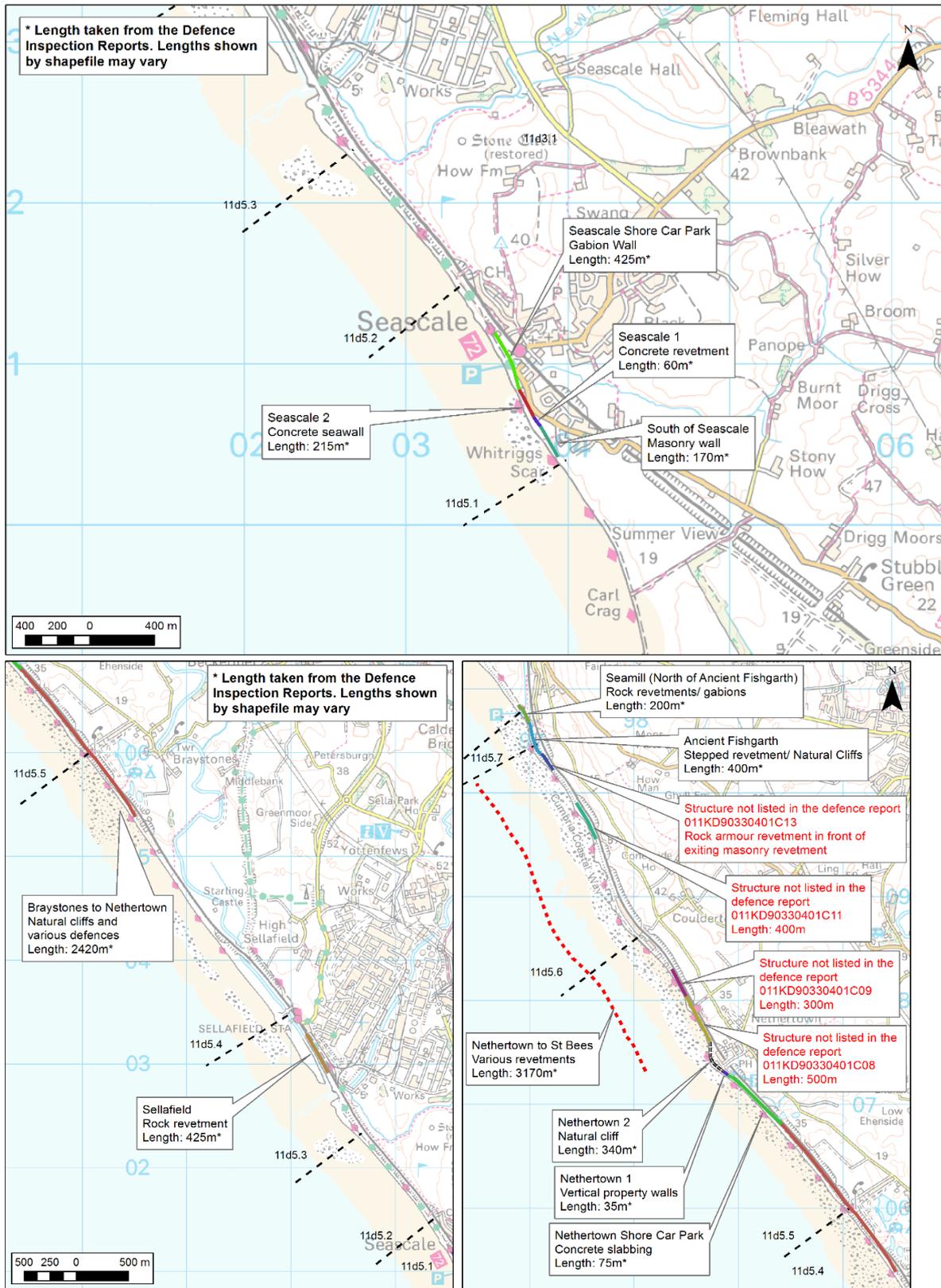


Figure 3 Policy unit location plan and defence overview. Baseline mapping © Crown copyright and database rights, 2019. Ordnance Survey licence number: 1000019596.

1.2 Current SMP policy

The policy details for the whole policy area are shown in the table below, taken directly from the SMP2 (Halcrow, 2011).

Table 1 Current SMP policy for policy area 11d5.

Location		Policy and Approach (from 2010)		
		0-20 years	20-50 years	50-100 years
11d5.1	Seascale	Hold the line – By maintaining the rock gabions at Shore car park and maintaining or re-constructing the seawall fronting the B5344.	Hold the line – By maintaining defences and potential requirement for extending revetment adjacent to the B5344 and address outflanking to the south.	Hold the line – By constructing larger defences.
11d5.2	Seascale to Sellafield	No active intervention – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk.	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk.
11d5.3	Sellafield	Hold the line – Maintain linear revetment and rock armour defences.	Hold the line – Maintain and construct larger defences.	Hold the line – Maintain and construct larger defences.
11d5.4	Sellafield to Braystones	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk. Undertake a study to assess tidal risks in the Ehen flood plain upstream of SMP boundary.	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk.	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk.
11d5.5	Braystones, Nethertown, Coulderton	Managed realignment – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk. Develop adaptation strategy for properties on beach. Subject to consent, ongoing beach management could help reduce risks in the short-term. No further development should be permitted along the beach	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk. Not technically viable or economically justified to defend properties on beach in medium or long-term. No further development should be permitted along the beach.	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk. No further development should be permitted along the beach.
11d5.6	Coulderton to Sea Mill	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk.	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk.	No active intervention – Monitor flood and erosion risk to railway; only carry out works if the railway is at risk.
11d5.7	Sea Mill to Pow Beck	Hold the line – With limited intervention, monitor erosion risk to railway, then maintain and upgrade railway defences as necessary.	Hold the line – With limited intervention until the railway is at risk, maintain and upgrade railway defences as necessary.	Hold the line – Maintain and upgrade railway defences as required. (No active intervention if railway no longer operational).

2 Appraisal of priority units

There are seven policy units within Seascale to St Bees Head (11d5): all have been defined as priority policy units for the strategy:

- 11d5.1 Seascale
- 11d5.2 Seascale to Sellafield
- 11d5.3 Sellafield
- 11d5.4 Sellafield to Braystones
- 11d5.5 Braystones, Nethertown, Coulderton
- 11d5.6 Coulderton to Sea Mill
- 11d5.7 Sea Mill to Pow Beck

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 this priority unit. The primary justifications for the policies at the SMP level were:

- **Social:** 11d5.1 Maintains the integrity of Seascale, associated residential assets and infrastructure and allows for maintenance of railway as transport linkage, including use by nuclear site. Policy unites where properties lie at the back of the beach the short-term policy allows ongoing beach management and development of an adaptation strategy for properties. But the SMP stated that defending these properties will be unsustainable in the future as sea level rises, resulting in the loss of properties on the beach crest in the long-term.
- **Environmental:** Works with natural processes and avoids potential contamination risks (11d5.3). No known designated conservation sites¹ or intertidal habitat present to constrain a Hold the line policy.
- **Economic:** At 11d5.1, policy is economically viable, and social and community benefits justify maintenance of defences in the long-term. At Sellafield, economic values and potential contamination issues would justify defences, whilst elsewhere there is no justification for intervention until railway is at risk, when viability would depend on overall case for railway.

2.1.2 Current defences

The frontage from Seascale to Pow Beck includes a variety of formal and informal coastal defences. Table 2 provides defence structural details. 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). Additional information has been provided by Network Rail, identifying key works required along their network; this is summarised in Table 3.

¹ Since the SMP2 was developed the Cumbria Coast MCZ protecting habitats on the beach and intertidal zone was designated in 2013

Table 2 Details of existing defences: 11d5. Information taken from the latest asset inspections (CH2M, 2017a)

Location		Structure Type	Length (m)	Crest Level (mOD)	Foreshore Toe Level (m)	Condition	Residual Life (years)
11d5.1	South of Seascale	Masonry Wall	170	+5-10			20-50
11d5.1	Seascale 1	Concrete Revetment	60	+6.5			10-20
11d5.1	Seascale 2	Concrete Sea Wall	215	+6.5	+1.05-1.72		5-20
11d5.1	Seascale Shore Car Park	Gabion Wall	425	+7.3	-0.04-2.72		10-20
11d5.3	Sellafield	Rock revetment (1-4t rock armour)	425	+9.9	No data	Fair	20-50
11d5.4 11d5.5	Braystones to Nethertown	Natural Cliffs and Various Defences	2,420	+6.0-12.0	+5.19-10.23	Fair/Good	20-50
11d5.5	Nethertown Shore Car Park	Concrete Slabbing	75	+8.0-10.0	+7.5-8.0	Fair/Poor	10-20
11d5.5	Nethertown 1	Vertical Property Walls	35	+8.0-10.0	+7.5-8.0	Fair	20-50
11d5.5	Nethertown 2	Natural Cliff	340	+5.0-8.0	+4.86-6.82	Fair	20-50
11d5.5 11d5.6	Nethertown to St Bees*	Various Revetments	3,170	+8-10	+2.7-8.6	Fair/Good	20-50
11d5.6 11d5.7	Ancient Fishgarth*	Stepped Revetment/Natural Cliffs	400	+9.7	+5.41-7.39	Fair/Poor	10-20
11d5.7	Sea Mill (North of Ancient Fishgarth)	Rock Revetment (1-4t rock armour) and Gabions	200	+7.0	+4.76-5.88	Poor	10-20

Table 3 Network Rail Assets

Policy unit	Name	Number	Additional Notes	Work Required	Implement Year
11d5.3	Calder Viaduct and Approaches	1521546		19/20 renewal works recently completed; removal of concrete invert, installation of rock armour upstream of viaduct and concrete repairs.	2019/20
11d5.3	Sellafield Pitching	1508991	Coastal defence located between Seascale and Sellafield stations. The defence comprises of stone and concrete pitched revetment with square protruding concrete sections (dragon's teeth) equally spaced and rock armour at the toe in some locations.	The revetment has suffered significant scour with random areas of missing and damaged dragon's teeth. Large voids along the rock armour section. Preventative repair works also required to stone and concrete pitched revetment with works to replace missing dragon's teeth. Essential preventative works are required to infill areas of large voids. 19/20 renewal works recently completed, including concrete	2019/2020

				repairs to pitching slabs and access platform.	
11d5.4 and 11d5.5	Braystones Embankment	1521421	Coastal defence centred at Braystones Station. Comprises an embankment protecting the railway along the rear of the shore. There are isolated areas of rock armour and gabion basket present, but the majority of the frontage is unprotected. The defence is fronted by a sloping shingle beach and a non continuous terrace supporting beach huts/dwellings at the toe of the rail embankment.	There are areas along the defence that are showing signs of erosion. Protection measures are needed at the toe to improve the resilience of the defence.	2017/2018
11d5.5 to 11d5.7	Nethertown-St Bees Sea Walls	1521421		Littoral drift and erosion to embankment. Essential review and options/solutions required to enhance the resilience of the defence.	2018/2019

Policy unit 11d5.1 (Seascale)

Along the Seascale frontage (Figure 4) the concrete revetment along the southern section is susceptible to damage from lowering beach levels and potential outflanking from erosion of unprotected cliffs to the south.

Along the car park, the condition of the gabion wall and rock is generally Fair (see Figure 5). Winter storms of 2013 and 2014 damaged gabions in front of car park which has resulted in intermittent armour stone protection being provided. Remaining unprotected gabion sections are vulnerable to damage in future, which could lead to armour protection being extended across the whole frontage, north of the jetty (CH2M, 2017a). Cumbria Highways have already undertaken some work to enhance toe protection. Ongoing exposure could lead to breach of the existing defences, erosion of the hinterland and an increase in flood risk from overtopping.



Figure 4 (a) Seascale concrete seawall (b) South of Seascale masonry wall (Site visit photo 2015; CEUK, 2016)



Figure 5 Seascale Shore car park defences looking south (Site visit photo 2015; CEUK, 2016)

Policy unit 11d5.2 (Seascale to Sellafield)

The beach is backed by low sand dunes and the railway embankment. The dunes are well vegetated and show little sign of change (CH2M, 2017b).

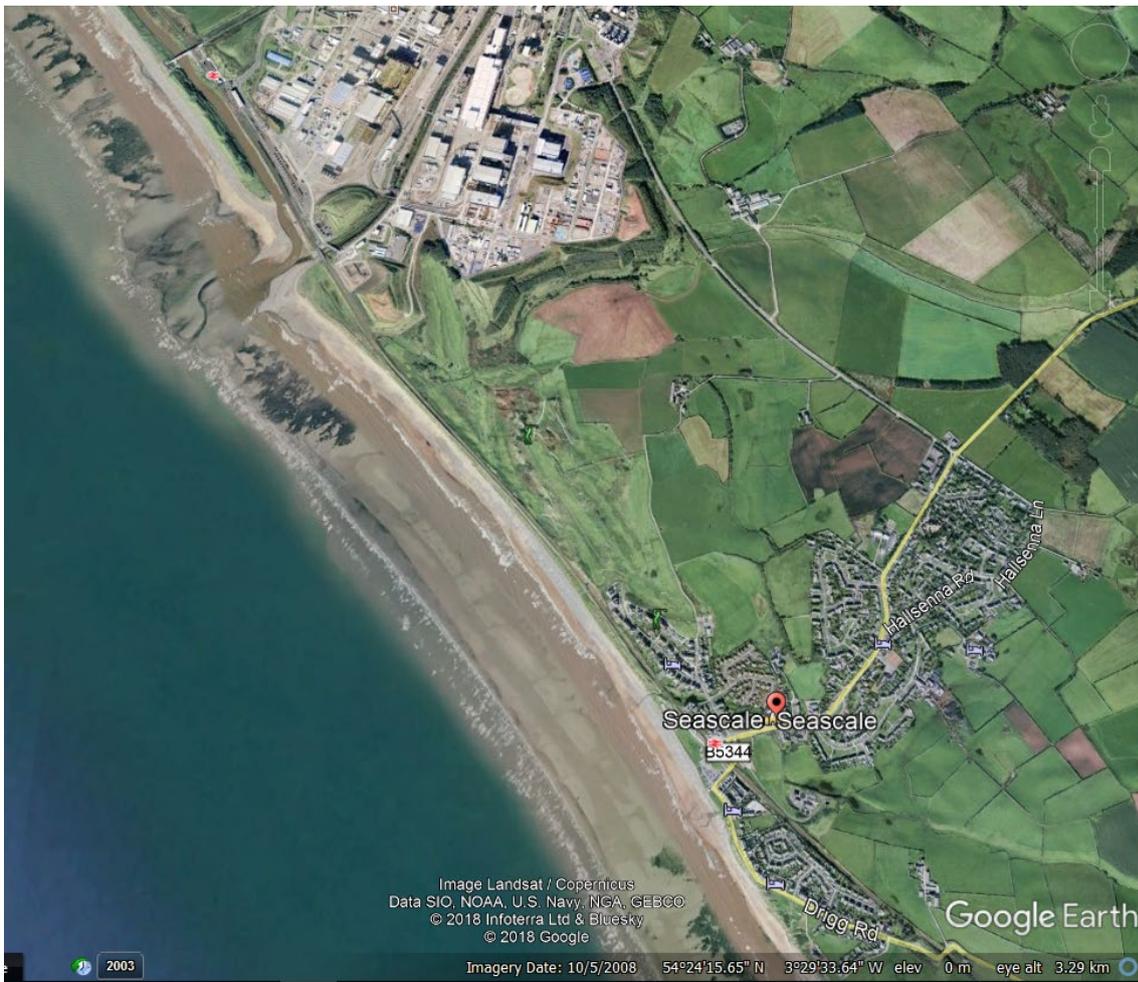


Figure 6 Seascale to Sellafield (11d5.2) (Google Earth)

Policy unit 11d5.3 (Sellafield)

A large rock revetment defends the nuclear plant and railway line to the north of the Calder and Ehen outlet. There is some evidence that toe blocks have been displaced over time but overall condition of the structure is Fair (Figure 7). Network Rail have recently undertaken defence repair works to the southern end of the frontage towards the River Calder, to the access platform and the revetment.



Figure 7 Sellafield (11d5.3) (Site visit photo 2015; CEUK, 2016)

The outlet channel of the River Ehen is diverted southwards, parallel to the coast, by a dune capped shingle spit. This runs along the shoreline for over two kilometres forcing the channel to outlet where it meets the discharge from the River Calder at Sellafield (11d5.3). The spit was subject to manmade modifications in 1949 when two pipe lines were installed (Coastal Engineering UK, 2016a).

In 2010, a notch was cut in the spit to form an access route for the beach import of the Evaporator D unit to the Sellafield site, which revealed that the top of the spit was artificial, probably consisting of excess fill from excavations associated with the pipeline installations. The notch was subsequently remediated. Repairs were also made to the southern end of the spit following damage during the 2014 storms.



Figure 8 Sellafield nuclear facility, fronted by the Ehen and Calder river mouth (11d5.3) © North West Regional Monitoring Programme, 2015

Policy unit 11d5.4 (Sellafield to Braystones)

There are formal coastal defences at Braystones station at the northern end of the policy unit. Here, there is a defended embankment with the railway to the rear; elsewhere there are isolated rock armour and gabion baskets but much of the remaining frontage is undefended. A shingle beach and non continuous terrace supports beach huts and properties at the seaward toe of the railway embankment to the north of the policy unit. In 2016, Network Rail extended a section of the rock armour revetment along the railway embankment immediately south of Braystones station across sections previously occupied by properties which were taken down in 2015. New gabion defences were constructed at the first property south of Braystones station, filled with beach shingle rather than single sized stone. Therefore, it is likely the fines will be washed out and the gabion structure will settle (see Figure 9).



Figure 9 Braystones – rock revetment and gabions (Site visit photo 2015; CEUK, 2016)

Policy unit 11d5.5 (Braystones, Nethertown and Coulderton)

Between Braystones and Nethertown, there are various defences (Figure 10) including sections of revetment protecting the railway, which are in good condition, and informal defences along the beach properties comprising of gabion baskets and reprofiled shingle berms in various states of condition. At Nethertown car park, the concrete slabbing has failed and overall condition is Poor.



Figure 10 Nethertown 2 – Natural Cliff and Slipway at Nethertown shore car park (11d5.5) (Site visit photo 2015; CEUK, 2016)



Figure 11 Coulderton – beach properties (11d5.5 and 11d5.6) © North West Regional Monitoring Programme, 2015

Across the Coulderton frontage (Figure 11), there are a range of defences that have been placed in an attempt to reinforce the crest of the shingle bank north of the railway arch. There are gabions, random blocks and vertical stone and timber construction and also a number of properties lie at the railway embankment seaward toe.

Winter storms in 2013 and 2014 caused movement in the shingle beach and damage to some properties. Local property owners built up the shingle fronting their properties to try and improve the standard of protection. Along this frontage, monitoring has indicated beach reprofiling, with a recorded increase in the shingle crest height and width fronting the properties (see Figure 12).



Figure 12 Braystones to Coulderton – shingle beach reprofiling (Site visit photo 2015; CEUK, 2016)



Figure 13 11d5.5 to 11d5.6 random tipped protection to the railway embankment. Rock shown in right photo appears to act as a spillway to a minor culvert. (Site visit photo 2015; CEUK, 2016)

Policy unit 11d5.6 (Coulderton to Sea Mill)

Various types of slope protection have been used in front of the railway line; these are the responsibility of Network Rail. There are two sections of revetment protecting the railway, which are in reasonable condition, with shorter sections of rock protection. Further north near Ancient Fishgarth, the stepped revetment is fronted by a revetment which is missing in several places. The cliffs behind appear fairly stable but there has been erosion at the southern end.



Figure 14 11d5.6 (Coulderton to Sea Mill) - various defences (Site visit photo 2015; CEUK, 2016)

Policy unit 11d5.7 (Sea Mill)

At Sea Mill (11d5.7), there is a linear gabion and rock revetment in a poor condition; the gabion baskets have failed and parts of the rock revetment are also displaced (Figure 15, Figure 16 and Figure 17).

A coastal protection options appraisal was undertaken for this frontage in 2012 (Capita Symonds, 2012) and provided additional details of the existing defences (Table 4). This report examined the effectiveness of the existing defences, clarifying their ownership and maintenance responsibilities, and examined options for the future management; it is discussed further in Section 2.10.



Figure 15 Sea Mill defences (Capita Symonds, 2012)

Table 4 Sea Mill Additional Existing Defence Details, taken from Sea Mill Coast Protection Options Appraisal, Capita Symonds (2012).

Location		Structure Type	Length (m)	Condition	Maintainer
11d5.7	Ancient Fishgarth Section 1	Stone and precast concrete revetment to face of clay cliff	68	3	Network Rail
	Section 2	Stepped concrete revetment to clay cliff with rock armour revetment from northern end to approximately the midpoint and around half the height of the concrete revetment. The rock armour overlaps onto section 3.	33	2	Network Rail
	Section 3	Rock armour revetment (continued from Section 2) with random quarried stone on the upper section of the cliff face.	23	2	Network Rail
	Section 4	Stepped concrete revetment with rock armour toe protection. Terminates at a drainage outfall immediately adjacent to the southern end of the Sea Mill defences.	26	3	Network Rail
	Sea Mill	Rock armour revetment to the front and rear of a gabion basket wall. The southern end of the gabion basket has rotated forwards.	116	3	Copeland BC



Figure 16 Sea Mill (North of Ancient Fishgarth) - rock revetment and gabions. (Site visit photo 2015; CEUK, 2016)



Figure 17 Ancient Fishgarth (Site visit photo 2015; CEUK, 2016)

2.1.3 Shoreline change

This unit encompasses the villages and smaller communities of Seascale, Braystones, Nethertown, Coulderton and Sea Mill beach, as well as the Sellafield nuclear site.

Along the Seascale frontage (11d5.1) there are low till cliffs; these are susceptible to erosion due to wave overtopping of defences (CH2M, 2017b). The shingle cover along the beaches is sparser than further north, particularly along the southern section of this frontage. In places sandstone crops out at the back of the beach, particularly where the defences have held the shoreline position seawards of where it may have moved to naturally, creating a slight promontory (Halcrow, 2011).

The long-term picture of change from the regional coastal monitoring data shows less extensive change than the short-term, indicating that the interannual change can be greater than the long-term net change at this location. The data also show that despite experiencing a net lowering between 2015 and 2016, the upper beach fronting the main Seascale car park is currently higher than recorded in 2009 (CH2M, 2017b).

There are seasonal changes in beach levels, with up to 1 m change evident from the monitoring data, but these tend to be cyclical and relate to the natural redistribution of sand in response to prevailing conditions. There is no net trend observed and, overall, the beach can be considered dynamic but stable (Coastal Engineering UK, 2016a; CH2M, 2017b).

Between Seascale and Braystones, the net littoral drift is small and variable as the shore is aligned almost perpendicular to the predominant wave direction, whilst further north, towards St Bees Head, the sediment transport becomes net northwards (Halcrow, 2011). This coast is not believed to receive significant amounts of sediment from the south, i.e. Morecambe Bay, the offshore or rivers (Halcrow, 2011). Erosion of the beach, nearshore profile and cliffs is, therefore, the key contemporary source of sediment and contributes a wide range of sediments to the beach systems, from muds to boulders (Halcrow, 2002). There is limited net transport of the upper shingle beach, with this predominantly taking place during storms, whilst the lower sandy foreshore is more mobile (Coastal Engineering UK, 2016; CH2M, 2017b).

Between Seascale and Sellafield (11d5.2), the beach is backed by low sand dunes and the railway embankment. The dunes are well vegetated and generally show little signs of ongoing change, apart from some fluctuation in both beach height and frontal dunes (both accretion and erosion) over time, in response to prevailing conditions (CH2M, 2017b). There is a shingle upper beach and sandy

lower beach and as to the north, the shingle cover is quite sporadic and intermixed with sand. The sand cover on the lower beach appears to be slightly greater along this stretch. As elsewhere along this frontage, net littoral sediment transport of shingle is low along this stretch due to the orientation of the coastline relative to the predominant wave direction. The outlet of the Calder and Ehen also interrupts any littoral drift from the north. The sand across the lower foreshore is more mobile than the upper shingle beach, with cyclical changes observed, but overall the beach can be considered generally stable (Coastal Engineering UK, 2016a; CH2M, 2017b).

The outlet channel of the River Ehen is diverted southwards, parallel to the coast, by a dune capped shingle spit (that has previously been artificially modified and maintained). This shingle spit runs along the shoreline for over two kilometres forcing the channel to outflow where it meets the discharge from the River Calder at Sellafield (11d5.3). Longshore drift is bi-directional, but the net magnitude is southwards albeit at a low rate of sediment transport (Coastal Engineering UK, 2016a). There is a drift divide at the northern end of the spit. Data indicate that there has been very little net change in recent years, but like elsewhere along the frontage, fluctuations in beach levels do occur, relating to the redistribution of the more mobile sand component of the lower beach (Coastal Engineering UK, 2016a; CH2M, 2017).

Till cliffs back the shoreline between Sellafield and St. Bees (11d5.4 to 11d5.7). Although the cliffs are composed of till, there are variations in the lithology along this coastline, which affects both the primary mechanism of cliff failure and the local composition of the beaches (Halcrow, 2011). The sand cover along the foreshore is thinner along this stretch, with scars a more dominant feature. The upper shingle beach is also less continuous than to the north and forms more of a fringing beach, particularly north of Nethertown, overlying sand, and in places sandstone beds outcrop, e.g. Nethertown Station (Brig Stones) (Halcrow, 2011). There is little net drift of sediment and the coarser upper beach sediment also tends to be only mobilised during storm conditions, when the main mechanism of transport seems to be cross-shore drawdown. The small headlands along this coast may also act as partial barriers to alongshore movement of the upper beach sediments. The sand on the lower beach is more mobile, but along this stretch is sparse and forms a thin, transient veneer on top of the scars (Halcrow, 2011).

Seaward of the railway line there are several permanent and seasonally occupied beach dwellings which have been constructed on the crest of the gravel and rely on the beach for protection. The winter storms of 2013 and 2014 caused some localised damage to beach front properties and movement of the beach; subsequent beach management was carried out (Coastal Engineering UK, 2016a). Data suggests that there is general stability in the upper beach with more movement of lower sandy beach (Coastal Engineering UK, 2016a), although at a local level the most recent data indicates that in places the upper foreshore is currently at its lowest level on record around Braystones and Sea Mill beach (CH2M, 2017). The coarse upper beach can be mobilised and transported by waves, although this tends to be mainly during storms, such as observed during the winter storms of 2013 and 2014.

Erosion of the till cliffs is understood also to be predominately during storms, for example as observed along the cliffs at Ancient Fishgarth (11d5.7) during the 2013 and 2014 winter storms (Coastal Engineering UK, 2016a). However, at other times the beach provides adequate protection along most of this frontage (Halcrow, 2011).

The longer term data shows that there has been little change in the cliff top position south of Sea Mill beach car park, however there has been recession of the face and toe. This will eventually lead to recession of the cliff top, although changes to the cliff top position are unlikely to be dramatic in the short-term (CH2M, 2017b).

Predictions of future erosion from NCERM suggest the following bands of change, under a scenario of No active intervention. It is important to note, however, that these erosion scenarios, as shown in Table 5, would only occur if current sea defences and rail embankment are not maintained and repaired as required.

Table 5 Estimated erosion risk extents from NCERM

	By year 20	By year 50	By year 100
11d5.1 Seascale	0 to 8 m	0 to 20 m	0 to 40 m
11d5.2 Seascale to Sellafield	0 to 20 m	0 to 48.5 m	0 to 97 m
11d5.3 Sellafield	0 to 20 m	0 to 48.5 m	0 to 97 m
11d5.4 Sellafield to Braystones	0 to 20 m	0 to 48.5 m	20 to 97 m
11d5.5 Braystones, Nethertown, Coulderton	0 to 8 m	1 to 20 m	3 to 40 m
11d5.6 Coulderton to Sea Mill	0 to 8 m	0 to 20 m	0 to 40 m
11d5.7 Sea Mill to Pow Beck	0 to 8 m	0 to 20 m	0 to 40 m

Erosion predicted for the frontages is slightly lower than erosion predicted by the SMP2, which suggested that between 50 and 100 m erosion could occur by year 100 along undefended cliffs and 40 to 80 m along currently defended sections (Halcrow, 2011). These erosion bands were considered broad enough to incorporate any effects of sea level rise.

2.2 Outline of the problem

2.2.1 Background

The key risk to this frontage is storm erosion of the beach and backing cliffs. There are localised tidal flood risks beneath the railway bridges and within the River Ehen floodplain. The properties on the beach and access road (B5344) are also susceptible to erosion of the beach, wave action and tidal flooding.

Between Seascale and Sellafield (11d5.2), the beach is backed by low sand dunes and the railway embankment. The Cumbrian Coast Line runs along the top of, or in front of, the till cliffs between Sellafield and St. Bees (11d5.4 to 11d5.7). The railway embankment currently plays a key role as the frontline defence for the northern part of the policy unit and is showing signs of erosion. Network Rail recognise the need for options and solutions to enhance the resilience of the defence along various sections.

The SMP2 advised that Seascale (11d5.1) required a scheme to address erosion issues. This has become more urgent following damage caused in 2013 and 2014. Seascale suffered from flooding on 30th August 2012, when 23 properties were reported to have suffered internal flooding. Very intense rainfall was the main cause of the flooding and the performance of culverts within drainage systems contributed to the flooding impacts that occurred (Cumbria CC, 2014). Cumbria County Council (Cumbria CC, 2014) identified measures to reduce the risk of future flooding that ranged from cleaning drainage systems, installing property level protection, to longer term solutions. There are currently three fluvial flood defence schemes in development to improve water quality and reduce fluvial flood risk to the properties and United Utilities (UU) waste water treatment works (WWTW).

Currently there is a relatively small number of assets at risk within the River Ehen floodplain, but these include farmsteads, agricultural land and caravan park. The Moorside site also lies within part of the Ehen floodplain.

There is also a risk of erosion and tidal flooding to properties located on beach seawards of railway embankment at Braystones, Nethertown and Coulderton.

2.2.2 Issues, constraints and opportunities

There are no statutory land-based environmental designations along this frontage, but Drigg Dune system lies approximately 400 m to the south of the frontage, which is part of the Drigg Coast SAC

and SSSI. Since the SMP2 was developed, the Cumbria Coast Marine Conservation Zone (MCZ) was designated in 2013 to protect habitats and a diverse range of supported plant and animal communities. This includes intertidal and shallow subtidal zones along this and adjacent frontages north and south. Potential impacts of any works on these designations, therefore, need to be considered. Relating to this frontage, concern has also been raised regarding the possible natural extension of the Calder and Ehen spit and potential impacts on the River Ehen flood plain.

There are plans to extend the national cycleway and consideration needs to be given to future erosion risk to the proposed cycleway route.

The SMP policies along this frontage assume that the railway will continue to operate for decades to come, as it is the preferred transport approach to delivering planned major investments in West Cumbria. The railway is also an important asset to transport fuels and wastes to and from the Sellafield site. Although the decommissioning of the nuclear plant may potentially decrease the need of the railway for those activities, depending on the timing and location of a future geological disposal facility, the railway plays an important role as an essential link across the entire Cumbrian Coast. Consideration of a strategic approach to managing risks to the railway could provide potential efficiencies in future management.

Sellafield, which lies within 11d5.3, has entered decommissioning process, including gradual reduction of personnel, decommissioning of current and historical buildings, and clearance and remediation of the site resulting in a much reduced spatial extent. There have been proposals in place for a new nuclear power station adjacent to Sellafield, known as the Moorside Project. This project was to involve the construction, operation and maintenance of a nuclear power station, together with railway works between Corkickle and Mirehouse, St Bees and at the Moorside Site, amongst other development (including a marine off-loading facility at the Moorside Site, highway improvements and worker accommodation). The project was originally planned to be complete by the end of 2018, but in November 2018 the project was scrapped and the Moorside site was handed back to the Nuclear Decommissioning Authority. At present, the future strategy for the site is uncertain.

It is understood that responsibility for the defences at Seascale Shore car park gabion wall lies with Copeland Borough Council (CBC), who carried out the works to bolster the gabions following the winter storms of 2013 and 2014. Copeland Borough Council's responsibility extends almost to the slipway. However, land ownership of the foreshore rests with the Nuclear Decommissioning Authority (NDA) and should major works be required in the future it would be appropriate for contributions to be sought from them (CH2M, 2017a). To the north of Sellafield the railway embankment provides the primary line of defence. Consultation regarding coastal defences fronting the Sellafield site may be required between CBC, NDA and Network Rail as coastal defences at Sellafield other than those needed to support the railway would be responsibility of CBC or NDA.

There is also a need to consider a strategic approach to managing risks to beach properties. Copeland BC commissioned Capita Symonds to prepare a report for the Sea Mill frontage (11d5.7), produced in May 2012, to: aid the process of planning investment in future coastal defence improvements across Sea Mill and the Ancient Fishgarth frontage to the south, clarify defence ownership and maintenance responsibility and investigate the long-term effectiveness of the defences as well as exploring several options for future management. Information from this report has been reviewed and summarised here.

2.2.3 Strategy considerations and general approach

Key considerations

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

- Current defence conditions and risks
- Recent shoreline change and changes in risk to assets

Impacts of the potential future development of the Moorside site, which may require a change in SMP policy or policy unit boundary as the extent of the original Moorside Project extended beyond the boundary of 11d5.4, both into 11d5.5 and 11d5.3.

- Consideration of Capita Symonds' (2012) Coast Protection Options Appraisal for 11d5.7 (Sea Mill). For this strategy, a review of that document has been undertaken, taking into account latest observations from the asset inspections and monitoring data collated as part of the North West Regional Monitoring Programme.
- Consideration needs to be given to the strategic management of the entire frontage, given the potential environmental contamination after Sellafield decommissioning is completed. Even if plans for the railway change, there will be a need to continue to protect any contamination risk areas from erosion and flooding. However, in the long term the economic justification for the railway may reduce, due to reduced labour force at the site and, depending on the timing and location of a geological disposal facility, the railway may not be needed for movements of fuels and wastes to and from the site.

Strategy approach

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

- SMP appropriate - the SMP2 policy does not need review so the aim of the strategy is to develop measures to implement the policy. Future works to manage flood and erosion risk may be eligible for a proportion of FDGiA funding and the economic appraisal will consider costs and benefits, following FCERM-AG guidance.
- 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 and 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 assessment 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 and Do minimum:

Table 6 Long list options considered for the priority units

Priority unit	Hold the line								Managed realignment				Other considerations
	Maintain: proactive maintenance	Maintain: reinforce existing defences	Sustain: reinforce existing defences	Improve: improve existing defences	Improve: construct new shore control structures	Improve: construct new revetments or seawalls	Improve: beach recharge	Improve: cliff or slope stabilisation measure	Construct erosion slowing defences	Construct defences once set back	Construct secondary embankments	Remove existing defences	Reprofiling of shingle beach
11d5.1 Seascale	✓	✓		✓	✓	✓	✓	✓					
11d5.2 Seascale to Sellafield	✓	✓		✓	✓	✓	✓	✓	✓				
11d5.3 Sellafield	✓	✓	✓	✓	✓	✓	✓						
11d5.4 Sellafield to Braystones	✓	✓		✓	✓	✓	✓	✓	✓				✓
11d5.5 Braystones, Nethertown, Couderton	✓	✓		✓	✓	✓	✓	✓	✓				✓
11d5.6 Couderton to Sea Mill	✓	✓		✓	✓	✓	✓	✓	✓				
11d5.7 Sea Mill to Pow Beck	✓	✓		✓		✓							✓

The second stage has been to appraise the short listed options. Each of 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 will be provided in a **Strategic Environmental Assessment: Environmental Report** which systematically appraises the potential environmental consequences of the proposed strategy and recommends any actions needed to mitigate and monitor identified adverse effects.

The economic feasibility of implementing a particular option has been appraised through considering the packages of measures required for its implementation which have then been costed and the benefits of the strategic options identified and evaluated. The No active intervention option provides the baseline for the economic appraisal. This is reported in the **Economic assessment** report.

It is important to note that, given the interlinked nature of the coastal system, any significant changes to the current coastline resulting from either intervention or managed realignment may require consultation with Sellafield Ltd and LLWR Ltd so they can assess any potential impact on shoreline behaviours in the vicinity of the sites as either a direct or indirect result of the action.

2.4 11d5.1 Seascale

Seascale is a small seaside resort, which originally developed in Victorian times when the Furness Railway was constructed. It remains a popular tourism destination, supporting fishing, walking, wind surfing and water skiing. There are also listed buildings located within the village centre. The main road through the village is the B5344; this runs close to the shoreline in the centre of this unit.

Seascale village frontage consists of low till cliffs which are slowly eroding despite defences at the toe of the cliffs. These cliffs are fronted by a wide sandy beach interspersed by scars (also known as skears). Seascale village itself is mainly located on higher ground and the key risk is from erosion, although there is a small area at risk from flooding south of the station, which is presumably where Whitriggs Beck originally discharged to the sea (discharge is now via an outfall). Here, there is localised flood risk to properties and access road.

A series of short sections of defences consisting of gabions and concrete revetments currently protect the frontage. The cliffs to the south are undefended and railway embankments provide a line of defence in the north of the village. There are sections where the highway is protected which are understood to be managed by Cumbria CC; other defences, for example those protecting the car park, are managed by Copeland BC.

The Cumbrian Coast Line railway is a significant feature along a large stretch of this coast between Seascale and St Bees and provides an important link to adjacent villages as well as a regional link to other areas.

Within this policy unit, there are a number of United Utilities (UU) assets: a 2 km long, 650 mm clay outfall pipe from the Seascale Wastewater Treatment Works (WwTW) runs through the beach car park, at Whitriggs Beck. It is known that this asset has structurally failed previously. The Crescent Wastewater Pumping Station (WwPS) discharges into Seascale WwPS from just off the beach in front of Wansfell Hotel. There are also a number of smaller combined sewage pipes that run along Drigg Road into the pumping station.

Land ownership of the foreshore rests with the Nuclear Decommissioning Authority (NDA) and therefore development of any major coastal works in the future should involve them.

2.4.1 11d5.1 - Initial screening of options

Table 7 Screening of long list options

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail	Baseline only	This option would not manage the erosion risk to properties and access road (B5344). It has been assessed for comparative purposes only.
Do minimum	Reactive patch and repair of defences only	Baseline only	Option would delay damages but does not completely reduce erosion risk. Option to be considered if funding cannot be justified.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	Yes	Utilises the existing defences and reduces breach risk.
Hold the line: maintain through reinforcing existing defences	For this frontage, the measures involved are likely to be the same as those considered above, so this has not been considered further as a separate option.		
Hold the line: improve existing defences	Measures to strengthen existing structures. Such as strengthen, widening existing defences, incorporating additional toe works to mitigate storm erosion and manage risk of outflanking to the south.	Yes	Strengthen existing structures to improve resilience against storm erosion. Would reduce risk of undermining and the potential to provide a consistent approach along the frontage.

Hold the line: improve through constructing new shore control structures	Construction of new shore control structures, such as groynes, reefs, breakwaters to manage the ongoing erosion.	No	Any control structures would require careful design and consideration of any negative implications along the coastline. Due to the erosion occurring under storm events technically a difficult option to achieve. It would be an imposing structure along the frontage, requiring detailed studies to confirm no adverse implications along the coast or to the MCZ designation. This approach would need significant capital investment, and is unlikely to attract sufficient funding, and has therefore not been considered further.
Hold the line: improve through constructing revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	This option would require a large capital investment, possibly not justified in the short to medium term. Option would allow a consistent approach along the frontage, part of which would be the inclusion of cliff or slope stabilisation measures in the south to mitigate the risk of outflanking.
Hold the line: improve through beach recharge	Recharge beach through either nourishment or recycling, which could include a range of different sediments.	No	This option would require ongoing costs to maintain a 'recharge' beach profile and does not offer a resilient solution to the storm erosion problem. This option would also require the construction of shore control structures to retain the placed beach material. Detailed studies to confirm no adverse implications along the coast or to the MCZ designation would therefore be required. This approach would need significant capital investment, and is unlikely to attract sufficient funding, and has therefore not been considered further.
Hold the line: improve through cliff or slope stabilisation	Introduce cliff or slope stabilisation measures, such as rock toe works, netting, rock bolting, drainage schemes.	No	Not considered as a separate option for undefended cliffs to the south of the policy unit. This option would need to be considered with other options for the defended Seascale frontage to the north and has therefore been combined with Hold the line: improve – construction of new revetments or seawalls for a whole frontage solution.

2.4.2 11d5.1 - 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	Under a Do nothing approach, the defences would deteriorate leading to eventual failure and leaving the railway, residential assets and infrastructure exposed. Based on the existing condition of the defences this could occur within 5 to 10 years. The failure is likely to be through an initial breach in the defence, leading to further flooding and outflanking. Increasing health and safety risk to community as defences erode.
Environmental	This option would result in failure of defences ultimately leading to a loss of properties, and severance of the B5344 and National Cycle Route 72. This would increase the isolation of the local community and prevent access to emergency services, as well as decreasing the recreational value of the area including a reduction in area of amenity beach and potential impacts on the designated bathing waters at Seascale. As a result of increased flooding and erosion risk, there would be loss of the Cumbrian Coast Line and the Seascale railway station. An uncontrolled risk of erosion and deteriorating defences would also result in an unsightly coastal frontage. In the long-term, this option would allow the reinstatement of more natural coastal processes, which would support WFD objectives and may enhance the SSSI, MCZ and SAC to the south of the unit. Further consideration would need to be given to the Habitats and Species Conservation Regulations 2017, to assess the potential for significant effects (e.g. through changes in coastal processes) on the integrity of the SAC to the south of the site. Additionally, further assessment may be required to consider any changes to the MCZ (under the Marine and Coastal Access Act 2009) and SSSI (Countryside and Rights of Way Act 2000).

Cost	There are no costs associated with the Do nothing option.
Damages	<p>Damages would include loss of property, car park and access road B5344.</p> <p>The cost of damages is estimated to be £1,180 k. Note that this is property damages only, damages related to the road, railway, tourism or amenity have not been monetised for the strategy but could add additional benefits if investigated further at scheme level.</p>

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>The works under this option would be low cost and reactive, involving variety of repair methods. They would address storm damage and could therefore prolong the lifespan of the defences for a short period of time (to approximately 10 to 20 years).</p> <p>Existing gabion structures are not typically suited to such an exposed location and could present a weak point and be potentially damaged in storm events.</p>
Environmental	This option would maintain a similar level of protection to today in the short-term, however impacts would be the same as Option 1 once the defences fail, which is assumed to be between year 10 and 20.
Costs	There is no Present Value Capital Cost, since costs are restricted to patch and repair works of the existing defences only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £250 k over 20 years.
Benefits	<p>Provides protection to the properties at erosion risk along the frontage for the short-term. Damages would be limited but in the longer term there would be economic impacts similar to the Do nothing option.</p> <p>Due to delay of onset of Do nothing, the benefits are estimated to be £480 k.</p>

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

Measures to maintain the existing defences. This would involve more proactive works than the Do minimum option, such as the addition of rock to the existing defences to prevent it from being undercut.	
Technical	<p>To reduce the risk of a breach developing in the existing defences, placement of a designed rock toe, including geotextile (as used when rock armour was placed in front of gabions), which could be used to improve the structures resilience to storm erosion.</p> <p>This utilises the existing defences and reduces breach risk. This option could prolong the life of the existing structures by approximately a further 10 to 15 years compared to the Do minimum option so has a design life of about 35 years. There are no measures within this option to address any increased risk of overtopping in the long-term due to sea level rise.</p>
Environmental	<p>This approach would be effective for up to 35 years. Beyond this, extensive works would be required to sustain the required level of protection. The existing defences would be maintained and the flood and erosion risk to properties, infrastructure, and recreational features would continue for a number of years. However, this option would not defend against any increase in overtopping risk that might arise as a result of sea level rise or climate change factors. Without additional capital works, the defences will reach the end of their effective life and will start to fail. Beyond this, the situation will revert to the same as Do Nothing.</p> <p>The origin of the rock material used in the rock toe would have to be considered to ensure it blends in with the surrounding visual amenity of the frontage. Recycled material is preferred wherever possible.</p> <p>Additional rock toe protection to the existing defence may result in the loss of intertidal habitats, which are a part of the MCZ. This may result in direct encroachment in the larger footprint of the defence or indirectly through intertidal narrowing. Impacts should be monitored to ensure that the increased footprint would not be detrimental to the condition of the mudflats, which are a priority habitat. There are no statutory land based environmental designations along this frontage, but Drigg Dunes lie to the south of the frontage and these are designated as a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC). Rock toe works are unlikely to impact of alongshore sediment transport but impacts on the SSSI, MCZ and SAC should be reassessed when the strategy is reviewed in future, based on ongoing monitoring. Additionally, further assessment may be required to consider any changes to the MCZ (under the Marine and Coastal Access Act 2009) and SSSI (Countryside and Rights of Way Act 2000).</p> <p>Implementation of this approach would need to be in a manner that does not compromise the WFD objectives for the Cumbria coastal water body.</p>

Costs	<p>Regular monitoring, post storm events and repair or replacement of rock toe structure involves ongoing costs.</p> <p>The Present Value Capital Cost is estimated to be £620 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,340 k.</p> <p>Design life: 35 years.</p>
Benefits	<p>Provide ongoing protection to the properties from erosion risk for several years. In the short-term, damages would be limited but in the longer term there could be economic impacts of any increase in overtopping flooding, due to any increase in sea level.</p> <p>Due to delay of onset of Do nothing, the benefits are estimated to be £830 k compared to Do nothing option.</p>

Hold the line: improve existing defences (Option 4)

<p>This would involve measures to improve the existing standard of protection.</p> <p>This would be a continuation of existing works involving the addition of rock to the revetment toe to prevent it from being undercut, but would also include works to remove the existing gabions at Shore car park and refurbishment of the seawall fronting the B5344.</p>	
Technical	<p>This option would involve: refurbishment of the seawall to provide tidal flood protection, extension of the rock armour toe to reduce the risk of undermining and replacement of the existing gabions in order to provide a more robust and resilient defence in this exposed location; a suitable replacement could be an extended rock toe.</p> <p>This option would provide a consistent approach along the frontage, provide an improved level of protection from flooding and erosion and would extend the residual life to around 35 years.</p>
Environmental	<p>The flood and erosion risk to properties, infrastructure, and recreational features would continue to be managed, for several years. In addition to this, this option would defend against increased risk of overtopping in the future that might result from sea level rise or climate change. However, without additional capital works in the future, the defences will reach the end of their effective life and will start to fail. Beyond this the situation will revert to the same as Do Nothing.</p> <p>Consideration as to the origin of any rock material used as part of this option must be considered, see option 3.</p> <p>The additional rock toe protection to the existing defence may result in the loss of intertidal habitats which are a part of the MCZ. This may result in direct encroachment in the larger footprint of the defence or indirectly through intertidal narrowing. Impacts should be monitored to ensure that the increased footprint would not be detrimental to the condition of the mudflats which are a priority habitat. There are no statutory land based environmental designations along this frontage, but Drigg Dunes lie to the south of the frontage and these are designated as a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC). Rock toe works are unlikely to impact of alongshore sediment transport but impacts on the SSSI, MCZ and SAC should be reassessed when the strategy is reviewed in future, based on ongoing monitoring. Additionally, further assessment may be required to consider any changes to the MCZ (under the Marine and Coastal Access Act 2009) and SSSI (Countryside and Rights of Way Act 2000).</p> <p>Implementation of this approach would need to be in a manner that does not compromise the WFD objectives for the Cumbria coastal water body.</p>
Costs	<p>It may be necessary to monitor and replace any displaced rock after storm events, therefore substantial costs could be involved. Raising the crest would also incur additional costs.</p> <p>The Present Value Capital Cost is estimated to be £1,540 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,520 k.</p> <p>Design life: 35 years; costs assume capital works implemented in year 10</p>
Benefits	<p>Provide improved protection to the properties and community from coastal flood and erosion risk along the frontage for several years.</p> <p>Due to delay of onset of Do nothing, the benefits are £830 k compared to Do nothing option.</p>

Hold the line: improve through constructing new revetments or seawalls (Option 5)

<p>This would involve measures to improve the existing level of protection and would extend the life of defences.</p> <p>It would involve the removal of the existing defences and construction of a continuous revetment and seawall along the frontage. Consideration of the tie-in at the base of the cliff to ensure a whole frontage option and mitigate potential outflanking risk.</p>	
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Technical	<p>The demolition of the existing defences and replacement with a consistent defence along the frontage would reduce the erosion and flooding risk by introducing a consistent and resilient solution for the length of the frontage. A suitable structure at this location would be a rock revetment with the inclusion of a seawall along the existing alignment.</p> <p>Cliff or slope stabilisation measures would be included for the undefended cliffs immediately to the south of the policy unit, ensuring a suitable tie-in detail to ensure the risk of potential outflanking is addressed.</p> <p>These works would be undertaken in the short-term, or delayed through implementation of shorter term options (options 2, 3 or 4).</p>
Environmental	<p>The flood and erosion risk to properties, infrastructure, and recreational features would be managed into the longer term. Additionally, this option would mitigate future increasing risk arising from sea level rise or other climate change factors.</p> <p>This option would result in changes to the existing landscape and visual amenity through the introduction of new hard structures. It would, however, provide long-term protection to the community, infrastructure and supported amenities, unlike the other options considered here.</p> <p>The additional rock toe protection to the existing defence may encroach on intertidal habitats which are a part of multiple designations. This may result in direct loss of these habitats to the larger footprint of the defence or indirect loss through changes to the regimes of the coastline. Impacts should be monitored to ensure that the increased footprint would not be detrimental to the condition of the mudflats which are a priority habitat.</p> <p>Although there are no statutory land based environmental designations along this frontage, Drigg Dunes lie to the south of the frontage and these are designated as a Site of Special Scientific Interest (SSSI) and a Special Area of Conservation (SAC). This option would involve more substantial works than options 2, 3 and 4 and therefore although there would be no direct effect on the SSSI/ SAC, indirect impacts would need to be appraised in more detail at scheme level. Additionally, further assessment may be required to consider any changes to the MCZ (under the Marine and Coastal Access Act 2009) and SSSI (Countryside and Rights of Way Act 2000), as well as ensure that implementation of the approach does not compromise the WFD objectives for the Cumbria coastal water body.</p>
Costs	<p>It may be necessary to monitor and replace any displaced rock after storm events, therefore substantial costs could be involved. Raising the crest would also incur additional costs.</p> <p>Design life: 100 years.</p> <p>The Present Value Capital Cost is estimated to be £4,3070 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £7,170 k. Assumes capital works undertaken in year 10.</p>
Benefits	<p>Long term protection to the properties at erosion risk and any localised flooding along the frontage.</p> <p>Provide protection to the properties at erosion risk along the frontage from outflanking due to erosion of the cliffs in the south.</p> <p>The benefits are £1,140 k compared to Do nothing option.</p>

2.4.3 11d5.1 - Discussion

Table 8 summarises the cost and benefit calculations for the various options presented above. It should be noted, however, that only Option 5 provides a long term solution. Options 3 and 4 would only extend effective life of defences up to around year 35. The economic assessment of the options indicates that none of the Hold the line options involving repairing or improving the existing defences would be economically viable. However, more detailed economic assessment at scheme level may be able to include estimates of additional benefits related to the delay of erosion risk to the railway, road and tourism and amenity value of Seascale, which could easily generate sufficient benefit to make the benefit cost ratio robustly greater than one, but is unlikely to generate significant FDGiA. Alternative sources of funding related to the railway, and highway would need to be sought as a joint scheme.

The SMP2 identifies a long term policy to Hold the line for this frontage (Halcrow, 2011), with a recommendation to replace the existing defences with a structure designed to withstand any further erosion over the remainder of the SMP period. There are several alternative approaches to Hold the line in the long term; it is considered that along this frontage the most suitable technical approach is to provide a formal rock revetment with a seawall (Option 5), other methods could be considered with further investigation. It is likely that the defence may need to be higher than the current low bank level to prevent overtopping and flooding in the future.

However, due to funding constraints, delaying large scale capital works may be a more realistic approach along this frontage. Option 2 (Do minimum) would only retain defences for up to 15 years, whilst more substantial works, such as Option 3 or 4, should extend defence life up to around year 35. Option 4 is more expensive than Option 3, as it involves replacing the rock gabions with rock and refurbishing the seawall, but this would improve the defences and reduce the need to repeatedly repair the gabions. In terms of environmental impacts, there is very little difference between the two options; both involve additional rock being added in front of the defences, resulting in a small increase in footprint but limited anticipated impact on alongshore sediment drift.

Table 8 Policy unit 11d5.1 Summary of economics

Option	Present Value Capital Works £m	Present Value Total cost (PVC)* £m	PV Benefit (Damage Avoided) £m	Average Benefit Cost Ratio
Option 1 Do nothing	0.00	0.00	0.00	-
Option 2 Do minimum (up to 20 years)	0.00	0.25	0.48	1.91
Option 3 Hold the line: maintain through proactive maintenance (up to 35 years)	0.62	1.34	0.83	0.62
Option 4 Hold the line: improve existing defences in year 10 (up to 35 years)	1.54	2.52	0.83	0.33
Option 5 Hold the line: improve - construct new revetments or seawalls in year 10 (100 years)	4.3	7.17	1.14	0.16

**Present Value cost (PVC) inclusive of 60% optimism bias*

2.4.4 11d5.1 - Strategic way forward

In the short term the SMP policy is to hold the current defence line. However, a Do minimum approach to hold the line (Option 2) is all that can be economically justified at this time.

This approach would not sustain protection for many years and so further investigations are needed to better identify the risks related to defence failure and value and timing of economic impacts related to the road and railway before Option 3, Maintain through proactive maintenance or one of the improve options could be identified as preferred. This will also allow the investigation of potential cost efficiency gained by packaging elements of work across the strategy frontage and development of a funding strategy. Ongoing monitoring can identify key risk areas for repair and allow a programme of works to be developed to ensure the defence is maintained.

In the longer term, more extensive works are likely to be required to ensure continued protection, such as replacing existing defences with new revetments (Option 5). Short term measures as considered under options 3 and 4 would not be detrimental to this longer term approach.

The following activities are recommended in the future:

- Improved understanding of risk to the railway through continued monitoring of beach and dune change (this should be undertaken throughout 11d5).
- Monitoring of defence condition to inform residual risk with repairs and maintenance undertaken as required.

- Liaison with United Utilities to assess constraints relative to rising mains and outfalls on the beach and with the Nuclear Decommissioning Authority (NDA), who own the foreshore.
- Liaison with Network Rail as part of development of an Asset Management Plan for the frontages to the north.
- Development of a funding strategy for defence maintenance and a joint scheme approach to future improvements, which should consider potential investment from stakeholders including Copeland BC, Network Rail, Cumbria County Council Highways, the Nuclear Decommissioning Authority (NDA), and United Utilities.

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

2.5 11d5.2 Seascale to Sellafield

Between Seascale and Sellafield, the beach is backed by low sand dunes and the railway embankment. The area is largely undeveloped, with a golf course located along the top of dunes. The Cumbria Coast Line also runs along the length of the coastline, in front of the golf course.

There is a shingle upper beach and sandy lower beach and to the north, the shingle cover is quite sporadic and is intermixed with sand. The dunes are well vegetated and generally show little signs of ongoing change, apart from some fluctuation in both beach height and frontal dunes (both accretion and erosion) over time, in response to prevailing conditions (CH2M, 2017b).

The sand dunes provide protection to the railway and there appear to be no formal defences along this frontage². Overall the beach can be considered dynamic but stable (CH2M, 2017b). Seaward of the railway is a cycle path. The current understanding is this is to be surfaced as part of the Moorside Project with an aim to reduce traffic on the Sellafield site. There are no other assets at risk along this policy unit.

2.5.1 11d5.2 - Initial screening of options

The current SMP2 management policy is No active intervention. Due to the strategic link the railway provides, monitoring of the flood and erosion risk to railway and undertaking works if the railway is at risk are included within this SMP2 policy management approach. The options considered focus on managing the risk to the railway and consideration of the proposed extension to the national cycleway.

For this strategy, both Hold the line and Managed realignment options have been considered alongside No active intervention.

Table 9 Screening of long list options for 11d5.2

Long list options	Description	Short listed?	Rationale
Do nothing	No new defences.	Yes	This option is feasible in the short term but would need further investigation to determine if it would manage the medium and long term erosion risk to the railway assets.
Do minimum	Reactive patch and repair of defences only.	No	There are no formal defences along this frontage, therefore this option is not feasible. Managed realignment: Construction erosion slowing defences with low technical solutions may be considered as an alternative to Do minimum for comparison purposes (see below).

² (Site visit undertaken 14.05.2018 by Copeland BC to check to see if gabions were present – none seen, just evidence of old railway sleepers within embankment next to foot/cycle path.)

Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	No	There are no formal defences along this frontage, therefore this option is not 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.	No	There are no formal defences along this frontage, therefore this option is not considered.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising defence crest.	No	There are no formal defences along this frontage, therefore this option is not considered.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwater.	No	This an exposed location but with limited net alongshore drift so for this solution to be viable significant volume of beach material would need to be sourced to fill the groyne bays. This is not considered a viable option given the high capital cost and potential implications to the adjacent shoreline.
Hold the line: improve through constructing new revetments or seawalls	Construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide long term protection to the railway. It does require a significant capital cost which may not be viable given the present risks.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conducive to artificial beach development. Any beach material placed would require several shore control structures to retain the material or significant ongoing recharge to maintain the profile. These would incur high capital and ongoing maintenance costs and are likely to have impacts on adjacent environmental designations; therefore, this option is not considered further.
Hold the line: improve through cliff or slope stabilisation measures	This may include toe protection works, drainage or netting.	No	The key risk for this strategy is erosion and scour of the toe of the railway embankment, therefore provision of toe protection is likely to be the most effective solution. Where this is in front of the existing defences this is considered as part of "Hold the line: improve existing defences", where new defences are required it is considered as "Hold the line: improve through construction new revetments or seawalls". This has therefore not been taken forward as a separate option.
Managed realignment: construction of erosion slowing defences	Low tech measures such as rock armour toes and sand filled geotextile bags.	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.

2.5.2 11d5.2 - Development and appraisal of short listed options

Do nothing (Option 1)

Under this option no new defences would be constructed and no works would be undertaken to restore the dunes should they become damaged during storms.	
Technical	<p>Currently the railway is protected by low sand dunes which front the railway embankment. As the shoreline is currently stable this has been sufficient to date. There is, however, a risk of increased erosion in the future due to accelerated sea level rise. This may mean that the railway could become at risk of loss within the next 20 to 50 years, depending upon the rate of change.</p> <p>In the short term, a Do nothing approach is viable although the proposed cycleway seaward of the railway would be at risk sooner.</p>
Environmental	<p>The Do nothing option would not change the current risk of tidal flooding and would allow coastal erosion to occur. This would allow the coastline to develop naturally, potentially enhancing the Cumbria Coast MCZ, and the intertidal mudflats and sand dunes present (BAP habitats). There are currently no defences present protecting the railway other than the natural sand dunes which may be subject to erosion as a result of this option.</p> <p>This option would also continue to benefit the Cumbria coastal water body, allowing it to evolve naturally without hydromorphological constraints.</p> <p>In the longer term, there is likely to be increasing risk of damage to the railway line from erosion and more frequent overtopping. The Cumbrian Coast Line railway is important for both passenger and freight transport, and its erosion or reduced capacity due to flooding would impact on the connectivity of the communities on the coastline as well as the decommissioning works ongoing at the Sellafield site to the north. Additionally, there are potential erosion risks to the National Cycle Route 72 and the golf course which are key recreational assets in this unit.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are to the railway assets and infrastructure and associated impacts on rail transport of goods and passengers. No benefit values associated with the railway have been calculated.

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

This involves the construction of a formalised revetment to provide improved protection to the railway. Although no current defence management is undertaken, intervention may be required in the medium to long term. This would require a change to SMP policy.	
Technical	<p>The construction of a new revetment would provide a consistent and formalised defence for the railway, providing the required protection in the long term.</p> <p>A vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment is therefore a preferred approach, to reduce wave scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered.</p>
Environmental	<p>This option would manage the long term risk of damage from coastal erosion and frequent flooding to the railway, National Cycle Route 72, the long distance Coast to Coast Path and Seascale Links golf course. This would protect the connectivity of coastal communities, maintain current land uses in the hinterland and maintain access to the railway for ongoing activity at the Sellafield site. Provision of any new defences should take into consideration the route of the current proposed cycle route, with potential to provide combined benefits.</p> <p>However, there are likely to be negative impacts on the environment including the loss of intertidal mud and sandflats against new fixed defences and the direct loss of established, vegetated sand dunes (BAP habitat) and intertidal habitats, which are a designated feature of the Cumbria Coast MCZ.</p> <p>Additionally, new defences have the potential to affect coastal processes and sediment transport, which could affect the Drigg Coast SAC and SSSI, which lie at a minimum distance of 1.5 km to the south. Further consideration would need to be given to the Habitats and Species Conservation Regulations (2017), to assess the potential for significant effects on the integrity of this Natura site. Additionally, further assessment may be required to consider any changes to the SSSI under the Countryside and Rights of Way Act 2000.</p> <p>The introduction of new defences will affect local landscape character and may affect views of the sea from Seascale Links golf course. This option may compromise the WFD objectives of the Cumbria</p>

	coastal water body as new defences would increase hydromorphological pressure on the water body, and therefore a scheme-specific WFD assessment would be required.
Costs	Large capital cost to construct a new defence along frontage. The Present Value Capital Works are estimated to be £2,240 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £3,820 k. This assumes capital works undertaken in year 0 as a worst case.
Benefits	This option would provide benefits by protecting to the railway and future-proofing the infrastructure against potential increases in sea level, changes in wave climate and storminess. However, given the current beach stability it is not anticipated the future benefits would justify a large capital scheme in the short term, therefore a more likely approach would be to delay construction until risks increase. No benefit values have been calculated at this stage.

Managed realignment: construction of erosion slowing defences (Option 3)

This would involve measures to reduce erosion risk to embankment such as introducing a rock toe, or similar low tech solution, in front of the railway embankment.	
Technical	This option would only provide temporary short term protection to the railway embankment and cycleway. Loose tipped rock could be considered at this set back alignment as a sacrificial defence with a life span of less than 10 years. Given there is no imminent risk to the railway this option could be considered as a reactive measure to any dune erosion, avoiding the need for large scale up-front capital costs whilst developing a design for the frontage such that as and when piecemeal repair works are undertaken, they follow a consistent robust solution.
Environmental	This option would provide short term protection to the railway and hinterland assets, should the dunes erode or become damaged and the existing protection afforded by them reduces. In the short term the cycle path seaward of the railway appears feasible, although it could be susceptible to storm damage and wind-blown sand. Beach monitoring data collated as part of the North West Regional Monitoring Programme also indicate that there is a natural variation in the position of the dune toe over time, which may have implications for the cycle path. Implementation of this option would need to consider potential impacts on the vegetated sand dunes (BAP habitat) - it is assumed that works would only be carried out as an emergency measure, once damage to the dunes had occurred, but opportunities should be sought to utilise measures which may also encourage dune recovery. The Drigg Coast SAC and SSSI lies around 1.5 km to the south and it is unlikely that measures would impact on this site, but further consideration may be required at scheme stage. Additionally, further assessment may be required to consider any changes to the SSSI under the Countryside and Rights of Way Act 2000.
Costs	Costs include the preparation of embankment toe and placement of rock toe. The Present Value Capital Works are estimated to be £390 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £760 k. These present value costs assume capital works undertaken in year 10.
Benefits	The options would provide short term protection to the railway embankment should a localised breach occur in the dunes. No benefit values have been calculated at this stage.

2.5.3 11d5.2 - Discussion

Table 10 summarises the cost calculations for the various options presented above: note that on this frontage the economic benefits relate primarily to the railway but have not been calculated at this stage. The ongoing and future capital and maintenance coastal defence provision for this frontage is the responsibility of Network Rail.

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 therefore be developed for the entire frontage of 11d5 frontage, including stability assessments, overtopping potential, identification of trigger levels, monitoring and responses.

The recent stable nature of this frontage has meant that holding the line through doing nothing has been an effective measure; however, there is potential for risks to increase in the future due to anticipated accelerated sea level rise. The timing of this change is uncertain, which makes management planning difficult.

In the short term, managing erosion risk through measures to address storm damage (Option 3) may remain adequate for some years, but longer term a more strategic approach is likely to be required. The most effective approach is likely to be through constructing a new rock revetment along the railway embankment (Option 2), but alternative approaches could be investigated, which could consider incorporation of a new cycle path. Given the location of the railway along this frontage, realignment could also be a viable option in the future.

Table 10 Policy unit 11d5.2 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)
						Year	Year	£m	£m
11d5.2	Option 1	Do nothing	20	-	0.00	0.00	0.00	0.00	0.00
11d5.2	Option 2	Hold the line: Improve through constructing new revetments/seawalls	100	-	5.28	2.24	0.15	2.39	3.82
11d5.2	Option 3	Hold the line: Improve existing defences	30	10	0.60	0.39	0.03	0.42	0.67

2.5.4 11d5.2 - Strategic way forward

The current SMP policy is No active intervention through to the long term, but allows works to the railway if required. The railway is currently at low risk, due to the general stability of the dunes. There is however a risk of occasional storm damage which, assuming an intent to retain the railway in its current location, could be addressed in the short term through low tech measures such as rock toe work. It is recommended that rather than these works being carried out in an ad-hoc manner, an asset management plan is developed for this frontage (as part of a larger plan for the whole policy area 11d5), such that damage to the natural environment, in particular the sand dunes BAP habitats, is mitigated or minimised through best practice working. Alternative measures may also be more appropriate depending upon the scale of dune damage. A change in SMP policy may be appropriate to support such works.

In the longer term, should the level of erosion risk increase, more substantial measures may need to be required to ensure the long term protection of the railway in its current location. A change in SMP policy may be required to hold the line, which would also be consistent with adjacent frontages (11d5.1 and 11d5.3). The approach in this unit should be developed in conjunction with the other frontages within the policy area to ensure a strategic solution; in addition to the risk to the railway, the potential contamination risk associated with Sellafield (11d5.3) post decommissioning needs to be taken into account.

The following actions are recommended in the future:

- Improved understanding of level of risk to the railway through continued monitoring of the beach and cliffs (this should be undertaken throughout 11d5).
- Development of an Asset Management Plan for the entire 11d5 frontage, setting out strategic aims. This should involve liaison with Natural England in developing a short term response to erosion risk along the dunes. Other key stakeholders along the frontage should also be involved to consider multi-benefits of any longer term solution.
- Consider the need for a change in SMP policy to support future shoreline management actions and to be consistent with adjacent frontages. This would need to follow a formal SMP change process.
- Monitoring of risk to the cycling route and further consideration of future route viability in line with developing long term solutions.

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

2.6 11d5.3 Sellafield

This unit comprises the Sellafield nuclear site. The site is being decommissioned; the decommissioning programme will run for over 100 years i.e. beyond the lifetime of the strategy. However, consideration needs to be given potential environmental contamination after Sellafield decommissioning is completed.

A linear rock revetment with a crest level of 9.9 mOD currently provides protection to this stretch of coast. It is considered to be in a fair condition with a residual life of 20 to 50 years. The revetment is partially protected by the Ehen spit. The revetment provides protection to the railway and the Sellafield nuclear site which lies immediately adjacent to the coastline. Network Rail has recently completed repair and renewal works to some sections of the defences.

Network Rail coastal defences located along parts of the route between Seascale and Sellafield stations comprise of stone and concrete pitched revetment with square protruding concrete sections equally spaced and rock armour at the toe in some locations. Although the beach is considered to be generally stable, the revetment has suffered significant scour.

A dune capped shingle spit, the Ehen spit, runs along the shoreline for over two kilometres forcing the River Ehen southwards until it meets the discharge from the River Calder at Sellafield Power station. Fronting the dunes is a generally stable beach although there are dynamic changes where the Calder and Ehen discharge crosses the beach.

2.6.1 11d5.3 - Initial screening of options

The SMP2 management policy is to Hold the line by maintaining the existing revetment and rock armour defences in the short term, and maintain or construct larger defences in the medium to long term.

Since the SMP2 was developed the Cumbria Coast Marine Conservation Zone (MCZ) protecting habitats on the beach was designated in 2013.

Table 11 Screening of long list options for 11d5.3

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 the long term risk to the railway or other assets within the frontage. It has been assessed for comparative purposes.
Do minimum	Reactive patch and repair of defences only.	Baseline only	This option would not manage the long term risk to the assets and the railway. However, may become the default short term option if funding is not 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 in the short term until the defence meets the end of its residual life. It is understood that localised repairs have previously been undertaken to the end of the spit following storm damage by beach management with recycling of beach material. Similar maintenance work could be included under this and other options.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works to defences	Yes	Options to modify or adapt the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life

	improve longevity of existing defences.		attained. It is a viable option to be considered.
Hold the line: sustain through reinforcing and raising existing defences	Measures to retain the current standard of protection through the reinforcement of existing defences	No	This option is similar to Hold the line: Improve existing defences therefore has not been considered further.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Options to reinforce the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life 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, breakwater.	No	This is an exposed location with protection provided by both the Ehen spit and the revetment on landward side of the channel. Shore control structures would need to be located on the seaward side of the spit. Evidence from monitoring suggests that the spit has been slowly growing and so there is no justification for intervention to modify the spit with control structures.
Hold the line: improve through constructing new revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide a resilient approach to long term protection to the railway. It does require a significant capital cost which may not be viable.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conducive to beach development. Any beach material placed would require several shore control structures to retain the material or significant ongoing recharge to maintain the profile. These represent high capital and ongoing maintenance costs. There would also be potential issues with maintaining fluvial discharge from the Ehen and Calder. Therefore, this option is not considered further.

2.6.2 11d5.3 - 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	Without investment the defences will deteriorate, leading to eventual failure. The existing concrete and rock toe revetment has suffered significant scour with areas of missing and damaged concrete elements. Large voids along the rock armour sections means further scouring of these sections will lead to eventual breach in the defence. Based on current condition this could occur within the next 20 to 50 years.
Environmental	Do nothing may increase the frequency of tidal inundation to the site as well as risk of damage to current assets as a result of coastal erosion. With no intervention, coastal erosion during the strategy period would result in the release to the environment of potentially contaminated soils currently in situ on the Sellafield site. The railway is a key strategic link and this option would lead to damage to the railway from coastal erosion and overtopping, disrupting service and potentially leading to loss of this asset completely in the long term. This would impact on the connectivity of the coastal communities and impact on the

	<p>ongoing decommissioning works at Sellafield as the railway and Sellafield Station are regularly used to transport material and personnel to and from the site.</p> <p>When current defences ultimately fail as a result of this option, the debris would be distributed along the frontage and may take many years to dissipate which could impact on visual amenity, the Cumbria Coast MCZ and possibly in the long term the SAC in the policy areas to the south as well as the WFD objectives of the Cumbria Coastal water body.</p> <p>Although it is expected that eventually, more natural processes would create a more natural coastline, this is outweighed by the high contamination risk of the Sellafield nuclear site which is undergoing decommissioning, expected to last for up to 100 years. Additionally, the site itself contains two landfill sites known as the Calder Tip and the Calder Tip Extension.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are related to the high contamination risk due to potential for erosion of parts of the Sellafield site, and damage and loss of railway assets and critical infrastructure. No damage values have 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, including of Ehen spit, with no works to address any increase in risk due to sea level rise.	
Technical	<p>As the works would be low cost and reactive only, as for the Do nothing the future life span of the existing defences depends on the future conditions, for example storm frequency and magnitude. If works are not carried out promptly, this could accelerate the time to failure of the defence.</p> <p>Given the ad hoc placement of sections this is not a long term resilient solution and will revert to a Do nothing once the defences fail, providing only a short (5 year) delay to that of Do nothing.</p>
Environmental	Once defences fail, the impacts would be as for the Do nothing scenario.
Costs	There are no Present Value Capital Works, since costs are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £250 k.
Benefits	The key damages are related to the high contamination risk, and damage and loss of railway assets and critical infrastructure. No damage values have been calculated at this stage.

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

Measures to maintain the existing defences. This would be a continuation of the current activities of patch and repair to the defences, based upon regular monitoring and as part of a scheduled programme of works.	
Technical	The timely undertaking of repair works to the existing structure can prolong the integrity of the structure. Works to prevent undermining and scour of the toe, with the proactive approach to patch and repair may extend the residual life (20 to 50 years) by approximately 10 years.
Environmental	<p>This would simply involve works to the existing defences, so is unlikely to have additional impacts on the environment, compared to today. Once the defences ultimately fail, then potential risks will reflect those outlined in Option 1 after this 10 year delay period.</p> <p>It is assumed that the works would be within the existing footprint of defences, therefore there would be no direct loss of habitat. Potential impacts on the Drigg Coast SAC and SSSI in policy area 11d4 to the south are considered minimal due to the distance from the site and the low net alongshore drift. In the longer term, continuing to hold the line could result in intertidal habitat loss due to foreshore narrowing.</p>
Costs	The Present Value Capital Works are estimated to be £870 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,630 k.
Benefits	This would delay onset of damages by approximately 10 years to year 30. No benefit values have been calculated at this stage. However, the nature of the potential contamination from erosion of the site means that benefits are likely to significantly exceed costs.

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

This would involve low cost measures to reinforce the existing defences, such as the infilling of the large voids currently present along the rock toe and replacing displaced rocks. The level of protection would not be improved.

Technical	Capital works to infill the current rock toe voids and reprofile the armour could delay failure of the defence by a few years. During severe storm events the ad hoc placed rock armour could become displaced and damage adjacent sections of the structure due to poor interlock. There would therefore may need to be regular repairs following storm damage. The approach would not include upgrading the defences and so would not be future-proof, but would be an appropriate measure whilst a longer term solution is developed.
Environmental	This option would maintain current protection to hinterland assets, for some time but would not improve defences. Therefore, overtopping of defences may lead to inundation of the railway assets. It is assumed that the works would be within the existing footprint of defences, therefore there would be no direct loss of habitat. Potentially impacts on the Drigg Coast SAC and SSSI in policy area 11d4 to the south are considered minimal due to the distance from the site and the low net alongshore drift. If the defences ultimately fail after the expected 10 to 15 year delay then risks will reflect those under option 1.
Costs	Cost associated with the continual maintenance and filling the existing voids with rock armour. 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 £1,940 k.
Benefits	This would delay onset of damages by approximately 10 to 15 years. No benefit values have been calculated at this stage. However, the nature of the potential contamination from erosion of the site means that benefits are likely to significantly exceed costs.

Hold the line: improve existing defences (Option 5)

This would involve measures to improve defence resilience, such as rock toe works to address undermining and raising crest levels to improve the standard of protection through the reinforcement of existing defences. The option could involve reprofiling of rock armour to provide a more resilient solution to scour and storm damage.	
Technical	This option would include a formal rock toe along the revetment, ensuring interlock and extent to allow for variations in the beach fronting the structure. This offers a viable solution to extend the life of the defences with ongoing investment as the railway is slightly set back.
Environmental	This option would reduce flood risk and protect against damage from coastal erosion as well as accounting for potential overtopping in the future as a result of sea level rise. It is not a long term solution, as it is only anticipated to extend life of defences to around year 40. Beyond this, it is likely that new defences will be required, otherwise the defences will start to deteriorate and fail. This would result in an increased footprint of defences. Depending upon when works were undertaken and shoreline change, there is a risk that these may extend into the intertidal zone, potentially affecting habitats protected by the MCZ. The requirement to increase the footprint of the rock toe would also result in loss of riparian habitat along the River Ehen, although there is no BAP habitat recorded to be present. Potential impacts on the Drigg Coast SAC and SSSI in policy area 11d4 to the south are considered minimal due to the distance from the site and the low net alongshore drift. In the longer term, continuing to hold the line could result in intertidal loss due to foreshore narrowing. Impacts of this option on the WFD objectives of the relevant waterbodies must be taken into consideration.
Costs	Capital cost associated providing a formalised toe and reprofiling of the rock armour to resist scour and storm damage with reduced regular maintenance compared to options 3 and 4. The Present Value Capital Works are estimated to be £760 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,500 k. costs assume capital works implemented in year 20.
Benefits	This would delay onset of damages by approximately 20 years to year 40. No benefit values have been calculated at this stage. However, the nature of the potential contamination from erosion of the site means that benefits are likely to significantly exceed costs.

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

This could involve the removal of the existing structure and construction of a formalised revetment to provide improved protection to the railway. The intention would be to provide a long term solution.	
Technical	The removal and reconstruction of a new revetment would provide a consistent and formalised defence. A vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment with a rough face is preferred to reduce wave

	scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered.
Environmental	<p>This option would reduce flood risk and protect against damage from coastal erosion into the long term, as well as accounting for potential overtopping in the future as a result of sea level rise.</p> <p>It may result in an increased defence footprint. Depending upon when works were undertaken and shoreline change, there is a risk that these may extend into the intertidal zone, potentially affecting habitats protected by the MCZ. The requirement to increase the footprint of the rock toe would also result in loss of riparian habitat along the River Ehen, although there is no BAP habitat recorded to be present. Potential impacts on the Drigg Coast SAC and SSSI in policy area 11d4 to the south are considered minimal due to the distance from the site and the low net alongshore drift. In the longer term, continuing to hold the line could result in intertidal loss due to foreshore narrowing. Impacts of this option on the WFD objectives of the relevant waterbodies must be taken into consideration.</p>
Costs	<p>Larger capital cost to remove, dispose of existing structure and construction of new defence along frontage. Reduced costs for maintenance and repairs.</p> <p>The Present Value Capital Works are estimated to be £3,110 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £5,400 k.</p>
Benefits	<p>This option would provide long term protection to the assets and the railway and future proof the infrastructure against potential increases in sea level, changes in wave climate and storminess. No benefit values have been calculated at this stage. However, the nature of the potential contamination from erosion of the site means that benefits are likely to significantly exceed costs.</p>

2.6.3 11d5.3 - Discussion

Table 12 provides a summary of costs for the various options considered above: note that benefits relate primarily to the railway and Sellafield nuclear site and have not been calculated at this stage, but due to the nature of the potential contamination from erosion of the site that benefits are likely to significantly exceed costs if evaluated in more detail at scheme level.

The ongoing and future capital and maintenance coastal defence provision for this frontage is currently the responsibility of Network Rail. There is a need to better understand the level of risk to the railway and operations for continued safety and avoidance of unacceptable risk. An Asset Management Plan should therefore be developed for the entire frontage of 11d5 frontage, including stability assessments, overtopping potential, identification of trigger levels, monitoring and responses.

Based on the current monitoring data the frontage is relatively stable; erosion is predominately storm driven, with little net change in recent years. The current defences are expected to have a residual life of between 20 and 50 years, although some repair work is required to fill large voids in the rock work. Therefore works to maintain the defences should be sufficient to continue to protect the frontage for several years. This could be through options 3, 4 or 5.

This would allow time for development of a longer term solution, which would need to include provision for improving the defence. The most effective solution is likely to be through construction of a new rock armour revetment (Option 6), although alternative approaches could be considered at this later date. To plan for the required future upgrades to the current defences in front of the Sellafield Nuclear Site it is recommended that stakeholders consider development of a funding strategy for defence maintenance and a joint scheme approach to future improvements, which should consider potential investment from stakeholders including Copeland BC, Network Rail, Cumbria County Council Highways, the Nuclear Decommissioning Authority (NDA), and United Utilities.

Table 12 Policy unit 11d5.3 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	£m	£m	
11d5.3	Option 1	Do Nothing	20	-	0.00	0.00	0.00	0.00	0.00
11d5.3	Option 2	Do minimum	25	-	0.23	0.00	0.15	0.15	0.25
11d5.3	Option 3	Hold the line: maintain through proactive maintenance	30	5	1.28	0.87	0.15	1.02	1.63
11d5.3	Option 4	Hold the line: maintain through reinforcing existing defences	35	5	1.53	1.05	0.16	1.21	1.94
11d5.3	Option 5	Hold the line: Improve existing defences	40	20	1.84	0.76	0.17	0.94	1.50
11d5.3	Option 6	Hold the line: improve - construct new revetments/seawalls	100	20	7.61	3.11	0.26	3.38	5.40

2.6.4 11d5.3 - Strategic way forward

The current SMP policy is to Hold the line from the short term. Given the critical infrastructure and high contamination risk associated with the Sellafield site, no change in policy is recommended.

Given current defence condition, in the short and medium term the preferred approach is to Hold the current defence line – through proactive repair and maintenance of the existing rock revetment (Option 3).

In the long term, there may be a need to improve defences, with construction of a new rock revetment the preferred approach (Option 6). The timing of this may depend on several factors, in particular future development of the Moorside site (located in unit 11d5.4) and long term plans for the Cumbrian Coast Line railway (which in turn may be affected by changes in demand resulting from decommissioning of Sellafield).

The following activities are recommended in the future:

- Improved understanding of level of risk to the railway through continued monitoring of the beach and cliffs (this should be undertaken throughout 11d5) – this should incorporate any monitoring undertaken by others, such as LLWR Ltd.
- Monitoring of defence condition to inform residual risk with repairs and maintenance undertaken as required.
- Development of an Asset Management Plan for the entire 11d5 frontage, setting out strategic aims. This should involve liaison with Sellafield and other key stakeholders along the frontage to consider multi-benefits of any longer term solution. This should take account of the financial costs associated with flooding or erosion of any contaminated land and structures on the Sellafield site.
- Development of a funding strategy for defence maintenance and a joint scheme approach to future improvements for protection of the Sellafield nuclear site.

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

2.7 11d5.4 Sellafield to Braystones

The Cumbria Coast Line runs along the length of the coastline. The small village of Braystones is set back from the coast, but there is a caravan and camp site located close to the shoreline.

Along this frontage, there have previously been plans for a new nuclear power station adjacent to Sellafield, known as the Moorside Project. The site has now been handed back to the Nuclear Decommissioning Authority and at present, the future strategy for the site is uncertain. The original

plans extended just south of policy unit 11d5.4 to just north of policy unit 11d5.5. If this site was developed in the future, consideration would need to be given to a change in SMP2 policy.

Within this policy unit, United Utilities (UU) assets include Braystones WwTW, which is a fairly new treatment works located 15 m inland from the railway line and discharges final effluents to the Irish Sea through a 2 km long, 150 mm rising main at Braystones.

Defences along this frontage are centred at Braystones station, where there is an embankment with the railway located to the rear. There are also short stretches of rock armour and gabion baskets but the majority of the frontage is undefended. The shingle beach and a non continuous beach terrace supports beach huts and properties at the seaward toe of the railway embankment.

Monitoring data suggests that the upper beach is relatively stable with more movement of the lower sand beach (CH2M, 2016a), although around Braystones the levels are presently at their lowest since the North West Regional Monitoring began. The erosion of the frontage is typically storm driven causing localised damage to the beach front properties.

2.7.1 11d5.4 - Initial screening of options

The SMP2 management policy is No active intervention – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk. Options for the strategy need to consider managing the risk to the railway and the properties situated at the seaward toe of the railway embankment. Currently much of the frontage is undefended, with defences at Braystones Station and localised stretches of Network Rail defences along the Cumbrian Coast Line railway embankment.

To address the long term risk to the railway, for this strategy, both Hold the line and Managed realignment options have been considered alongside No active intervention.

Table 13 Screening of long list options for 11d5.4

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option would not manage the long term erosion risk to the railway or the beach properties located on the beach crest. It has been assessed for comparative purposes.
Do minimum	Reactive patch and repair of defences only.	Yes	This option would not manage the long term erosion risk to the railway assets or the beach front properties. However, may become the default option if funding is not available.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	Yes	The majority of the frontage is undefended, therefore this would only apply where there are defences present, such as at Braystones station and the ad hoc defences – arguably as these are the areas deemed to be at greater risk in the short term this option has been considered further.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works to improve longevity of existing defences.	No	Given the informal nature of some of the defences and erosion being the predominant risk this option is considered under Hold the line: Improve existing defences and Hold the line: Improve through constructing new revetments or seawalls. Therefore, this option is not considered further.
Hold the line: improve existing defences	Measures to improve defence resilience, such as	Yes	The majority of the frontage is undefended, therefore this would only

	rock toe works, raising crest levels.		apply where there are defences present, such as at Braystones station and the ad hoc defences. Arguably as these are the areas deemed to be at greater risk in the short term, therefore this option has been considered further.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwater.	No	This an exposed location and for this solution to be viable significant volumes of beach material would need to be sourced, with a high capital cost. The beach is also designated as an MCZ due to the rare honeycomb worm (Sabellaria alveolata) reefs. This option is therefore not considered further.
Hold the line: improve through constructing new revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide long term protection. It does require a significant capital cost, but should be investigated further.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conducive to artificial sand beach development. Any beach material placed would require several shore control structures to retain the material or significant ongoing recharge or recycling to maintain the profile. Importing large volumes of shingle or cobble material to significantly raise the beach is not considered viable as there are no suitable local sources. There would be significant capital and ongoing maintenance costs. Also, the beach is designated as an MCZ due to the rare honeycomb worm (Sabellaria alveolata) reefs. This option is therefore not considered further.
Hold the line: improve through cliff or slope stabilisation measures	This may include toe protection works, drainage or netting.	Not considered as a separate option	Undefended frontage to the south of the policy unit. This option would need to be considered with other options for the defended ad hoc and Braystones station frontage to the north. Therefore, has been combined with Hold the line: improve – construction of new revetments or seawalls for a whole frontage solution.
Managed realignment: construct erosion slowing defences	Low tech measures such as rock armour toes and sand filled geotextile bags.	No	The policy unit is exposed to waves and ongoing coastal processes such that a low tech solution will not offer the required resilience; therefore this option has not been considered further.
Managed realignment: Beach reprofiling	Reprofiling of existing beach material.	Yes	There may be benefit in reprofiling the shingle beach to provide protection along the frontage, therefore this option has been considered further.

2.7.2 11d5.4 - 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	The various defences along this frontage range in condition from good to poor. Without investment the defences will deteriorate further, leading to eventual failure and increased exposure to the railway embankment. Properties at the back of the beach are likely to be increasingly at risk in the future, as a result of anticipated accelerated sea level rise.
Environmental	<p>This option would not reduce risk of flooding or damage by coastal erosion to various assets. Principally, the railway line would remain at risk of damage or loss to erosion. This would reduce operation of this railway, limiting the connectivity of Braystones to the wider area. Reduced accessibility due to the severance of the railway would also affect the operations of the Sellafield site. Beachfront properties would remain at risk of damage or loss to coastal erosion.</p> <p>The wastewater treatment works in this frontage would be at risk of flooding or damage from erosion, which would impact on wider water resources and presents a risk of pollution should the material within the treatment works enter the wider environment.</p> <p>There are two caravan parks that appear to be directly at risk of damage from coastal erosion. This would impact on the recreational and tourist value of the area of Braystones. Additionally, increased frequency of inundation of the hinterland would likely reduce its viability as agricultural land. As tourism and agriculture are currently the two key economies for the area, loss of these areas would lead to wider economic impacts.</p> <p>Although the Do nothing option would potentially result in the loss of terrestrial and freshwater habitats with an associated change in landscape character, this option could, in the long term, allow a more natural evolution of the coastline along the frontage, benefitting the maritime cliffs and slopes, and the Cumbrian Coast MCZ. This option may also enhance the geological value of the frontage through establishment of more natural erosion rates of the cliffs and slopes present around the Braystones station.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are to the railway assets and infrastructure and the beach crest properties. The property damages are estimated to be £610 k. Damages relate primarily to the railway but these have not been valued 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 the works would be low cost and reactive only, as for the Do nothing the future life span of the existing defences depends on the future conditions, for example storm frequency and magnitude. If works are not carried out promptly, this could accelerate the time to failure of the defence.</p> <p>Given the ad hoc variety of defences, with no consistency and range of conditions this is not a resilient solution and will revert to a Do nothing once the defences fail.</p>
Environmental	Once defences fail, the impacts would be as for option 1 – see above for details.
Costs	There is no Present Value Capital Cost, since costs are restricted to patch and repair works only. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £410 k.
Damages	The key damages are to the railway assets and infrastructure and the beach crest properties, although timing would be delayed from the Do nothing option. The property related damages are estimated to be £510 k. Damages relate primarily to the railway and have not been calculated at this stage

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

Measures to maintain the existing defences. This would be a continuation of the current activities of patch and repair to the defences, based upon regular monitoring and as part of a scheduled programme of works.	
Technical	The timely undertaking of repair works to the existing structures can prolong the integrity of the structure. Works to prevent undermining and scour of the toe, with the proactive approach to patch and repair the existing defences may extend the residual life by approximately 10 years. However, it could be costly, given the range of defences along this frontage. Network Rail already have plans for remedial works for some of the defences.
Environmental	This is only a short term measure and would only be undertaken along existing defences. It could extend life of those defences by 10 years and over this time would continue to locally protect the railway assets, caravan parks, homes, and the Moorside site from erosion and flooding. Alone it would not address erosion occurring along currently undefended frontages.

	Once the defences fail, the impacts would be as for Option 1.
Costs	Cost of patch and repair on an annual basis. The Present Value Capital Works are estimated to be £240 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £690 k. Assumes capital works in year 5.
Benefits	The key damages are the increased risk to the railway and the beach crest properties should the defences breach, this option would delay this by approximately 5 to 10 years. The property related benefits are estimated to be £100 k compared to Do nothing option. Benefits related to the railway have not been calculated at this stage.

Hold the line: improve existing defences (Option 4)

This would involve measures to improve defence resilience, such as rock toe works and raising crest levels to improve the standard of protection through the reinforcement of existing defences. It has been assumed that a rock toe would be added along the entire length of frontage with refurbishment of existing defences.	
Technical	The inclusion of a formal rock toe along the revetment, ensuring interlock and extent to allow for variations in the beach fronting the structure. Although this would be incorporated along the existing defences, a separate detail would be required for each defence type and given this it would be difficult to provide a consistent defence along the frontage. It would also require significant refurbishment to the existing structures. Some defences are of non-standard construction or materials and there is uncertainty regarding the practical refurbishment of these to a sufficient standard.
Environmental	Maintains the current situation with a slight increase to the structure footprint due to the extension of the toe protection. This would be undertaken along the whole defence length and would extend life of existing defences by 20 to 25 years, such that the design life of the scheme would be around 40 years. Over this time period, there would be protection of railway assets, caravan parks, homes, and land related to the Moorside development from erosion and flooding. However, in the longer term, continuing to hold the line could result in foreshore narrowing and loss of the intertidal habitats, which are a part of the MCZ designation. This option would also restrict the natural erosion of the maritime cliffs and slopes, potentially affecting the geological value of the area, and would increase hydromorphological pressure on the Cumbria coastal water body. Increasing the crest of the defences may affect local landscape character and views afforded of the sea. Once the defences fail in the longer term, the impacts would be as for Option 1.
Costs	Cost associated with the refurbishment of the existing defences to a suitable condition, the continual maintenance and construction of a rock toe. The Present Value Capital Works are estimated to be £4,390 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £7,540 k. Assumes capital works in year 5.
Benefits	The key damages are the increased risk to the railway and beach properties should the defences breach, this option would delay this by approximately 20 to 25 years. The benefits are estimated to be £100 k compared to Do nothing option. Benefits related to the railway have not been calculated at this stage.

Hold the line: improve through constructing new revetments or seawalls (Option 5)

This may involve the removal of the existing structures and construction of a formalised revetment to provide improved protection. Consideration of the alignment as two options (a) protect the railway, therefore construct behind the beach crest properties or (b) to protect the beach crest properties.	
Technical	(a) The removal and reconstruction of a new revetment would provide a consistent and formalised defence for the railway. (b) The proposed alignment could be considered in line with the existing properties, although this is likely to result in a much larger structure, rather than being set back in line with the railway. For both alignments a vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment is preferred to reduce wave scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered.
Environmental	(a) To protect the railway:

	<p>This option would defend the railway and the land behind it, including caravan parks, wastewater treatment works, and the Moorside site. However, the beachfront properties will be left undefended and will be subject to increased inundation and loss due to coastal erosion.</p> <p>This is a long term solution and will constrain natural erosion and coastal processes. Continuing to hold the line could result in intertidal habitat loss due to foreshore narrowing; these habitats are designated as part of the MCZ. Impacts on the WFD objectives of relevant waterbodies must also be taken into consideration.</p> <p>(b) To protect beach crest properties:</p> <p>This option would defend the assets as in a) with the addition of protecting the beachfront properties.</p> <p>Depending on timing of construction and shoreline change by that point, construction of defences seaward of beach properties may directly encroach on intertidal habitats designated as part of the MCZ. In the longer term, continuing to hold the line could result in intertidal habitat loss due to foreshore narrowing. Introduction of new artificial structures along a previously exposed frontage may impact on the coastal processes and sediment movements along the shoreline, with increased hydromorphological pressure on the Cumbria coastal water body. Impacts on the WFD objectives of the relevant waterbodies must be taken into consideration.</p> <p>The location of the proposed defence on the exposed shoreline would result in a significant visual change and may limit the recreational and amenity value of the beach present. This in turn may impact on the attractiveness of the area to tourists and residents of the beach front properties.</p>
<p>Costs</p>	<p>Large capital cost to remove, dispose of existing structure and construction of new defence along frontage.</p> <p>Option (b) would be required sooner, potentially in the short to medium term and option (a) in the medium to long term.</p> <p>Cost would be significantly greater for alignment (b) due to the larger structure required as a result of the more exposed location.</p> <p>For option (a) The Present Value Capital Works are estimated to be £4,010 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £7,730 k. Assumes the capital works undertaken in year 35. For option (b) the Present Value Capital Works cost increases to £5,900 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) £10,770 k; assumes capital works in front of properties undertaken in year 15, remainder of frontage in year 35.</p>
<p>Benefits</p>	<p>Option (a) This option would provide protection to the railway and future proof the infrastructure against potential increases in sea level, changes in wave climate and storminess. It will not provide protection to the beach crest properties.</p> <p>Option (b) As well as protecting the railway this option would also provide protection to the beach crest properties, given there are limited number of properties at risk the additional cost for this option may not be justified.</p> <p>The benefits for option (b) are estimated to be £610 k compared to Do nothing option (property damages). No benefit values for the railway assets have been calculated at this stage.</p>

Managed realignment: Beach reprofiling (Option 6)

<p>This option would be the reprofiling of the existing beach material to provide some limited protection to the beach front properties.</p>	
<p>Technical</p>	<p>This option is consistent with current practice observed further along the frontage (11d5.5) although potentially greater in scale and frequency. The option is likely to be constrained by the volume of shingle currently available and is therefore unlikely to be suitable beyond the short term as additional material would be required to raise the beach in order to adapt to rising sea levels in the medium or long term.</p> <p>The removal of sediments from at or below the mean water line will expose underlying sediments that will typically contain a higher percentage of finer particles leading to potential problems of near vertical cliffs forming in the beach profile (CIRIA, 2010).</p> <p>The operation of reprofiling may be counterproductive if it does not collect material from the below the low water line, which is where the sediment removed during storm events is deposited. Reprofiling of the upper inter tidal zone tends to leave an unnaturally steep beach profile in the upper inter tidal zone allowing larger waves to travel further inshore. This may discourage onshore movement of the sediment from below the low tide mark during calm beach building conditions as well as leading to more rapid erosion of the beach crest in storms (CIRIA, 2010).</p>
<p>Environmental</p>	<p>This option would continue to manage coastal risks to the variety of assets discussed in this assessment without a hard engineering solution, but only for a short period. It could, however, be considered in</p>

	<p>combination with other options discussed above. The proposed wider beach profile may increase the recreational value of the area and so lead to increased attractiveness to tourists. This may have positive economic benefits.</p> <p>However, the requirement for regular reprofiling of the beach is likely to have an adverse impact on the MCZ designation that covers the area from mean high water to mean low water. This area is designated for its extensive intertidal soft sediments which will be directly impacted by this option. The regular removal and redistribution may make it difficult for intertidal species to establish and flourish, and there are many bird species that feed on these intertidal species. Additionally, this option may have impacts on the geological processes of this frontage and the wider area due to wider impacts of sediment transport along the coastline.</p>
Costs	<p>Ongoing maintenance costs post storms, likely an annual operation. It is assumed that the option is only viable for up to 20 years.</p> <p>There is no Present Value Capital Cost and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,050 k.</p>
Benefits	<p>Potentially provides a wider and higher shingle beach fronting the properties improving the standard of protection against flooding in the short term. Benefits estimated as approximately £100 k. No benefit values for the railway assets have been calculated at this stage.</p>

2.7.3 11d5.4 - Discussion

Table 14 summaries the cost and benefit calculations for the various options presented above: note that on this frontage the economic benefits relate primarily to the railway but have not been calculated at this stage.

The ongoing and future capital and maintenance coastal defence provision for this frontage is the responsibility of Network Rail. 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 therefore be developed for the entire frontage of 11d5 frontage, including stability assessments, overtopping potential, identification of trigger levels, monitoring and responses.

Monitoring data suggest that the upper beach is relatively stable with more movement of the lower sand beach (CH2M, 2016a) with erosion of the frontage typically storm driven causing localised damage to the beach front properties.

The primary beneficiary is the railway, therefore future management along this coast will therefore depend on the overall case for the railway. The railway is not at imminent risk, therefore continuing to maintain the existing defences should be sufficient in the short term: Option 3 Hold the line: maintain through proactive maintenance is the preferred strategic approach and is also the preferred environmental approach. However, in the longer term, the risk of erosion is anticipated to increase, as a result of accelerated sea level rise. Therefore a more consistent approach to managing the entire shoreline is likely to be required. Option 4 would be suitable, if the long term viability of the railway is uncertain, whilst Option 5a would provide a long term solution of improving the defence by constructing a new revetment, with rock armour likely to be most cost effective measure.

There is little economic justification to provide protection to the beach crest properties. Option 6, reprofiling the shingle beach to provide a higher and wider beach crest, is consistent with current practice along some of the frontage (11d5.5) and could provide some short term reduction in coastal risks to the beach front properties. However, this is not a longer term solution. An alternative solution would be Option 5b, the construction of a formal rock toe in front of the properties, although this would be a much higher capital cost and would not attract government funding. This approach would have impacts on designated features of the MCZ and therefore is unlikely to be environmentally acceptable. As per the SMP policy, no further development should be permitted along the beach.

Table 14 Policy unit 11d5.4 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	0.41		
Option 3 Hold the line: maintain through proactive maintenance	0.24	0.69		
Option 4 Hold the line: improve existing defences (works in year 5)	4.39	7.54		
Option 5a Hold the line: improve through constructing new revetments or seawalls – to protect railway (Works in year 35)	4.01	7.73		
Option 5b Hold the line: improve through constructing new revetments or seawalls – to protect railway and beach front properties (works in front of properties in year 15)	5.90	10.77	0.6	<<1
Option 6 Other considerations: adaptive management of assets	0.00	1.05	~0.1	<<1

**Present Value cost (PVC) inclusive of 60% optimism bias
Options 2 -5a do not protect the properties seaward of the railway, just the railway.*

2.7.4 11d5.4 - Strategic way forward

The current SMP policy is No active intervention through to the long term, but allows works to the railway if required. The railway is currently at low risk, therefore the preferred approach in the short term is to continue to monitor and undertake proactive maintenance (Option 3) as required. A change in SMP policy may be appropriate to support such works.

Should the beach deteriorate and risk of coastal erosion increase (not anticipated within next 20 years) more substantial works could be required to continue to protect the railway. Constructing a new rock armour revetment, is likely to be most cost effective solution, in the long term (Option 5a), but the decision will rest with Network Rail, who are responsible for maintaining defences along this frontage. This would require a change in SMP policy.

The approach in this unit should be developed in conjunction with the other frontages within the policy area to ensure a strategic solution; in addition to the risk to the railway, the potential contamination risk associated with Sellafield (11d5.3) post decommissioning needs to be taken into account.

Any revetment constructed by Network Rail will not protect the beach front properties as that would require earlier intervention and larger scale works and therefore consultation with the property owners is recommended to discuss future options, such as relocation.

At the current time there are no known plans for the Moorside site, but continued liaison with the site owners, Nuclear Decommissioning Authority, is recommended to inform future shoreline management decisions.

The following activities are recommended in the future:

- Improved understanding of level of risk to the railway and beach properties through continued monitoring of the beach and cliffs (this should be undertaken throughout 11d5).
- Monitoring of defence condition to inform residual risk with repairs and maintenance undertaken as required.

- Development of an Asset Management Plan for the entire 11d5 frontage, setting out strategic aims. This should involve liaison with key stakeholders along the frontage to consider multi-benefits of any longer term solution.
- Consider the need for a change in SMP policy to support future shoreline management actions and to be consistent with adjacent frontages. This would need to follow a formal SMP change process.
- Local and low scale private beach management to continue subject to consents and whilst sustainable to do so. Ongoing liaison with property owners to consider longer term options, such as relocation.

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

2.8 11d5.5 Braystones, Nethertown, Coulderton

The frontage includes the small village of Nethertown and associated infrastructure, including a beach car park. The Cumbrian Coast Line runs along the length of the coastline. The remainder of the frontage is undeveloped.

Between Braystones and Nethertown there are various defences including sections of revetment protecting the railway, which are in good condition. At Nethertown car park, the concrete slabbing has failed and overall condition is poor.

There are also informal defences along the beach properties, comprising of gabion baskets and reprofiled shingle berms in various states of condition.

United Utilities (UU) assets in this policy unit include a short 150 mm overflow outfall from Nethertown pumping station.

At a local level the most recent beach data indicated that in places the beach upper foreshore was at its lowest level on record, around Braystones and Sea Mill (CH2M, 2017). The coarse upper beach can be mobilised and transported by waves, although this tends to be mainly during storms, such as observed during the winter storms of 2013 and 2014.

Monitoring data suggests there is general stability in the upper beach, NCERM erosion risk predictions are slightly less along this frontage than toward Seascale in the south.

2.8.1 11d5.5 - Initial screening of options

The short term SMP2 policy is Managed realignment with the monitoring of flood and erosion risk to the railway and to only carry out works if the railway is at risk. It identified the need to develop an adaptation strategy for properties on the beach and advised that no further development should be permitted along the beach. This policy changes to No active intervention in the medium to long term with monitoring of the flood and erosion risk to the railway, only carry out works if the railway is at risk. For this strategy, both Hold the line and Managed realignment options have been considered alongside No active intervention.

The SMP policy unit boundary is centred on Coulderton but it is suggested that for policy consistency across frontage where beach properties are located the boundary should be moved north to include them in 11d5.5.

Table 15 Screening of long list options for 11d5.5

Long list options	Description	Short listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option would not manage the long term erosion risk to the railway assets or the beach properties located along the beach crest. It has been assessed for comparative purposes.

Do minimum	Reactive patch and repair of defences only.	Baseline only	This option would not manage the long term erosion risk to the railway assets or the properties located along the beach crest. However, it may become the default option if funding is no longer available.
Hold the line: maintain through proactive maintenance	Measures to maintain the existing defences.	Yes	Patch repairs if carried out well and are timely could be effective in maintaining the integrity of the structure. This would not provide a long term solution to the storm erosion along the frontage.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works to improve longevity of existing defences.	No	The existing defences within this policy unit are a variety of structures and some are in poor condition or are not considered suitable for the exposed location. The defences would require significant refurbishment as well as incorporation of measures to maintain their current level of protection – which is not considered to be enough. This option is therefore not considered further.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Options to reinforce the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life attained. It is a viable option to be considered, although noted that significant refurbishment of the existing defences is required due to their poor condition.
Hold the line: improve through constructing new shore control structures	Measures to retain beach material, such as timber or rock groynes, breakwater.	No	This an exposed location and for this solution to be viable significant volumes of beach material would need to be sourced. This is not considered a viable option given the high capital cost and potential impact on the adjacent shoreline.
Hold the line: improve through constructing new revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide long term protection. Consideration of the proposed alignment could be considered in line with the existing properties. It does require a significant capital cost which may not be viable.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conducive to beach development. Any beach material placed would require several shore control structures to retain the material or significant ongoing recharge or recycling to maintain the profile. These would incur high capital and ongoing maintenance costs; therefore, this option is not considered further.
Hold the line: improve through cliff or slope stabilisation measures	This may include toe protection works, drainage or netting.	Not considered as a separate option	The key risk for the coastal strategy is erosion and scour of the toe of the structure, therefore provision of toe protection is likely to be the most effective solution. Where this is in front

			of the existing defences this is considered as part of “Hold the line: improve existing defences”, where new defences are required it is considered as “Hold the line: improve through construction 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 rock armour toes and sand filled geotextile bags.	No	The policy unit is exposed to waves and ongoing coastal processes that a low tech solution will not offer the required resilience therefore has not been considered further.
Managed realignment: Beach reprofiling	Reprofiling of existing beach material.	Yes	There may be some benefit in reprofiling the shingle beach for the properties built on the beach therefore this option has been considered further.

2.8.2 11d5.5 - 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 railway is slightly set back from the beach along most of the frontage and is not considered to be at imminent risk. Beach front properties are exposed under storm events and are situated at the toe of the railway embankment.</p> <p>Without investment in the existing defences the beach front properties and railway will become increasingly at risk throughout the appraisal period as a result of increased erosion resulting from accelerated sea level rise.</p> <p>The ad hoc beach front property defences will be lost with each storm event and eventual failure and loss of the defences and eventually the properties themselves.</p>
Environmental	<p>The beach properties would remain at high risk from coastal erosion and loss. In the longer term, this option is likely to result in coastal erosion and flooding of the Cumbrian Coast Line railway which is a key link for coastal communities. Reduced accessibility due to the severance of the railway, would also affect the operations of the Sellafield site. There may also be impacts on the recreational amenity of the area is erosion results in loss of beach access.</p> <p>This option would allow natural coastal processes, which may enhance the Cumbria Coast MCZ habitats and benefit the Cumbria coastal water body. There are also potential impacts on the Silver Tarn, Hallas and Harnsey Mosses SSSI and appraisal under the Countryside and Rights of Way Act would need to be undertaken.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are to the railway assets in the long term and infrastructure and the beach crest properties in the short term. The property related PV damages are estimated to be £1,870 k. Damages relating to the railway have not been valued 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. This option would only apply where defences are present.	
Technical	<p>As the works would be low cost and reactive only, as for the Do nothing the future life span of the existing defences depends on the future conditions, for example storm frequency and magnitude. If works are not carried out promptly, this could accelerate the time to failure of the defence.</p> <p>Given the ad hoc variety of defences, with no consistency and range of conditions this is not a resilient solution and will revert to a Do nothing once the defences fail.</p>

Environmental	Once defences fail, the impacts would be as for option 1 after approximately a 5 to 10 year delay.
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 £330 k.
Damages	The key damages are to the railway assets in the medium to long term and infrastructure and the beach crest properties, although timing would be delayed slightly from the Do nothing option. The property damages are estimated to be £900 k. Damages relating to the railway have not been valued at this stage.

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

Measures to maintain the existing defences. This would be a continuation of the current activities of patch and repair to the railway defences, based upon regular monitoring and as part of a scheduled programme of works. This option would only apply where defences are present.	
Technical	<p>The timely undertaking of repair works to the existing Network Rail structures can prolong the integrity of the structures. Works to prevent undermining and scour of the toe, with the proactive approach to patch and repair the existing defences may extend the residual life by up to 20 years.</p> <p>For the beach front properties defences this could be costly, given the range of defences along this frontage and the suitability to the exposed location. It is suggested that where gabions are present the fill material be replaced with more suitable single sized rock fill to prolong the structures life, although this is still not a resilient solution.</p>
Environmental	This option would maintain the current situation. Once the defences fail following the 20 year delay, impacts would be as in option 1.
Costs	<p>Cost of patch and repair on an annual basis. Refurbishment of any gabion structures.</p> <p>The Present Value Capital Works are estimated to be £300 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £820 k.</p>
Benefits	The key damages are the increased risk to the railway in the long term and the beach crest properties should the defences breach in the short term, this option would delay this by approximately 10 to 20 years. The property benefits are estimated to be £970 k compared to Do nothing option. Damages relating to the railway have not been valued at this stage.

Hold the line: improve existing defences (Option 4)

This would involve measures to improve defence resilience, such as rock toe works and raising crest levels to improve the standard of protection through the reinforcement of existing defences. The option could involve consideration of improvements to the toe of the existing structure to provide a more resilient solution to scour and storm damage. This option would only apply where defences are present.	
Technical	<p>The inclusion of a formal rock toe along the revetment, ensuring interlock and extent to allow for variations in the beach fronting the structure. Although this would be incorporated along the existing defences, a separate detail would be required for each defence type and given this it would be difficult to provide a consistent defence along the frontage. It would also require significant refurbishment to the existing structures.</p> <p>Some defences are of non-standard construction or materials and there is uncertainty regarding the practical refurbishment of these to a sufficient standard. For example, where gabions are present the fill material could be replaced with more suitable single-sized rock to prolong the structures life, although this is still only a short term solution.</p>
Environmental	<p>This option would maintain the current coastal defence to the railway assets and homes for up to 40 years. However, in the longer term, continuing to hold the line could result in foreshore narrowing and loss of the intertidal habitats, which are a part of the MCZ designation. This option would also restrict the natural erosion of the maritime cliffs and slopes, potentially affecting the geological value of the area, and would increase hydromorphological pressure on the Cumbria coastal water body. Raising crest levels to improve the standard of protection may affect local landscape character and views afforded of the sea.</p> <p>Once the defences fail in the longer term, the impacts would be as for Option 1.</p>
Costs	Cost associated with the refurbishment of the existing defences to a suitable condition, the continual maintenance and construction of a rock toe.

	The Present Value Capital Works are estimated to be £2,270 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £4,060 k.
Benefits	The key damages are the increased risk to the railway and beach properties should the defences breach, this option would delay this by approximately 20 to 25 years. The property benefits are estimated to be £970 k compared to Do nothing option. Benefits related to the railway have not been calculated at this stage.

Hold the line: improve through constructing new revetments or seawalls (Option 5)

This may involve the removal of the existing structure and construction of a formalised revetment to provide improved protection. Consideration of the alignment as two options (a) protect the railway, therefore construct behind the beach crest properties or (b) to incorporate and protect the beach crest properties.	
Technical	<p>Option (a) The removal of existing defences and reconstruction of a new revetment would provide a consistent and formalised defence for the railway. This option could tie into adjacent frontages to provide a consistent approach along this coastline to protect the railway.</p> <p>Option (b) The proposed alignment could be considered in line with the existing properties, although this is likely to result in a much larger structure, rather than being set back in line with the railway.</p> <p>For both alignments a vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment is preferred to reduce wave scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered.</p>
Environmental	<p>(a) To protect the railway:</p> <p>This option would protect the railway and the land behind it. However, the beachfront properties will be left undefended and will be subject to increased inundation and loss due to coastal erosion.</p> <p>This is a long term solution and will constrain natural erosion and coastal processes. Continuing to hold the line could result in intertidal habitat loss due to foreshore narrowing; these habitats are designated as part of the MCZ. Impacts on the WFD objectives of relevant waterbodies must also be taken into consideration.</p> <p>(b) To protect beach crest properties:</p> <p>This option would defend the assets as in a) with the addition of protecting the beachfront properties.</p> <p>Depending on timing of construction and shoreline change by that point, construction of defences seaward of beach properties may directly encroach on intertidal habitats designated as part of the MCZ. In the longer term, continuing to hold the line could result in intertidal habitat loss due to foreshore narrowing. Introduction of new artificial structures along a previously exposed frontage may impact on the coastal processes and sediment movements along the shoreline, with increased hydromorphological pressure on the Cumbria coastal water body. Impacts on the WFD objectives of the relevant waterbodies must be taken into consideration.</p> <p>The location of the proposed defence on the exposed shoreline would result in a significant visual change and may limit the recreational and amenity value of the beach present. This in turn may impact on the attractiveness of the area to tourists and residents of the beach front properties.</p>
Costs	<p>Large capital cost to remove, dispose of existing structures and construction of new defence along frontage.</p> <p>Option (b) would be required sooner, potentially in the short to medium term and option (a) in the medium to long term.</p> <p>Cost would be significantly greater for alignment (b) due to the larger structure required as a result of a more exposed location.</p> <p>For option (a), the Present Value Capital Works are estimated to be £4,230 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £7,450 k assuming implementation of capital works in year 35.</p> <p>For option (b) the Present Value Capital Works are estimated to be £12,150 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £20,480 k assuming implementation of capital works in year 15.</p>
Benefits	Option (a) This option would provide protection to the railway and future proof the infrastructure against potential increases in sea level, changes in wave climate and storminess. It will not provide protection to the beach crest properties.

Option (b) As well as protecting the railway this option would also provide protection to the beach crest properties, given there are limited number of properties at risk the additional cost and earlier intervention for this option may not be justified.

The property benefits for option (b) are estimated to be £970 k compared to Do nothing option. No allowance for railway benefits.

Managed realignment: Beach reprofiling (Option 6)

This option would be the reprofiling of the existing beach material to provide some limited protection to the beach front properties.	
Technical	<p>This option is consistent with current practice observed, although potentially greater in scale and frequency. The option is likely to be constrained by the volume of shingle currently available and is therefore unlikely to be suitable beyond the short term as additional material would be required to raise the beach in order to adapt to rising sea levels in the medium or long term.</p> <p>The removal of sediments from at or below the mean water line will expose underlying sediments that will typically contain a higher percentage of finer particles leading to potential problems of near vertical cliffs forming in the beach profile (CIRIA, 2010).</p> <p>The operation of reprofiling may be counterproductive if it does not collect material from the below the low water line, which is where the sediment removed during storm events is deposited. Reprofiling of the upper inter tidal zone tends to leave an unnaturally steep beach profile in the upper inter tidal zone allowing larger waves to travel further inshore. This may discourage onshore movement of the sediment from below the low tide mark during calm beach building conditions as well as leading to more rapid erosion of the beach crest in storms (CIRIA, 2010).</p>
Environmental	<p>This option would continue to defend the variety of assets discussed in this assessment without a hard engineering solution, but only for a short period. It could, however, be considered in combination with other options discussed above. The proposed wider beach profile may increase the recreational value of the area and so lead to increased attractiveness to tourists. This may have positive economic benefits.</p> <p>However, the requirement for regular reprofiling of the beach is likely to have an adverse effect on the MCZ designation that covers the area from mean high water to mean low water. This area is designated for its extensive intertidal soft sediments which will be directly impacted by this option. The regular removal and redistribution may make it difficult for intertidal species to establish and flourish, and there are many bird species that feed on these intertidal species. Additionally, this option may have impacts on the geological processes of this frontage and the wider area due to wider impacts of sediment transport along the coastline.</p> <p>There would also be a potential impact on the UU overflow outfall in Nethertown that would need to be assessed further.</p>
Costs	<p>Ongoing maintenance costs post storms, likely an annual operation.</p> <p>There are no Present Value Capital Works. The Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £4,560 k. (assumes option only viable for 20 years)</p>
Benefits	<p>Provides a wider and higher shingle beach fronting the properties improving the standard of protection against flooding in the short term. Property benefits not calculated at strategy stage. No benefit values for the railway assets have been calculated at this stage.</p>

2.8.3 11d5.5 - Discussion

Table 16 summarises the cost and benefit calculations for the various options presented above: note that on this frontage the economic benefits relate primarily to the railway but have not been calculated at this stage.

The ongoing and future capital and maintenance coastal defence provision for this frontage is the responsibility of Network Rail. There is a need to better understand the level of risks to the railway and operations for continued safety and avoidance of unacceptable risk: this is already identified by Network Rail as a frontage likely to require additional interventions in the near future. An Asset Management Plan should therefore be developed for the entire frontage of 11d5 frontage, including stability assessments, overtopping potential, identification of trigger levels, monitoring and responses.

There are currently various defences including sections of revetment protecting the railway, which are in good condition, and informal defences along the beach properties, comprising of gabion baskets and reprofiled shingle berms in various states of condition. Monitoring data suggest that the upper beach is relatively stable with more movement of the lower sand beach (CH2M, 2016a) with erosion of the frontage typically storm driven causing localised damage to the beach front properties.

The primary beneficiary is the railway, therefore future management along this coast will therefore depend on the overall case for the railway. The railway is not at imminent risk, therefore continuing to maintain the existing defences should be sufficient in the short term: Option 3 Hold the line: maintain through proactive maintenance is the preferred strategic approach and is also the preferred environmental approach. However, in the longer term, the risk of erosion is anticipated to increase, as a result of accelerated sea level rise. Therefore a more consistent approach to managing the entire shoreline is likely to be required. Option 4 would be suitable, if the long term viability of the railway is uncertain, whilst Option 5a would provide a long term solution of improving the defence by constructing a new revetment, with rock armour likely to be most cost effective measure.

There is little economic justification to provide protection to the beach crest properties. Option 6, reprofiling the shingle beach to provide a higher and wider beach crest, is consistent with current practice along some of the frontage (11d5.5) and could provide some short term reduction in coastal risks to the beach front properties. However, this is not a longer term solution and the strategic level costs estimates are significantly higher than the potential benefits. An alternative solution would be Option 5b, the construction of a formal rock toe in front of the properties, although this would be a much higher capital cost and would not attract government funding. This approach would have impacts on designated features of the MCZ and would alter the nature of the beach and restrict access to and views of the beach, possibly counter to the reasons the properties are there and therefore is unlikely to be environmentally acceptable. As per the SMP policy, no further development should be permitted along the beach, although it is noted that there are several replacement properties that have been constructed along the beach crest since the SMP2.

Table 16 Policy unit 11d5.5 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	0.33		
Option 3 Hold the line: maintain through proactive maintenance	0.30	0.82		
Option 4 Hold the line: Improve existing defences	2.27	4.06		
Option 5a Hold the line: improve through constructing new revetments or seawalls – to protect railway	4.23	7.45		
Option 5b Hold the line: improve through constructing new revetments or seawalls – to protect railway and beach front properties	12.15	20.48	0.9	<<1
Option 6 Managed realignment: reprofiling of beach to lower flood risk	0.00	4.56	-	<<<1

**Present Value cost (PVC) inclusive of 60% optimism bias
Options 2 -5a do not protect the properties seaward of railway, just the railway.*

+ Benefits for protecting the railway not calculated at this stage.

2.8.4 11d5.5 - Strategic way forward

The short term SMP2 policy is Managed realignment with the monitoring of flood and erosion risk to railway and to only carry out works if the railway is at risk. This allows for private adaptation or short term measures for the beach front properties. This policy changes to No active intervention in the medium to long term, but allows works to the railway if required.

The railway is currently at low risk, therefore the preferred approach in the short term is to continue to monitor and undertake proactive maintenance (Option 3) as required. A change in SMP policy may be appropriate to support such works.

Should the beach deteriorate (not anticipated within next 20 years) more substantial works could be required to continue to protect the railway. Constructing a new rock armour revetment, is likely to be most cost effective solution, in the long term (Option 5a), but the decision will rest with Network Rail, who are responsible for maintaining defences along this frontage. This would require a change in SMP policy.

Any revetment constructed by Network Rail will not protect the beach front properties and therefore consultation with the property owners is recommended to discuss future options, such as relocation. This also applies to the properties located near Couderton, where properties are situated approximately 500 m into policy unit 11d5.6.

The following activities are recommended in the future:

- Improved understanding of level of risk to the railway and beach properties through continued monitoring of the beach and cliffs (this should be undertaken throughout 11d5).
- Monitoring of defence condition to inform residual risk with repairs and maintenance undertaken as required.
- Development of an Asset Management Plan for the entire 11d5 frontage, setting out strategic aims. This should involve liaison with key stakeholders along the frontage to consider multi-benefits of any longer term solution.
- Consider the need for a change in SMP policy to support future shoreline management actions and to be consistent with adjacent frontages. At the same time, consider a change in policy unit boundary to include all the Couderton properties. This would need to follow a formal SMP change process.
- Local and low scale private beach management to continue subject to consents and whilst sustainable to do so. Ongoing liaison with property owners to consider longer term options, such as relocation.

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

2.9 11d5.6 Couderton to Sea Mill

This is a largely undeveloped stretch of coast; the only coastal asset being the Cumbrian Coast Line, which runs the length of the unit. It encompasses the southern end of a small headland, which is designated as part of St Bees Head SSSI for its geological interest.

There are two sections of revetment protecting the railway, these are in reasonable condition (residual life of 20 to 50 years), with shorter sections of rock protection. The cliffs behind are stable but there is outflanking at the southern end. The northern section of revetment is in front of the designated cliff.

Erosion of the undefended till cliffs is primarily during storms, at other times the beach provides adequate protection along much of the frontage (Halcrow, 2011).

Across the Coulderton frontage there are a variety of defences (gabions, random blocks, vertical stone or timber structure) in an attempt to reinforce the shingle beach crest. Beach properties situated at Coulderton have been considered within the discussion above for policy unit 11d5.5.

2.9.1 11d5.6 - Initial screening of options

The SMP2 management policy for the policy unit is No active intervention – Monitor flood and erosion risk to railway, only carry out works if the railway is at risk.

To address the long term risk to the railway, for this strategy, both Hold the line and Managed realignment options have been considered alongside No active intervention.

Table 17 Screening of long list options for 11d5.6

Long list options	Description	Short-listed?	Rationale
Do nothing	No further works undertaken, defences left to deteriorate and fail.	Baseline only	This option would not manage the long term erosion risk to the railway assets. It has been assessed for comparative purposes.
Do minimum	Reactive patch and repair of defences only.	Baseline only	This option would not manage the long term erosion risk to the railway assets. However, 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 existing defences. This would not provide a long term solution to the storm erosion along the undefended stretches of frontage.
Hold the line: maintain through reinforcing existing defences	Low cost measures such as ad hoc rock toe works to improve longevity of existing defences.	No	Options to reinforce the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life attained. This option is similar to Hold the line: Improve existing defences therefore has not been considered further. As erosion is the key risk, the difference between the two options is a small increase in the toe protection equating to a minimal increase in the cost to 'improve' the existing structure.
Hold the line: improve existing defences	Measures to improve defence resilience, such as rock toe works, raising crest levels.	Yes	Options to reinforce the existing defences may offer a suitable solution. Consideration should be given to the expected performance and design life 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, breakwater.	No	This is an exposed location and for this solution to be viable significant volume of beach material would need to be sourced. This is not considered a viable option given the high capital cost and potential implication to the adjacent shoreline.
Hold the line: improve through constructing new revetments or seawalls	Removal of the existing defences and construction of new revetments or seawalls.	Yes	Construction of a new revetment or seawall along this frontage would provide a resilient and ongoing protection. It does involve a significant capital cost, but should be investigated further.
Hold the line: improve through beach recharge	Addition of new material to beaches.	No	It is not thought this area is conducive to beach development. Any beach material

			placed would require several shore control structures to retain the material or significant ongoing recharge to maintain the profile. These would incur high capital and ongoing maintenance costs, therefore this option is not considered further.
Hold the line: improve cliff or slope stabilisation measures	This may include toe protection works, drainage or netting.	No	The key risk for the strategy is coastal erosion and scour of the toe of the structure, therefore provision of toe protection is likely to be the most effective solution. Where this is in front of the existing defences this is considered as part of "Hold the line: improve existing defences", where new defences are required it is considered as "Hold the line: improve through construction 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 rock armour toes and sand filled geotextile bags.	No	The policy unit is exposed to waves and ongoing coastal processes so a low tech solution will not offer the required resilience therefore has not been considered further.

2.9.2 11d5.6 - 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 existing defences are not along the full length of the policy unit, but the undefended sections are typically set back so are unlikely to be at risk in the medium to long term.</p> <p>The existing rock armour revetment is in a fair condition, but without investment the defences will deteriorate further, leading to eventual failure and increased exposure to the railway. Undefended frontages would be at increasingly risk of erosion in the future, as a result of accelerated sea level rise.</p>
Environmental	<p>Principally, the railway line would remain at risk of damage or loss to erosion. This would reduce operation of this railway, limiting the connectivity of communities within the policy. Reduced accessibility due to the severance of the railway would also affect the operations of the Sellafield site.</p> <p>The beach properties would remain at high risk from coastal erosion and loss (note options for defending beach properties are considered in 11d5.5).</p> <p>This option would allow natural coastal processes, which may enhance the Cumbria Coast MCZ habitats and benefit the Cumbria coastal water body. There is not anticipated to be an impact on St Bees Head SSSI to the north.</p>
Cost	There are no costs associated with the Do nothing option.
Damages	The key damages are to the railway assets in the long term and infrastructure and the beach crest properties in the short term. The property related damages are estimated to be £300 k. Damages relating to the railway have not been valued 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 the works would be low cost and reactive only, as for the Do nothing the future life span of the existing defences depends on the future conditions, for example storm frequency and magnitude. If works are not carried out promptly, these events could accelerate the time to failure of the defence.</p> <p>Undefended frontages would be at increasingly risk of erosion in the future, as a result of accelerated sea level rise.</p>
Environmental	Once defences fail, the impacts would be as for option 1 after approximately 5 to 10 year delay.

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 £700 k.
Damages	The key damages are to the railway assets and infrastructure and the beach properties, although timing would be delayed slightly from the Do nothing option. Damages relating to the railway have not been valued at this stage.

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

Measures to maintain the existing defences. This would be a continuation of the current activities of patch and repair to the defences, based upon regular monitoring and as part of a scheduled programme of works. This option would only apply where defences are present.	
Technical	<p>The timely undertaking of repair works to the existing structure can prolong the integrity of the structure. Works to prevent undermining and scour of the toe, with the proactive approach to patch and repair may extend the residual life by up to 10 years.</p> <p>The undefended sections would not be included within this option, therefore risk to the railway still remains in the medium to long term.</p>
Environmental	This option would maintain the current situation for up to 30 years. Once the defences fail the impacts will as in Option 1.
Costs	<p>Cost of patch and repair on an annual basis.</p> <p>The Present Value Capital Works are estimated to be £550 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £1,490 k.</p>
Benefits	The key benefits are the reduced risk to assets and the railway. This option would delay the Do nothing damages by approximately 10 years. There are no property related benefits for this option. Damages relating to the railway have not been valued at this stage.

Hold the line: improve existing defences (Option 4)

This would involve measures to improve defence resilience, such as rock toe works and raising crest levels to improve the standard of protection through the reinforcement of existing defences. The option could involve consideration of improvements to the toe of the existing structure to provide a more resilient solution to scour and storm damage. This option would only apply where defences are present.	
Technical	<p>The inclusion of a formal rock toe along the revetment, ensuring interlock and extent to allow for variations in the beach fronting the structure. This offers a viable solution to extend the life of the defences with ongoing investment as the railway is slightly set back.</p> <p>The undefended sections would not be included within this option, therefore risk to the railway would still remain in the medium to long term.</p>
Environmental	<p>This option would maintain the current protection to the Cumbrian Coast Line railway for several years (up to year 45), but the undefended sections would not be included within this option, therefore risk to the railway still remains in the medium to long term.</p> <p>In the longer term, continuing to hold the line could result in foreshore narrowing and loss of the intertidal habitats, which are a part of the MCZ designation. This option would also impact on the natural erosion of the cliffs and slopes, potentially affecting the geological value of the area. Impacts on the WFD objectives of the relevant waterbodies must be considered. Note that the defences already lie in front of the SSSI designated cliff, but any works to raise crest levels would need to consider impacts on this geological site.</p> <p>Once the stretches of defence fail in the longer term, the impacts would be as in Option 1.</p>
Costs	<p>Cost associated with the continually maintenance and improvement to the toe by filling the existing voids and providing a formalised toe to resist scour and storm damage.</p> <p>The Present Value Capital Works are estimated to be £1,270 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £2,590 k. Assumes intervention in year 20.</p>
Benefits	The key damages are the increased risk to the assets and the railway should the defences breach, this option would delay this by approximately 20 to 25 years to year 45. There are no property related benefits for this option. Benefits related to the railway have not been calculated at this stage.

Hold the line: improve through constructing new revetments or seawalls (Option 5)

This may involve the removal of the existing structure and construction of a formalised revetment to provide improved protection to the railway. This would include the currently undefended sections of the frontage.	
Technical	<p>The removal of existing defences and reconstruction of a new revetment would provide a consistent and formalised defence for the railway.</p> <p>A vertical sea wall is not considered a suitable option as storm scouring and potential of undermining is a significant risk along this frontage. A sloping revetment is preferred to reduce wave scour and offer a resilient solution that can be easily repaired. Rock armour is proposed, although other revetment armouring solutions could be considered. The revetment would be placed adjacent to the railway, after the properties have been lost.</p>
Environmental	<p>This option would protect the railway and the land behind it into the long term. This is a long term solution and will constrain natural erosion and coastal processes. Continuing to hold the line could result in intertidal habitat loss due to foreshore narrowing; these habitats are designated as part of the MCZ. Impacts on the WFD objectives of relevant waterbodies must also be taken into consideration.</p> <p>The location of the proposed defence on the exposed shoreline would result in a significant visual change and may limit the recreational and amenity value of the beach present. Additionally, this hard engineering in a previously exposed frontage may impact on the coastal processes and sediment movements along the shoreline. This may also impact on the St Bees Head SSSI.</p>
Costs	<p>Large capital cost to remove, dispose of existing structure and construction of new defence along frontage.</p> <p>The Present Value Capital Works are estimated to be £4,790 k and the Present Value Total Cost with Optimism Bias (PV(OB)c) is estimated to be £8,580 k. Assumes intervention in year 30.</p>
Benefits	<p>This option would provide long term protection to the railway and future proof the infrastructure against potential increases in sea level, changes in wave climate and storminess. There are no property related benefits for this option. Benefits related to the railway have not been calculated at this stage.</p>

2.9.3 11d5.6 - Discussion

Table 18 summaries the cost and benefit calculations for the various options presented above. However, on this frontage the economic benefits relate primarily to the railway but have not been calculated at this stage.

The ongoing and future capital and maintenance coastal defence provision for this frontage is the responsibility of Network Rail. There is a need to better understand the level of risks to the railway and operations for continued safety and avoidance of unacceptable risk: this is already identified by Network Rail as a frontage likely to require additional interventions in the near future. An Asset Management Plan should therefore be developed for the entire frontage of 11d5 frontage, including stability assessments, overtopping potential, identification of trigger levels, monitoring and responses.

There are two sections of revetment protecting the railway, these are both in reasonable condition (residual life of 20 to 50 years) and if maintained these should be sufficient to provide protection to the hinterland and the railway for in excess of 50 years. Option 3 Hold the line: maintain through proactive maintenance is the preferred strategic approach and is also the preferred environmental approach. This approach would only apply to the currently defended sections, but the remainder of the frontage is currently at low risk, so this should allow time for development of a long term solution of improving the defence. In the longer term, the risk of erosion is anticipated to increase, as a result of accelerated sea level rise. Therefore a more consistent approach to managing the entire shoreline is likely to be required. A new rock armour revetment is likely to be most cost effective solution, in the long term (Option 5), but other options could be considered at this later date.

The properties located at Couderton are considered within policy unit 11d5.5 (see Section 2.8).

Table 18 Policy unit 11d5.6 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	0.70		
Option 3 Hold the line: maintain through proactive maintenance	0.55	1.49		
Option 4 Hold the line: improve existing defences in year 20	1.27	2.59		
Option 5 Hold the line: improve through constructing new revetments or seawalls in year 30	4.79	8.58		

**Present Value cost (PVC) inclusive of 60% optimism bias
Options 2 -5 do not protect the properties seaward of the railway, just the railway. The strategy for properties located at Couderton are considered within policy unit 11d5.5. Benefits related to protection of railway not calculated at this stage.*

2.9.4 11d5.6 - Strategic way forward

The current SMP policy is No active intervention through to the long term, but allows works to the railway if required. The railway is currently at low risk, therefore the preferred approach in the short term is to continue to monitor and undertake proactive maintenance (Option 3) as required. This option would involve maintaining the existing defences. A change in SMP policy may be appropriate to support such works.

Should the beach deteriorate and risk of coastal erosion increase (not anticipated within next 20 years) more substantial works could be required to continue to protect the railway. Constructing a new rock armour revetment (Option 5a) is likely to be most cost effective solution in the long term but the decision will rest with Network Rail, who are responsible for maintaining defences along this frontage. This would require a change in SMP policy.

The following activities are recommended in the future:

- Improved understanding of level of risk to the railway through continued monitoring of the beach and cliffs (this should be undertaken throughout 11d5).
- Monitoring of defence condition to inform residual risk with repairs and maintenance undertaken as required.
- Development of an Asset Management Plan for the entire 11d5 frontage, setting out strategic aims. This should involve liaison with key stakeholders along the frontage to consider multi-benefits of any longer term solution.
- Consider the need for a change in SMP policy to support future shoreline management actions and to be consistent with adjacent frontages. This would need to follow a formal SMP change process.

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

2.10 11d5.7 Sea Mill to Pow Beck

This short stretch of coastline includes a small collection of properties at Stoney Croft, some of which lie between the coastal defences and the railway embankment. There is also a beach access and car park which lies seaward of the railway. The Cumbrian Coast Line railway runs along the clifftop before turning inland at Sea Mill. United Utilities (UU) assets within this policy unit include Sea Mill Lane WwPS and a passing 200 mm rising main that runs underneath Sea Mill Lane Car Park.

A small stream (Pow Beck) outflows to the sea at the northern end of the defences: this is discussed in the adjacent policy area, 11d6.

The SMP2 management policy is to Hold the line by maintaining the existing revetment and rock armour defences in the short term and by maintaining or constructing larger defences in the medium to long term.

At Sea Mill the gabion baskets have failed and parts of the rock revetment have also become displaced, meaning that the overall condition of the defence is poor. Erosion of the till cliffs is understood to be predominately during storms, for example as observed along the cliffs at Ancient Fishgarth (11d5.7) during the 2013 and 2014 winter storms (Coastal Engineering UK, 2016a), but at other times the beach provides adequate protection along most of this frontage (Halcrow, 2011).

Network Railway, in collaboration with CBC, is currently in phase of implementing a scheme (marine licence started on 14 October 2019) comprising the removal of existing rock armour and construction of a new revetment. In addition, the scheme aims to repair the existing brick wall..

2.10.1 11d5.7 - Initial screening of options

A coastal protection options appraisal was undertaken for this frontage in 2012 (Capita Symonds, 2012). Table 19 summarises the options considered by this (2012) report. All options that would have been considered as part of this strategy have been included in the short list of options by Capita Symonds.

Table 19 Options considered in the Capita Symonds (2012) report.

Capita Symonds short list options
1. Do nothing
2. Do minimum
3A. Do Something: Upgrade existing defences at current location, extending the life of the existing defences by improving their condition.
3B. Do Something: Continue maintaining the existing defences until they reach the end of their effective life span then replace them in their current locations. This option is similar to Option 2, but would replace the Sea Mill defences in front of the car park rather than constructing new defences adjacent to the railway.
3C: As Option 3B, but allowing the car park to erode and only providing new defences when properties come under threat from erosion.
3D: Reconstruction of the existing defences in their current positions in 2024. This option tests whether it may be advantages to replace all of the same time with a single structure rather than on a piecemeal basis. As for option 3A this would allow time for seeking funding, planning and designing the new structure before construction.
3E: As Option 3D by upgrading the defences in phases, when they reach condition 4.

2.10.2 11d5.7 - Development and appraisal of short listed options

Capita Symonds (2012) explored and assessed a range of implementation options for the frontage at Sea Mill, south of St Bees, from Pow Beck in the North to Ancient Fishgarth in the south. These have been considered from a technical, environmental and economic perspective.

The assessment concluded that the defences were in a generally reasonable condition, but that decisions need to be made by Copeland BC and Network Rail on future management options for the defences, not least whether the properties and the car park can continue to be defended (Capita, 2012).

A number of options were considered (Capita, 2012), including:

- Continuing present maintenance until the defences fail at which point the Ancient Fishgarth defences would be replaced at their current location and new Sea Mill defences would be constructed to protect the railway line only rather than at the current location (Option 2)
- Upgrade the defences at differing times to extend the effective lifespan (Options 3A and 3E)
- Replacement of the defences at their present locations (Options 3B and 3D)
- Replacement of Ancient Fishgarth defences at their present locations and construction of setback defences at Sea Mill to protect the properties and railway line, but not the car park (Option 3C).

Following the screening of the options presented by Capita against technical, environmental and economic criteria Options 3A and 3E to be the most sustainable.

2.10.3 11d5.7 - Discussion

Options proposed by Capita Symonds are considered to be reasonable and no additional relevant options have been identified as part of this strategy. Table 19 summaries the cost and benefit calculations: these have simply been uplifted to present day.

Proactive maintenance (Option 3A) could be sufficient to provide protection to the hinterland and the railway for in excess of 50 years; this would allow time for development of a long term solution of improving the defence by constructing a new revetment, with rock armour likely to be most cost effective solution, in the long term (Options 3C, D or 3E). This is already identified by Network Rail as a frontage likely to require additional interventions in the future.

There are several recommendations made in the Capita Symonds 2012 appraisal report and it is important that these are taken forward, such as seeking contributions toward the cost of the works from benefitting parties. In this case that would include the property owners whose properties would be directly protected and Network Rail (Capita, 2012). Capita concluded that Copeland BC should consult with Network Rail, property owners and the Environment Agency to discuss the options identified and how they can be funded.

Table 20 Policy unit 11d5.7 Summary of economics

Option	Capital works applied in year	Present Value Total cost (PVC)* £m	PV Benefit (Damage Avoided) £m	Average Benefit Cost Ratio
Option 1 Do nothing	-	0.00	0.00	-
Option 2 Do minimum	-	0.45	0.17	0.38
Option 3A Do Something: upgrade existing defences at current location, extending the life of the existing defences by improving their condition.	0	0.26	0.17	0.65
Option 3B Do Something: continue maintaining the existing defences until they reach the end of their effective life span then replace them in their current locations.	20	0.77	0.17	0.22
Option 3C Providing setback defences to protect properties and the railway.	20	0.67	0.17	0.25
Option 3D Reconstruction of the existing defences in 2014.	20	1.01	0.17	0.17
Option 3E Phased upgrading of defences when they reach condition 4.	20	0.32	0.17	0.53

*Present Value cost (PVC) inclusive of 60% optimism bias

Costs are updated from Capita (2012); Property related benefits derived under this study. No allowance for railway benefits.

2.10.411d5.7 - Strategic way forward

The SMP2 policy is to Hold the line. At present the railway line is not at high risk, therefore the preferred approach is for proactive maintenance (Option 3A), which should be sufficient to provide protection to the railway and properties beyond 50 years. It is assumed for the strategy that the benefits related to the railway that have not been calculated at present would make this option economically viable. This option would involve maintaining the existing defences until they reach the end of their effective life span then replace them in their current locations, with Sea Mill defences replaced in front of the car park rather than constructing new defences adjacent to the railway.

This would allow time for development of a long term solution (beyond 20 years) of improving the defence by constructing a new revetment, with rock armour likely to be most cost effective solution, in the long term (Option 3E). It is assumed for the strategy that the benefits related to the railway that have not been calculated at present would make this option economically viable.

The following activities are recommended in the future:

- Improved understanding of level of risk to the railway through continued monitoring of the beach and cliffs (this should be undertaken throughout 11d5).
- Monitoring of defence condition to inform residual risk with repairs and maintenance undertaken as required.
- Development of an Asset Management Plan for the entire 11d5 frontage, setting out strategic aims. This should involve liaison with key stakeholders along the frontage to consider multi-benefits of any longer term solution.
- Development of a funding strategy for defence maintenance and improvements – potential investment should be sought from properties directly protected and Network Rail.

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

3 Summary of proposed strategy: 11d5

Preferred strategic approach: Management of coastal risks to infrastructure and community assets by maintaining and reinforcing existing defences, provision of new defences and risk assessments for undefended frontages.

		Next 10 years	Beyond 10 years
11d5.1	Seascale	Continue to maintain defences (through do minimum) whilst a funding strategy is developed to enable proactive maintenance.	Continue to reduce the risk of coastal erosion and flooding to Seascale through improving defences when necessary, subject to funding being secured.
11d5.2	Seascale to Sellafield	Undertake local low tech measures to address erosion issues, as part of a wider asset management plan for the railway.	Continue to reduce the risk of coastal erosion and flooding to the railway line and shoreline assets through improving defences when necessary.
11d5.3	Sellafield	Hold the line: through proactive maintenance of defences, as part of a wider asset management plan for the railway.	Continue to reduce the risk of coastal erosion and flooding to Sellafield nuclear site and the railway line through improving defences when necessary.
11d5.4	Sellafield to Braystones	Proactive maintenance of existing defences to the railway, as part of a wider asset management plan for the railway. (Do nothing along undefended stretches.).	Continue to reduce the risk of coastal erosion and flooding to the railway line and shoreline assets through improving and extending defences to the railway when necessary.
11d5.5	Braystones, Nethertown, Coulderton	Proactive maintenance of existing defences to the railway, as part of a wider asset management plan for the railway.	Continue to reduce the risk of coastal erosion and flooding to the railway line and shoreline assets through improving and extending defences when necessary.
11d5.6	Coulderton to Sea Mill	Proactive maintenance of existing defences, as part of a wider asset management plan for the railway. (Do nothing along undefended stretches.)	Continue to reduce the risk of coastal erosion and flooding to the railway line and shoreline assets through improving and extending defences when necessary.
11d5.7	Sea Mill to Pow Beck	Proactive maintenance of existing defences, as part of a wider asset management plan for the railway.	Continue to reduce the risk of coastal erosion and flooding to the railway line and properties at Sea Mill through improving and building new defences (possibly seaward of car park) when necessary.

Key actions and activities (next 10 years):



- Monitor condition of defences
- Monitor beach and backshore (cliffs and dunes) to improve understanding of changes in risk



- Repair and maintain defences where and when required



- Studies to better understand risks to railway
- Development of Network Rail Asset Management Plan for the entire 11d5 frontage
- Consider need for a change in SMP policy (11d5.2, 11d5.4, 11d5.5, 11d5.6) to support future shoreline management actions and to be consistent with adjacent frontages.



- Liaison with key stakeholders along the frontage to consider multi-benefits of any longer term solution for the policy area.
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- Discussion with beach property owners (Braystones, Nethertown and Coulderton) to discuss long terms plans and potential adaptation/ relocation options
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- Development of funding strategy for Seascale (11d5.1) and Sea Mill (11d5.7)
 - Development of a funding strategy for defence maintenance and future defence improvements for protection of the Sellafield nuclear site (11d5.3).
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Further details on actions and responsibilities are provided in the **Action Plan**.

4 References

Capita Symonds (2012). Copeland Borough Council Sea Mill Coast Protection Options Appraisal.

CIRIA (2010) Beach Management Manual (second edition). Environment Agency. CIRIA C685

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CH2M (2017b) Copeland Analytical Report 2016. Sefton Borough Council.

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