Runswick Bay Strategy Option Screening Technical Assessment

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DATE: Revised 24th March 2014 (Record of 5th December 2013 storm surge added. Do minimum costs increased following actual costs incurred post 5th December 2013 storm surge)

PROJECT NUMBER: 473342.AA.01.05

Revised 27th July 2015 to exclude Appendices B & C (Port Mulgrave).

1 Introduction

This note aims to explain the methodology and assumptions used to develop the options and to carry out the high level screening assessment for the Runswick Bay Strategy Review (StAR). The scope of the review is to update the Runswick Bay Coastal Strategy dating from 2002. In doing so the study aims to provide an up-to date assessment of the risks to people and the built, natural and historic environments from sea flooding and coastal erosion along the frontage between Thorndale Shaft and Sandsend Ness, North Yorkshire. The area to be covered includes two locations with built environments. These are Port Mulgrave and the village of Runswick Bay. This particular paper deals with the options for holding the line at the village of Runswick Bay and Annexes A and B of this paper centre on background information and option descriptions. Annex C is included to provide an introduction to the problem at Port Mulgrave.

2 The Problem

2.1 Location

Runswick Bay is located approximately five miles north of Whitby on the east coast of North Yorkshire. It is a deeply indented bay approximately 2 km long, situated between two headlands - Caldron Cliff to the north and Kettleness to the south. The village of Runswick Bay is located between the valleys of the Runswick and Nettledale Becks in the north-western part of the bay. The location of Runswick Bay is shown in Figures 2.1 and Figure 2.2 shows the site of the village in more detail.

2.2 Coastal Defence Strategy 2002

The Runswick Bay Coastal Defence Strategy Study undertaken by High-Point Rendel (HPR Strategy) was finalised in August 2002 following completion of the coast protection and slope stabilisation emergency works in April 2001. The HPR Strategy noted the "*rapidly deteriorating condition of the existing coastal defence elements and slopes which were not engineered as part of the Emergency Works constructed in 1999-2000*", and recommended a programme of future capital works, together with details of the management, monitoring and maintenance needs required to successfully implement the strategy plan over the next 50 years (to around 2050).

With regard to capital works the HPR Strategy recommended the following in the short-term:

- Design and construction in year 2 of a small rock armour groyne on the raised rocky foreshore known locally as Cobble Dump headland (below Cauldron Cliff), and of a rock armour apron in front of the existing sea defences that flank the northern frontage of the village.
- Slope betterment works comprising drainage and earthworks in year 1 on the coastal slopes beneath Ings End.

The HPR Strategy also recommended a prioritised programme of beach, seawall and coastal slope monitoring, as well as maintenance works to the seawalls, coastal slopes and the 2001 emergency works.

To date the capital coast protection works (groyne and armour apron) have not been undertaken. Consequently the seawalls remain exposed to wave attack and the risk of further deterioration and subsequent failure remains.

2.3 Shoreline Management Plan Review 2007

The Shoreline Management Plan Review (SMP2) was completed in 2007 by Royal Haskoning. Runswick Bay is situated in Management Area 21 (MA 21), which extends from Runswick Bay Village to Sandsend Ness to the south. The village itself is covered by Policy Unit 21.1, for which the preferred policy options are to maintain and improve the defences in line with the strategy in the short term, and to maintain the defences in the medium and long term (around the next 100 years) i.e. Hold the Line for the short, medium and long term. The SMP2 commented that:

"*The village frontage is seen as being in a fundamentally sustainable position with regard to the overall geomorphology of the area. The strategy has confirmed a good economic benefit for continued defence and this would support the general objectives for the area……. The SMP, therefore, supports the findings of the strategy and the preferred policy for the village is to hold the line over the next 100 years.*"

The SMP2 policy options for policy units adjacent to Runswick Bay village are No Active Intervention (short, medium and long term) for both Runswick Bay to the south (PU 21.2) and for Lingrow (PU 20.3) to the north.

The SMP2 Action Plan recommended that in the short-term a scheme appraisal for the defence of Runswick Bay should be undertaken, and that the recommendations of the strategy should be developed.

2.4 Defence Condition Changes

The condition of the seawalls protecting the village have been recorded following several inspections. The 2009 walkover survey (Halcrow) notes, for example, that:

"*the sea wall defences to the north of the new pumping station show a variety of defects ranging from minor to more significant issues. The northern coastal sea wall, which gives direct protection to a private property, is suffering from surface cracking and erosion. Erosion of the underlying bedrock is causing undercutting of the sea wall. Further investigation is required to determine the rate of undercutting. Further defects include washed out sealant joints, flap valves which have seized shut, wash out of the joints under the capping beam, vertical cracks through the wall and wide voids emerging*."

As part of the regional monitoring programme the defences at Runswick Bay were inspected by Halcrow in October 2012. A summary of key points extracted from the inspection report is given in Table 2.1.

Table 2.1: Summary of defence condition data from October 2012 inspections

Rock armour defences (Asset ref: 1221D901D0602C01) 	The defences remain in very good condition, with the rocks tightly packed with good coverage and no evidence of significant deformation. The associated slipway towards the south from the end of the road and boat park is also in good condition. Beach levels appeared relatively high at the time of the inspection, so the toe was not visible. There is ongoing erosion of the undefended cliff at the southern end of the defence and some of the locally sourced smaller rock used at the tie in has been scattered, however this is not a cause for concern at present.
Slipway adjacent to the RNLI (Asset Ref. 1221D901D0601C04) 	The slipway adjacent to the RNLI building remains in good overall condition, although the timber strips to support the small boats are rotting in many places and will need replacing and joints between slabs need resealing, below left. The seawall around the pumping station to the north of the RNLI building is in very good condition, although the standards for all of the handrails are showing corrosion and need cleaning and repainting.
Concrete breakwater or groyne (Asset Ref. 1221D901D0601C02) 	The concrete groyne to the north of the pumping station and lifeboat slip was noted to be in need of repair during the 2009 survey, with large horizontal and vertical cracks on both sides propagating through the defence. The condition at the time of the 2012 inspections seems to be similar or worse. It was recommended that forthcoming strategy study should consider the need for this asset in terms of sheltering to the RNLI Slip and pumping station seawall, and the retention of sand and gravel beaches in the area.

Main length of wall below the properties (Asset Ref. 1221D901D0601C03) 	The wall is in variable condition. Although there are signs of repair work there are significant cracks in the wall and undercutting of the toe in several locations. The repair to the steps was noted as undercut, see photo opposite. There were also diagonal cracks, gaps at joints and missing blocks. The beach level had recovered slightly since the 2009 inspection with a small accumulation of coarse grey shale sand from the eroding landslip to the north of the village.
Protruding section of wall (Asset ref. 1221D901D0601C06) 	The protruding section of wall protecting the individual property is in fair condition. There are signs of repairs to the large vertical cracks in the wall and toe apron. However there are cracks in the top of the concrete bagwork part of the wall.
Northern coastal sea wall (Asset Ref. 1221D901D0601C01) 	The defence is suffering from surface cracking and erosion. As noted in previous inspections erosion of the underlying rocky foreshore continues to cause undercutting of the sea wall. Further defects include washed out sealant joints, flap valves on weep holes which have seized shut, wash out of the joints under the capping beam, vertical cracks through the wall, missing joints and filler in the seawall face and promenade surface with vegetation growth, and outflanking at tie in to eroding cliff at northern end. Although changes are limited since the 2009 inspection it is recommended that these issues are addressed.

In order to assess the change in condition of the seawalls over recent years a brief comparison of HPR Strategy photographs (taken in 2002) have been compared with more recent photographs from site visits in July and December 2013. This is summarised in Table 2.2 below. Refer to Annex A for the photographic record.

Table 2.2: Change in condition of the Runswick Bay Village seawalls over the last 12 years

Defence Element	HPR Strat. Aug. 2002	Later Photograph	Comments
240/6508 & 240/6507	Plate 18	Village seawall and Upgarth Hill defence element, 17th December 2013	Seawall damage following storm surge event of 5th December 2013 (refer to Section 2.5). Village seawall damaged with missing coping blocks at circa 6.0 mAOD. Elements of timber fencing on top of the seawall damaged. Upgarth Hill seawall - further erosion of cliff adjacent to north end of seawall () since July 2013. The previous concrete wall/cliff abutment (capping) at circa 8.0 mAOD is now missing.
240/6508	Plate 18	IMG_4509 & 7108206 July 2013	No visible signs of deterioration or displacement of the blockwork (masonry) faced wall or upper concrete wall. Failed length of concrete toe wall looks more rounded-off, but damage does not appear to have extended laterally or worsened significantly. No clear signs of a drop in beach level although the boulders have been relocated closer to the wall exposing more beach.
240/6508	Plate 21	IMG_4515 July 2013	No obvious signs of deterioration – blockwork facing still sound. Concrete toe in very similar condition (poss. some facing repair, seems less pitted?)
240/6508	Plates 19 and 20	IMG_4514 July 2013	Collapsed concrete steps have been re-instated and adjacent concrete toe has been substantially repaired. Also some repair works to cracks in the blockwork facing have been undertaken (date not known), with no signs of subsequent cracking.
240/6507	Plate 23	DCSF3496 Nov 2009	Old photograph shows significant area of facing missing from the wall. This has subsequently been repaired but existing repair is showing some signs of deterioration. Later photograph also shows a lower beach level with no loose sediment. It is not clear whether this is indicative of actual beach erosion or simply a fluctuation in beach sediment.

The limited review of the photographic evidence up until July 2013 suggested that, whilst there were numerous defects in the seawalls, significant areas of the visible walls were continuing to perform well. However, the storm surge event of December 2013 (see Section 2.5) highlighted the current deficiencies in the structure and brings into focus the true integrity of the seawalls. Further damage and erosion of the bedrock and undercutting of the toe would, for example, have the potential to de-stabilise the wall.

2.5 December 2013 Storm Surge Event

On 5th December 2013 a significant storm surge, driven by strong northerly winds, coincided with one of the highest astronomical tides of the year. The normal astronomical tide level prediction for Whitby on the afternoon of 5th December (circa 1730hrs) was expected to be 2.8mAOD but the actual real-time recorded sea level was 4.3mAOD, implying a 1.5m storm surge element. This resulted in reported damage to several coastal assets on Scarborough's Borough Council's frontage. Visual inspections of these assets were carried out in December 2013 and the records have been updated to include the latest findings. With regards Runswick Bay, significant elements of the patchwork defences north of the RNLI building were damaged and removed by the sea. Further erosion of the cliff adjacent to north end of seawall was also measurable. The fencing (fronting the private property) on top of the wall has been damaged during the storm surge indicating that there was significant wave overtopping in this area. The RNLI timber slipway was also damaged. Some of these elements have since been repaired under emergency powers.

2.6 Strategy Review Objective

The objective of the Strategy Review is to consider the conclusions of the previous HPR Strategy, and the more recent SMP2, taking into account monitoring data accrued to date. This will allow an assessment of current risks to be established and management options to be developed and appraised.

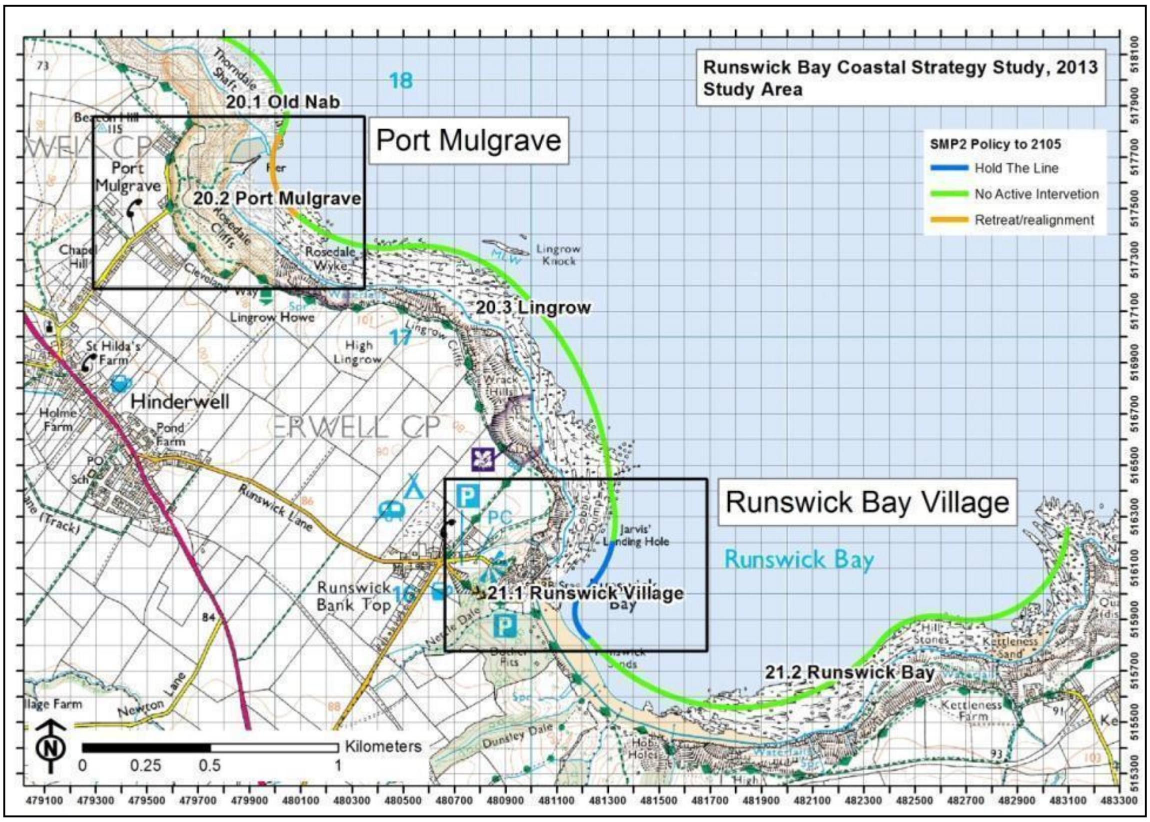

Figure 2.1: Runswick Bay Coastal Strategy Review includes Runswick Bay Village and Port Mulgrave
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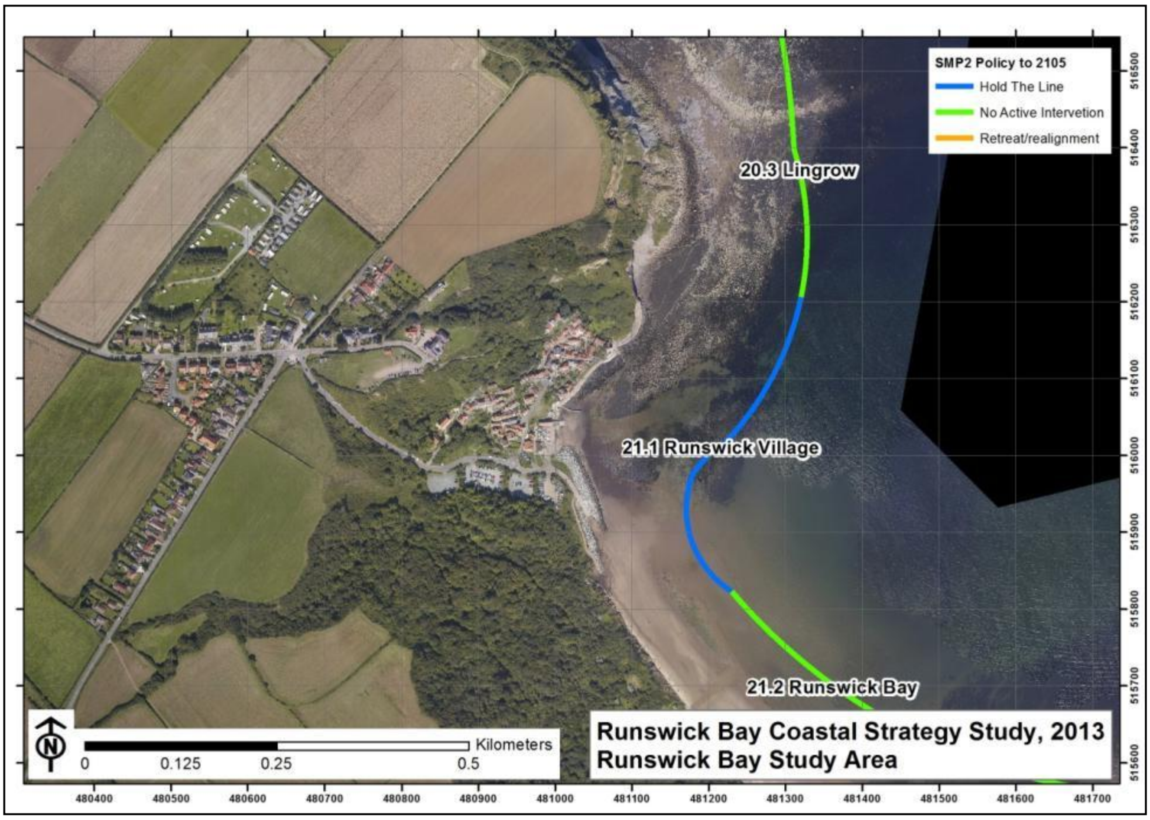


Figure 2.2: Runswick Bay Village and SMP2 policies

Figure 2.3: Runswick Bay lower village detailed plan with the village seawall toe outlined

3 Long List of Options

A long list of coastal management options has been developed with a view to undertaking an initial, high-level screening followed by a more detailed assessment of the most favourable options. This list includes No Active Intervention (Do Nothing) as a baseline against which all other options can be compared. All 'do Something' options incorporate works to the village and Upgarth Hill seawalls and to some extent Lingrow End. Options 7, 11 and 12 require works in the nearshore area up to 200m from the present (refer to Figure 3.1 which shows the coastline elevation mapping and these nearshore option outlines). Refer to Annex A for plans, sections and photomontages showing the existing condition and the options listed):

1. No Active Intervention (NAI) (Do Nothing baseline)
2. Do Minimum
3. Rock apron to seawall toe (see HPT Strategy Option 1 Rock Armour)
4. Seawall buttressing (see HPT Strategy Option 1 Mass Concrete)
5. Stepped concrete apron to seawall
6. Rock fillet (reduced section rock apron)
7. Rock groyne at Cobble Dump (see HPT Strategy Option 2)
8. Rock groyne at Cobble Dump together with a rock fillet (see HPT Strategy Option 2)

9A. Beach shingle nourishment

9B. Beach shingle nourishment with rock groynes

10. Rock berm to protect exposed cliff
11. Fishtail groyne
12. Offshore breakwaters

A preliminary assessment of these options has been carried out below in order to filter those options considered worth taking forward for more detailed appraisal.

The long list options generally allow for retaining and protecting the existing seawalls. It should be noted that an alternative option entailing the removal and replacement of part or all of the existing seawalls fronting the village with a new concrete structure on a similar footprint was also considered for but excluded from the long list. This would allow a seawall to be designed and constructed that would remove uncertainty over the robustness of the existing seawall itself. There may also be an opportunity to optimise the profile to reduce wave overtopping and improve access. The key benefit of a replacement seawall would be to provide a defence that with appropriate maintenance would have a long service life. However, assuming that the seawall was on a similar footprint to the existing wall, with either a vertical or steeply-sloping front face, then it will still be subject to direct wave attack and reflect much of the wave energy. However the main reason for not including this option in the long list is the potential risk of triggering landslips following removal of seawall section which is deemed to provide lateral restraint against such potential. Thus the costs and risks associated with demolition of the existing seawall and construction of a new wall far outweigh the benefits. Options to protect the existing wall offer similar benefits at much lower cost. Note that all of these options (except NAI) will include a sea defence monitoring component.

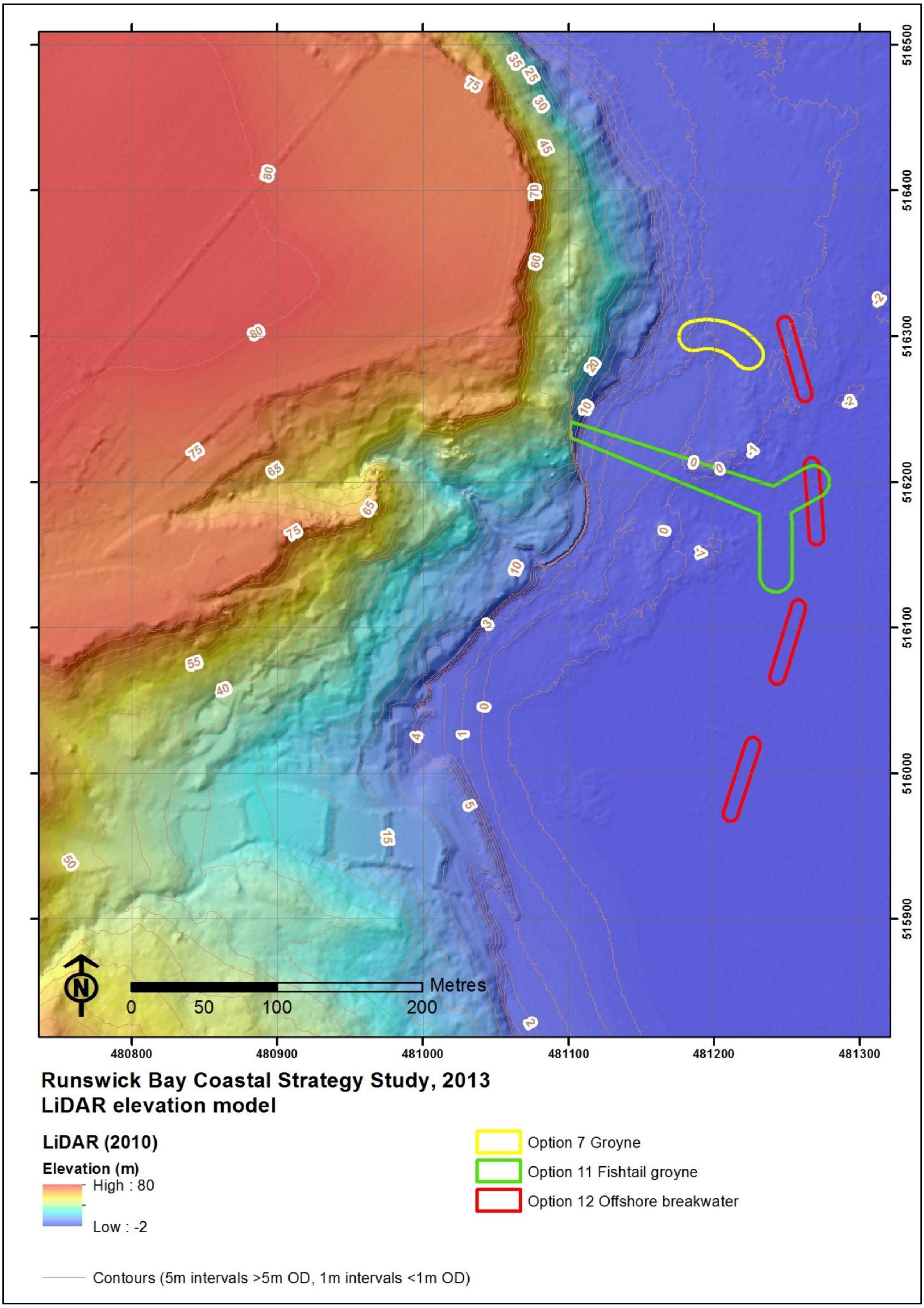


Figure 3.1: Runswick Bay Village LIDAR elevation mapping with superimposed nearshore option outlines

4 Review of Options

4.1 Consequence of No Active Intervention

The NAI (Do Nothing) option would mean that no work would be carried out to maintain or improve the current defences and existing structures, so the risk of erosion and of catastrophic slope failure would grow. Ongoing wave action would continue to degrade the existing seawalls and expose any weaknesses. The highly reflective nature of most of the seawalls effectively prevents any energy absorbing beach material from accumulating at their toes.

The immediate impact of seawall failure and defence breach would depend upon the scale and location of the failure, however it is clear that an un-repaired breach would be the trigger for escalating erosion, property damage and even risk to life. It is likely that the material behind the seawalls would be washed out relatively quickly by wave action, triggering slope failures and exposing properties to a risk of failure. Over time, as the extent of failure increased, erosion would continue with a risk of triggering pre-existing landslides on the glacial till slopes. The consequences of adopting a Do Nothing option are described in greater detail in the HPR Strategy. In addition, Figure 4.1 shows a current assessment of the consequences of seawall failure.

To the north of the Cauldron Cliff seawall there is clear evidence of cliff erosion, a small embayment having been formed in the cliffs. Without protection this erosion will continue, with the associated risk of outflanking of the seawall itself. It is noted, however, that this cliff area is in Policy Unit 20.3 which has a preferred policy option of No Active Intervention.

Another detrimental effect of the NAI option is the inability of the local authorities to plan and control the development in the northern part of the village. Development planning requires reasonable confidence in the longer-term stability of the cliff slopes, or the likely areas of slope failure.

4.2 Summary of Long List of Options

The following sub-sections give a brief description of the works to the defences that make up the options shown in Section 3, outlining the technical issues associated with each option, and making recommendations for further appraisal.

All 'Do Something' options involve an element of annual site monitoring to determine defence condition. Costs include estimates for the basic work elements plus allowances for preliminaries, insurances, contractor's fees, contractors risk budgets and licence fees. In addition to these allowances, further sums have been added to account for environmental enhancements, consultant design fees and an overall strategic level optimism bias of 60%. A summary of the initial estimated option cash and present value (PV) costs are shown in Table 4.1 at the end of this section.

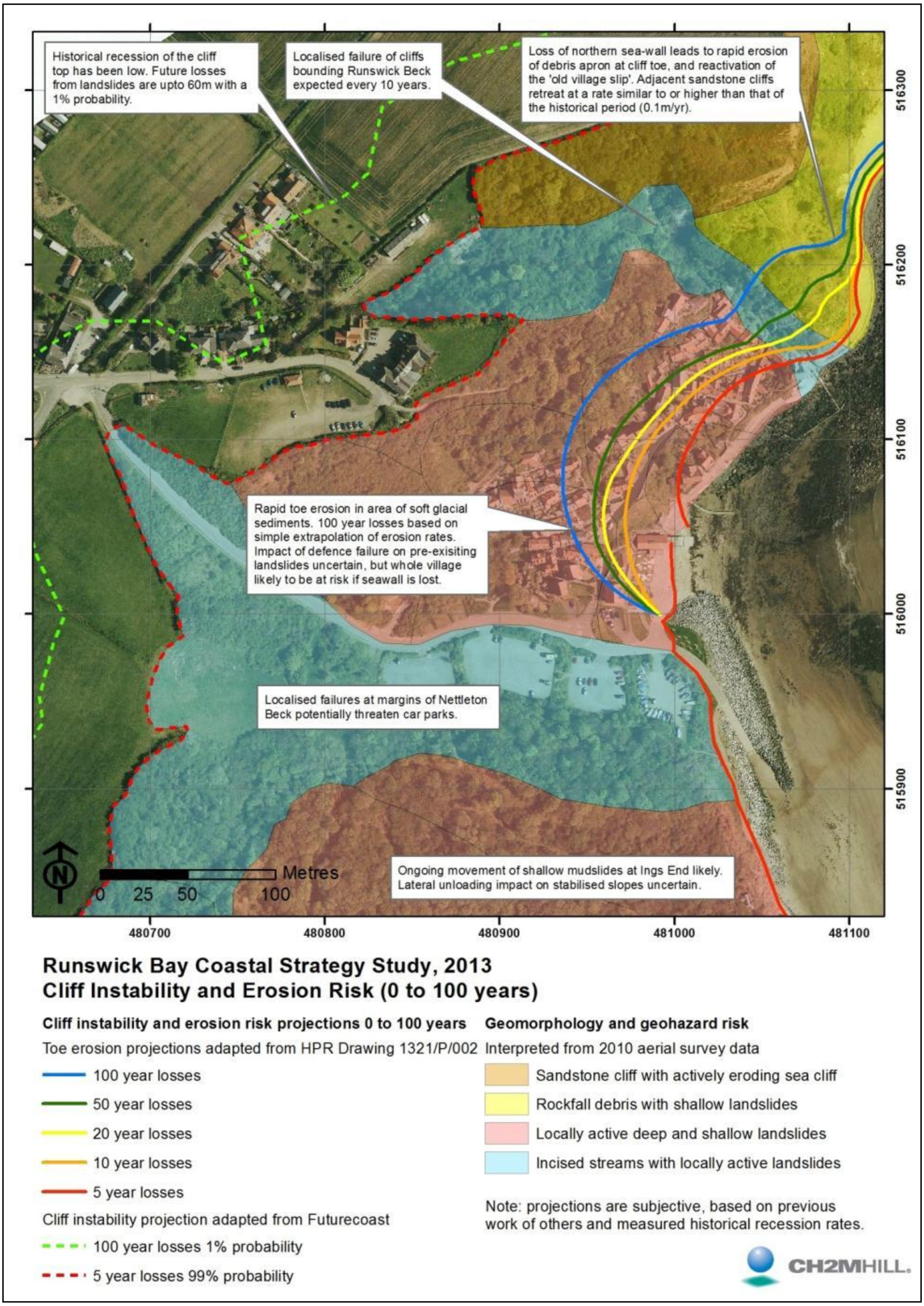


Figure 4.1: Runswick Bay Village projected cliff instability and erosion rates

4.2.1 Option 1 - Do Nothing

Description

This option assumes no active intervention for the frontage. No repair or maintenance works would be undertaken, other than minimal actions to eliminate immediate health and safety risks.

Performance

As described above, deterioration of the seawalls and ongoing erosion of exposed cliffs would continue. Any significant damage or failures would not be addressed, leading to a likely acceleration of damage and erosion. The actual rate of deterioration and time to significant failure is however difficult to predict, but over the 100-year appraisal period it is assumed that the whole of the village would have to be abandoned.

Initial Cost Assessment

There is no cost associated with this option which is used as the economic baseline for comparative purposes.

Recommendations

This option is required as a baseline option and is therefore taken forward to the economic assessment.

4.2.2 Option 2 - Do Minimum

Description

This option is a low cost maintenance option providing limited risk reduction and consequently benefits. It would consist of patch and repair works to the seawalls, and monitoring to provide early warning of any significant problems. However, it would not include for large scale repair works and consequently may have a limited design life.

This option effectively adopts a reactive maintenance approach. Monitoring of the seawalls would identify the occurrence of problems at an early stage so that repair works could be undertaken before problems escalated. It would include for example patch repairs to areas of concrete spalling or cracking, repair or replacement of loose or missing blockwork, repairs to access steps.

Performance

If repairs are undertaken effectively and carried out in a timely manner this type of Do Minimum approach can be effective, even in aggressive seafront conditions. It follows that this option is highly dependent upon regular monitoring, including post-storm surveys, and prompt repairs. However once a major failure, that cannot be dealt with as a minor repair, occurs this option would revert to do-nothing, with the consequences of eventual loss of the village during the 100-year appraisal.

Initial Cost Assessment

It is assumed that for the duration of the 'Do Minimum' option, two post-storm site visits will be conducted to inspect the structure and provide early warning of defects that may require repair. Notwithstanding the performance issues in the long term, it is assumed for costing purposes that patch repair of the concrete structure will on average occur every 10 years, and will require small repair works to 1-2m3 per 10m length of defence (0.1 to 0.2m3/m). It was initially assumed that the frequency of patch repairs would increase to every 5 years after year 50, due to the effects of climate change (giving a total cash cost of £0.65million), but more recent events suggest that failure of the sea wall may occur sooner. It is very difficult to predict when total failure may occur but for this appraisal it will be assumed that expenditure on this option will cease after 20 years. The whole life cash costs for this option are therefore assessed to be less then £0.1 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

It is very useful for the options appraisal to include a low cost 'Do Minimum' option for comparison with the larger scale 'Do Something' options, to understand the scale of costs in cash and PV terms and the benefits that could be secured for relatively low cost. Figure 4.2 demonstrates how regular cost inputs, through a 100 years appraisal period, corresponds to a relatively low discounted PV costs of £0.15 million (refer to the dashed lines). The solid lines indicate the cash and PV costs up to year 20. For appraisal purposes it is recommended that this option is taken forward for further consideration.

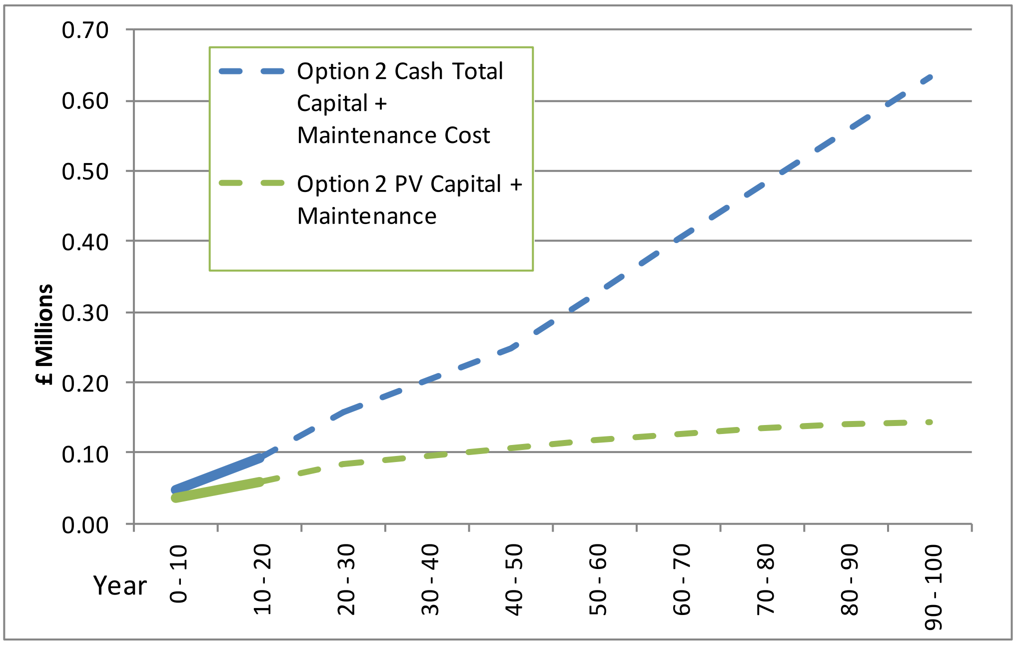


Figure 4.2: Runswick Bay Option 2 (type) expenditure profile

4.2.3 Option 3 – Rock Apron to Seawall Toe

Description

The option comprises the protection of the seawalls by the placement of rock armour aprons at the toe. The rock aprons extend from the lifeboat station to the outlet of Runswick Beck, and then around the convex seawall at Caldron Cliff tapering out along the cliff toe.

In the HPR Strategy this option was presented as a stand-alone option (Strategy Option1) assuming a 3 metre berm (at crest level of +6.0m AOD) and slope of 1 in 2, giving overall apron widths of 12 or 13 metres. Rock was provisionally sized at 3 to 6 tonnes. In addition HPR Strategy Option 2 adopted a smaller scale rock apron that was paired with a rock groyne to the north (see Options 6 and 8 below). The former option has been used as the basis for initial costing at this stage, although there is scope for adjusting the scale of rock armour apron.

Performance

The primary reason for protecting the toe of the seawalls is to reduce the amount of wave energy reaching the walls. Rock is very effective for a number of reasons. It is very good at dissipating wave energy, and would significantly reduce the energy reaching the walls themselves. This energy dissipation would also encourage any available sediments to settle. The rock also provides additional weight at the toe of the structure which improves overall seawall stability. Further, if limited erosion of the beach was to occur the rock could settle without losing the overall integrity of the apron.

Ongoing maintenance of the exposed upper part of the seawalls would still be required but this would be significantly less due to the protection provided by the rock apron. In addition no special measures would need to be undertaken to ensure that drainage through the seawall remained uninterrupted.

A further advantage of a rock structure of this type is that it would reduce wave overtopping at the existing seawall, as the water depth at the seawall would have effectively been reduced.

A rock structure of this type would be expected to last with minimal maintenance for 100 years plus. The most likely maintenance work would be the reinstatement of any displaced rocks.

A rock apron would have a significant footprint on the beach and would make access to this area difficult. Consideration must also be given to the fowl water drainage system feeding the Yorkshire Water pumping station. Either the rock will have to be kept well clear of the drainage or the pipes will have to be relocated to the wall itself.

Initial Cost Assessment

The development of the costs for the construction of a rock armour apron along the study area, with a small break at Runswick Beck, assumes construction in 2 to 3 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. The whole life (100 year) cash costs for this option are circa £2.1 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

It is recommended that this option is taken forward for further appraisal. Figure 4.3 demonstrates how a relatively large upfront capital cost followed by regular maintenance cost inputs through the appraisal period corresponds to relatively high discounted PV costs (circa £1.7 million). However rock is a very effective form of defence and it can be readily scaled according to need. In addition it has already been used successfully in the bay.

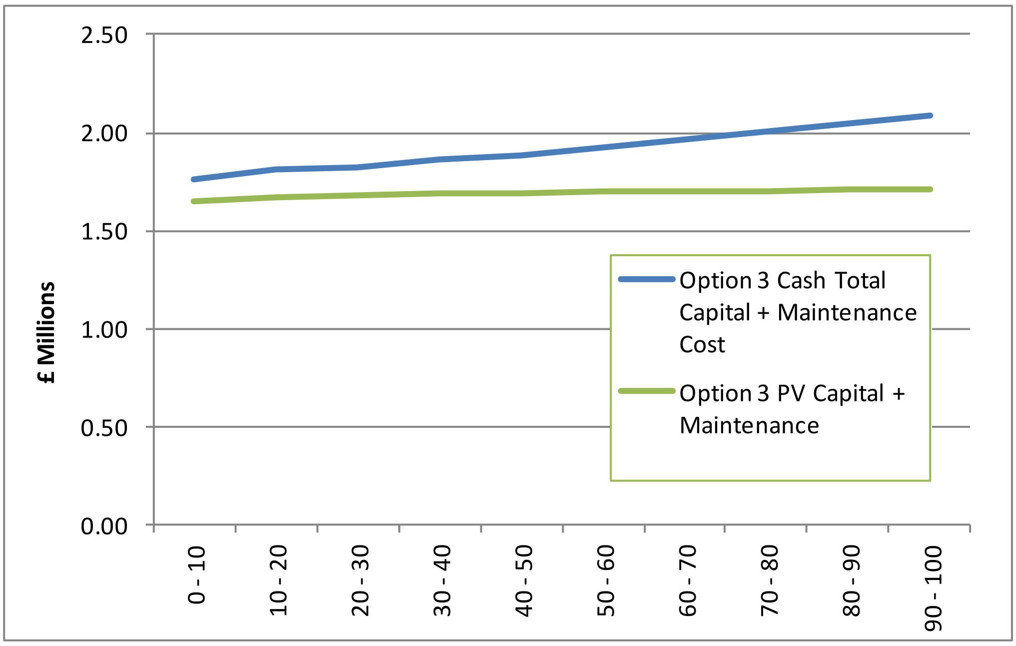


Figure 4.3: Runswick Bay Option3 expenditure profile

4.2.3 Option 4 - Seawall Buttressing

Description

An alternative approach to protecting the existing seawalls would be to cast a secondary mass concrete wall against the front faces of the seawalls. This option is as proposed in the HPR Strategy Option 1, which allows for a steep-faced mass concrete wall with an average crest width of approximately 2 metres and crest level of +6.0m AOD.

Performance

A mass concrete buttress of this type would be effective at protecting the face of the existing seawall, from both attrition of water-borne beach material and from hydraulic pressures drawing out weak and loose material. It would also have the potential to improve overall seawall stability with the provision of adequate foundations (or tying into the existing wall) to prevent forward rotation.

The concrete buttress would have the same highly-reflective properties as the existing seawalls, with minimal energy dissipation. Consequently the reflected energy would have the same impact on the beach as the present wall, promoting scour at the toe of the seawall where soft material is present and restricting the accumulation of sediment transported from other areas. In addition the wall itself would experience very high local impact pressures.

Mass concrete would be expected to be reasonably durable in this environment, however patch repairs would be required if impact damage and cracking occurred. As it is mass concrete there would be no concerns about exposure and corrosion of reinforcement, although the wall would probably need to be cast with frequent movement joints. It would also be important for the concrete buttress to accommodate existing drainage paths to ensure that there was no inadvertent build-up of water pressures behind the seawall.

Once constructed this option would provide limited flexibility with regard to any adjustments to improve its performance. The only option would be to cast an additional buttress in front of the first. In addition removal would be very expensive.

This option would have a relatively limited footprint and to that extent a more limited impact than some other options. However the mass concrete itself would not be visually pleasing, and any surface enhancements would add significantly to the cost.

Initial Cost Assessment

The development of the costs for the construction of a mass concrete buttress along the study area, with a break at Runswick Beck, assumes construction in 2 to 3 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. The whole life (100 year) cash costs for this option are circa £2.6 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

Following an initial assessment including the cost assessment it is considered that this option should not be taken forward for further appraisal. Technically it is considered to offer a lesser performance than a rock apron for an additional cost of £0.5 million. In addition it has no redeeming aesthetic or amenity features.

4.2.5 Option 5 - Stepped Concrete Apron

Description

A stepped concrete apron would be cast against the existing seawall, providing similar protection to the face of the seawall as the concrete buttress. However, instead of a near vertical face, the structure would step down at an overall slope of around 1 in 2, with the lower step being founded below existing beach level to avoid potential undermining at the toe.

Performance

The main advantage of this option over the concrete buttress is the provision of some wave energy dissipation, as wave breaking would be triggered further seaward from the wall resulting in reduced wave reaching the seawall. However, as the structure is not porous it would not provide as much energy dissipation as a similarly-sized rock apron.

It is possible that a stepped apron would encourage some sediment deposition given its reduced reflectivity compared to the existing seawall. It would also tend to reduce wave overtopping, as the water depth at the existing seawalls would be lower.

It is assumed that the structure would, with appropriate maintenance, last for at least 100 years. However, it is likely that this type of structure would need to be reinforced so it would be important to make any repairs to the concrete faces before any reinforcement became exposed and corroded.

A structure of this type also has the potential to enhance the amenity of the frontage – for example stepped aprons are often used as ad-hoc seating areas. Whilst it would have a reasonably large footprint stepped structures of this type are often considered to be visually attractive. However, it is noted that the attraction of stepped seawall structures can have health and safety implications as the surfaces can become very slippery due to marine growth. Also, the steps although offering refuge for beach users during the incoming tide may attract pedestrians into unsafe locations during storms (e.g. wave dodging).

Once in place this option would provide no flexibility with regard to any adjustments to improve its performance, and removal would be very expensive.

Initial Cost Assessment

The development of the costs for the construction of a stepped concrete apron along the study area, with a break at Runswick Beck, assumes construction in 2 to 3 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. The whole life (100 year) cash costs for this option are circa £3.7 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

Stepped concrete revetments have been used successfully at a number of coastal locations in the UK. At Runswick Bay this could be used to provide a high level of protection to all or part of the existing seawall, and it is recommended that this option is taken forward for further appraisal although the costs are considerably higher than for example the rock armour apron.

4.2.6 Option 6 – Rock Fillet to Seawalls

Description

A rock fillet approximately 2 metres high (i.e. at a crest level of +4.7m AOD) and 7 metres wide would be placed at the toe of the seawalls and extend some 30 or 40m north of the Upgarth Hill seawall.

Performance

The purpose of the rock fillet would be to provide protection to the toe of the seawall to limit outflanking, undermining and scour. The performance would be limited compared to a more substantial rock apron (as in Option 3) as there would be less wave energy dissipation, but nonetheless the lower face of the seawall would be protected from direct impact and the risk of scour would be reduced. There would remain an ongoing need to maintain the upper parts of the existing walls, to a greater extent than expected for option 3.

Initial Cost Assessment

The development of the costs for the construction of a rock armour fillet (reduced section rock apron) along the study area, with a break at Runswick Beck, assumes construction in 1 to 2 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. The whole life (100 year) cash costs for this option are circa £1.3 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

It is recommended that this option is taken forward for further appraisal. Rock is a very effective form of defence and it can be readily scaled and combined with other primary options according to need. In addition it has already been used successfully in the bay. If selected for further detailed appraisal, this option could be fine tuned in the future at relatively low cost, i.e. in response to overtopping calculations.

4.2.7 Option 7 – Rock Groyne at Cobble Dump

Description

This option was proposed by the HPR Strategy. The groyne would utilise existing rock to form the core, whilst 6 tonne rock armour would be placed on the front (north) face to protect against incoming waves from the north. The HPR strategy considered utilising existing rock to form the back face as well, but in consideration of wave overtopping it is considered prudent to include 3 to 6 tonne all around the core. To give the groyne a more effective life it is also considered that the top level should be nearer +4.5m AOD. The location is in an area where rocks and boulders have already accumulated on the foreshore.

Performance

The most severe waves approach Runswick Bay from the north. It is therefore feasible that a barrier groyne would cause larger storm force waves to break before they reach the seawalls in the bay. This would not only reduce impacts on the seawalls but also potentially allow sediments to deposit on the foreshores in front of the seawalls. A further potential benefit would be a reduction in seawall overtopping.

The height, length and orientation of the groyne would need to be optimised to ensure that an appropriate balance was achieved between effectiveness of wave energy dissipation and cost. In addition, any impacts on longshore sediment transport would need to be assessed.

It is worth noting that the HPR Strategy predicted that the rock groyne would not on its own be sufficient to protect the seawalls from high energy wave impacts, and considered that supplementary protection would be required. The HPR Strategy recommended a “reduced” rock armour apron, which is discussed in Option 6 above. It is therefore concluded that this option should not be considered in isolation but also in combination with the proposals outlined in Option 6. This will be referred to as Option 8 (see below).

Initial Cost Assessment

The development of the costs for the construction of a rock groyne, assumes construction in 2 to 3 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. The whole life (100 year) cash costs for this option are circa £1.7 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

Given the relatively low cost of this option it is considered that it could be taken forward for further appraisal, however in view of the limitations in directly protecting the seawalls, it should only be considered in combination with other defence measures. This will probably make this option more expensive then the straight forward rock apron option (refer to the example combination Option 8 below).

4.2.8 Option 8 – Reduced Rock Fillet to Seawalls (in combination with Option 7 Rock Groyne)

Description

This option includes for the rock groyne at Cobble Dump as described in Option 7 with the addition of a rock fillet approximately 2 metres high (as described in Option 6, i.e. at a crest level of +4.7m AOD and 7 metres wide), which would be placed at the toe of the seawalls. Unlike Option 6 the fillet would not extend north of the Upgarth Hill seawall as this area will be sheltered from the predominant waves from the north by the rock groyne.

This is an adaptation of the option which formed part of HPR Strategy preferred capital works scheme (Strategy Option 2). That scheme comprised a single layer of 3 to 6 tonne armour 1.25m thick (at a crest level of +3.7m AOD) over fill comprising rock and boulders taken from the foreshore. This would be placed against the seawalls at a slope of 1 in 3, with the toe embedded into the existing beach. However examination of the existing foreshore levels at the seawalls (+2.7m AOD) would have meant that this configuration would not have been readily achievable.

Performance

The purpose of the rock fillet would be to provide protection to the toe of the seawall to limit undermining and scour. The performance would be limited compared to a more substantial rock apron (as in Option 3) as there would be less wave energy dissipation, but nonetheless the lower face of the seawall would be protected from direct impact and the risk of scour would be reduced. The rock groyne would provide some protection to the undefended area to the north of the seawall, reducing the risk of outflanking.

Initial Cost Assessment

The development of the costs for the construction of a rock groyne and associated reduced length rock fillet, assumes construction in 2 to 3 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. The whole life (100 year) cash costs for this option are circa £2.5 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

It is recommended that this option is taken forward for further appraisal. Rock is a very effective form of defence and it can be readily scaled and combined with other primary options according to need. In addition it has already been used successfully in the bay.

4.2.9 Option 9A – Beach Nourishment

Description

This option would entail the placement of imported beach material over the existing beach along the whole of the defended frontage. Whilst the mobile sediments on the frontage are predominantly sand, a coarser material would be more stable and consequently it has been assumed that shingle would be used.

An initial assessment of beach levels indicates that a 1.0m depth of material at the seawall, with 10m wide berm and then seaward slope at 1 in 10 would give an overall nourishment width of approximately 45m. This assumes a beach slope of around 1 in 50. If the nourishment was carried out along the whole of the defended frontage it would have a length of around 210m.

It would be necessary to undertake periodic topping-up of the shingle beach as material would be lost from the beach over time. It has been assumed that further nourishment, equivalent to 40% of the original volume, would be required every 10 years.

Performance

A higher beach comprised of a mobile beach material would protect the existing seawalls from a significant amount of wave attack by dissipating most of the wave energy seaward of the seawall. This would extend the life of the seawall and reduce the amount of seawall maintenance required. It would also significantly reduce the amount of seawall overtopping.

In addition, the placement of additional material seaward of the existing seawall will improve the stability of the wall.

At this stage there is uncertainty as to how quickly material would be lost from the nourished beach, and therefore the frequency and volumes of further nourishment that would be required. In the absence of any additional beach control structures the full width of the beach is potentially subject to direct wave attack over time and is in its most vulnerable state. This is especially true at the Cauldron Cliff seawall.

There would be expected to be scour of the nourished beach at the outfall from Runswick Beck. Erosion of material from the nourished beach under wave action could result in accumulations of shingle on the sandy beach to the south that would require recycling back to the desired location. The addition of beach control structures would significantly enhance the stability of the beach by reducing exposure to wave attack, consequently reducing beach top-up volumes and frequencies.

Initial Cost Assessment

The development of the costs for the beach nourishment option, assumes construction in 2 to 3 years time with maintenance works every 10 years until year 50. Maintenance frequency is assumed to increase to 5 years between year 50 and year 100 due to the projected effects of climate change. The whole life (100 year) cash costs for this option are circa £7.0 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

This option carries with it a high level of uncertainty over the performance of the beach over time, i.e. the frequency and cost associated with future topping-up campaigns. Given the capital cost and uncertain future costs, it is not recommended that this option is considered further as a stand-alone option. However, it would warrant further appraisal in conjunction with other measures such as rock groynes (refer to Option 9B below).

4.2.10 Option 9B – Rock Groynes (in combination with Beach Nourishment)

Description

This option consists of a groyne field of around 6 rock groynes which run perpendicular to the seawalls. It is assumed that the groyne crest would be about 2.0m above the existing beach level at the toe of the seawall, and have an overall length of approximately 45m.

It is assumed that the most southerly groyne runs near to the line of the existing concrete groyne to the north of the lifeboat station. Two further groynes would be spaced at equal distance along the existing seawall with the last just south of Runswick Beck. Three more groynes of similar length and profile would be spaced equidistant around the Caldron Cliff.

Performance

The performance of stand-alone rock groynes on this frontage is uncertain. They would certainly provide the seawall with some shelter from waves, particularly those from the north and north east, but the seawall would still be exposed to waves approaching more perpendicular to the coastline.

The defences would benefit significantly if the groynes were to encourage the build-up of sediments. An established beach extending for tens of metres from the seawall would be very effective at dissipating wave energy and protecting the seawalls. However sediment accretion would depend upon a supply of sediment, and also coastal processes leading to deposition within the groyne bays. It is therefore considered that the rock groynes will require an initial shingle nourishment, as described in Option 9A, but with top up nourishments at intervals not as frequent as Option 9A.

The bay has extensive sandy deposition further south, including in front of the emergency works rock protection. The HPR Strategy notes the existence of extensive sand deposits and some gravelly deposits south of the defences. It also states that littoral drift is prevalent, with sand and shingle moving along the frontage primarily as a result of wave action. In addition however, the HPR Strategy notes that the concrete groyne, which was constructed in 1927, has had no recorded impact on beach levels, and commented that the elevated rock platform was restricting the influx of sediments from nearshore.

Initial Cost Assessment

The development of the costs for the beach nourishment and rock groynes option, assumes construction in 2 to 3 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. The whole life (100 year) cash costs for this option are circa £3.2 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

It is recommended that rock groynes are not taken forward for further development and appraisal. As described it is likely that they would need to be combined with shingle nourishment to create an effective option and this is considered an expensive and unsustainable solution.

4.2.11 Option 10 – Rock Berm at Toe of Cliff

Description

This option is specifically designed to limit erosion to the exposed cliff to the north of the seawalls at Upgarth Hill. It would consist of a 3 to 6 tonne rock berm with a crest approximately 2m above existing beach level, extending for approximately 65m from the end of the existing seawall approximately along the line of the existing rock and cobble deposition near to the toe of the cliff.

Performance

The berm would limit the size of waves reaching the exposed cliffs and consequently reduce cliff erosion, and reduce the risk of the existing seawall to the south being out-flanked.

Initial Cost Assessment

The development of the costs for the construction of a rock berm at the toe of the cliff north of the Upgarth Hill seawall, assumes construction in 2 to 3 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. The whole life (100 year) cash costs for this option are circa £1.0 million. Refer to Table 4.1 for a summary of the initial estimated costs associated with this option.

Recommendations

This length of coastline is in SMP2 Policy Unit 20.3 for which the recommended policy option was No Active Intervention. At this stage there is insufficient evidence of cliff erosion presenting a significant outflanking risk and justifying a change of SMP2 option. A bay has form within the cliff and this in itself will have reduced the incident wave energy impacting upon the cliff. It is recommended that the cliff is monitored, and that options for cliff protection are considered further if evidence of increasing risk emerges. In any case this option would need to be considered in association with other direct protection measures similar to Options 7/8 which would increase costs significantly.

4.2.12 Option 11 – Fishtail Groyne

Description

Fishtail groynes are generally constructed of rock. This type of groyne extends across part of or the entire intertidal zone and is designed to modify the longshore drift and therefore retain sediment within the groyne bay. Typically the structure has an initial alignment perpendicular to the shoreline, and then splits into two curved ends (the fishtail) which align almost parallel to the coastline at their seaward ends.

For Runswick Bay the root of the groynes would be located at the northern end of the Caldron Cliff seawall, and extend perpendicular to the coastline for a distance of approximately 150m. The entire length including tails would be approximately 230m in total. The height above existing beach level would increase from approximately 1m at the landward end to approximately 5.0m above the bed at the seaward end for a constant groyne crest level of approximately +3.5m AOD.

Performance

Fishtail and T-head groynes are a recent development from the standard linear structures, and as such their performance is not well-documented. Allied head extensions may improve groyne efficiency. The purpose of the head extensions is to increase the distribution of wave energy by diffraction and they are designed to affect the incoming waves as well as the longshore currents that the waves and tides produce.

Groyne head extensions may also allow groyne spacing to be increased and thus the number of structures required to decrease by extending the alongshore influence. For Runswick Bay it has been assumed that one fishtail groyne could be located at the northern end of the seawalls and create a large groyne bay bounded at the southern end by the coastline itself. In effect this would take advantage of the change in orientation of the coastline to the south where the emergency rock apron was placed to create a large bay.

This method of protecting the seawall from incident waves from the north should also encourage the growth of a beach in front of the seawalls, but as discussed above (Option 9B) this would be subject to available sediment budget and the impact of the groyne on coastal processes.

Initial Cost Assessment

The development of the costs for the construction of a large rock fish tail groyne north of the Upgarth Hill seawall, assumes construction in 2 to 3 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. The initial cost estimates for this option have taken into consideration the calculations carried out by Halcrow in 2008 - 2010 for a nearshore rock structure in Essex as well as rock berms in Norfolk. These costs have been updated to the present day calculated costs using various inflation indices (construction Output Price Index as well as Retail Price Index).

The estimated capital cost is £8 million. The additional costs for slope re-profiling works are also included, as are maintenance and monitoring costs.

Recommendations

The capital cost of this option is relatively high. In addition, there is uncertainty associated with its impact on coastal processes and limited scope for reversing its effects (including if necessary removal of the structure). Consequently it is recommended that this option is not considered in any more detail.

4.2.13 Option 12 - Offshore Breakwater

Description

A field of four rock submerged detached breakwaters would be situated just offshore protecting the beach from wave activity.

Each individual breakwater would have a crest length of approximately 60m with a crest width of approximately 3m. To enable the design for future projections of sea level rise the crest level would be at circa 0.85m above present Mean High Water Springs (MHWS), giving an overall height of approximately 5.0m above the seabed.

Performance

Breakwaters are structures built in the nearshore zone aligned parallel to the shoreline and designed to dissipate wave energy and decrease wave activity at the beach, promoting sediment deposition in their lee.

Waves break over the structures (due to depth limitation) and are diffracted through the gaps between them before they reach the beach. In principle this causes frontages in the lee of the breakwaters to accrete, resulting in the formation of salients behind individual structures, which may form tombolos linking the structure to the beach if there is sufficient sand supply. The direct impact of the breakwaters themselves coupled with increased beach levels would provide the seawalls with significant protection.

At Runswick Bay the largest waves come from the north and north east. It would be important to ensure that the alignment of the breakwaters was effective at intercepting these waves.

Initial Cost Assessment

The development of the costs for the construction of four offshore breakwaters, assumes construction in 2 to 3 years time with maintenance works every 20 years until year 50. Maintenance frequency is assumed to increase to 10 years between year 50 and year 100 due to the projected effects of climate change. This option would be of substantial cost due to the need to work in deeper water, requiring offshore marine plant, and due to the volume of imported materials required. The initial cost estimates for this option have taken into consideration the calculations carried out by Halcrow in 2012 for a similar option for a project appraisal for Filey.

The estimated capital cost is £13 million.

Recommendations

Due to the high capital cost of this option, the limited scope for reversing the effects and/or removal of the structure and the likely impact on the down-drift shoreline, it is recommended that this option is not considered in any more detail.

Table 4.1: Summary of options 2 to 12 - Cash costs and PV costs (Totals include 60% optimism bias)

	Costs £ (to 3 significant figures)					
Option number	**Option 2**	**Option 3**	**Option 4**	**Option 5**	**Option 6**	**Option 7**
Option name	Do Minimum (20 years)	Rock armour apron	Seawall buttressing	Stepped concrete revetment	Rock fillet	Rock groyne
AEP or SoP (where relevant)	N/A	N/A	N/A	N/A	N/A	N/A
Cash capital costs	0	988,000	1,300,000	1,920,000	462,000	518,000
Cash operation and maintenance costs	52,300	193,000	145,000	183,000	261,000	446,000
Total Cash Costs (incl. other/fees/OB)	**92,600**	**2,090,000**	**2,550,000**	**3,720,000**	**1,280,000**	**1,710,000**
PV capital costs	0	922,000	1,210,000	1,790,000	447,000	483,000
PV operation and maintenance costs	33,700	43,600	35,200	40,900	55,400	88,000
PV other (Env enhancement, etc. 5%)	1,690	48,300	62,300	91,600	25,100	28,600
PV fees etc. (12%)	4,040	116,000	149,000	220,000	60,200	68,500
Optimism bias adjustment (60%)	23,700	678,000	874,000	1,290,000	352,000	401,000
Total PV Costs	**63,100**	**1,810,000**	**2,330,000**	**3,430,000**	**940,000**	**1,070,000**

	Costs £ (to 3 significant figures)					
Option number	**Options 7 & 8**	**Option 9A**	**Option 9B**	**Option 10**	**Option 11**	**Option 12**
Option name	Rock groyne and reduced rock fillet	Shingle nourishment	Shingle nourishment and rock	Rock berm at cliff	Fish tail groyne	Offshore breakwaters
AEP or SoP (where relevant)	N/A	N/A	N/A	N/A	N/A	N/A
Cash capital costs	881,000	548,000	1,250,000	281,000	3,930,000	6,880,000
Cash operation and maintenance costs	537,000	3,390,000	607,000	254,000	511,000	511,000
Total Cash Costs (incl. other/fees/OB)	**2,510,000**	**6,970,000**	**3,290,000**	**948,000**	**7,850,000**	**13,100,000**
PV capital costs	823,000	512,000	1,170,000	263,000	3,670,000	6,420,000
PV operation and maintenance costs	104,000	689,000	116,000	54,300	111,000	111,000
PV other (Env enhancement, etc. 5%)	46,300	60,000	64,200	15,800	189,000	327,000
PV fees etc. (12%)	111,000	144,000	154,000	38,000	453,000	784,000
Optimism bias adjustment (60%)	651,000	843,000	901,000	223,000	2,650,000	4,590,000
Total PV Costs	**1,730,000**	**2,250,000**	**2,400,000**	**593,000**	**7,070,000**	**12,200,000**

5 Conclusion

Following the initial review of the long list of options the following options have been taken forward for further appraisal:

- Option 1 - Do nothing (mandatory baseline option);
- Option 2 Do minimum;
- Option 3 – Rock apron at seawall;
- Option 5 – Stepped concrete apron at seawall;
- Option 6 – Rock fillet to seawall;
- Options 7 & 8 – Rock groyne at Cobble Dump with reduced length rock fillet at seawall (combined option).

ANNEX A

Photographic record from 2002 HPR Strategy compared to present day 2013 (Runswick Bay village) and 2009 (Upgarth Hill). Also included is storm surge damage following the event of 5th December 2013.

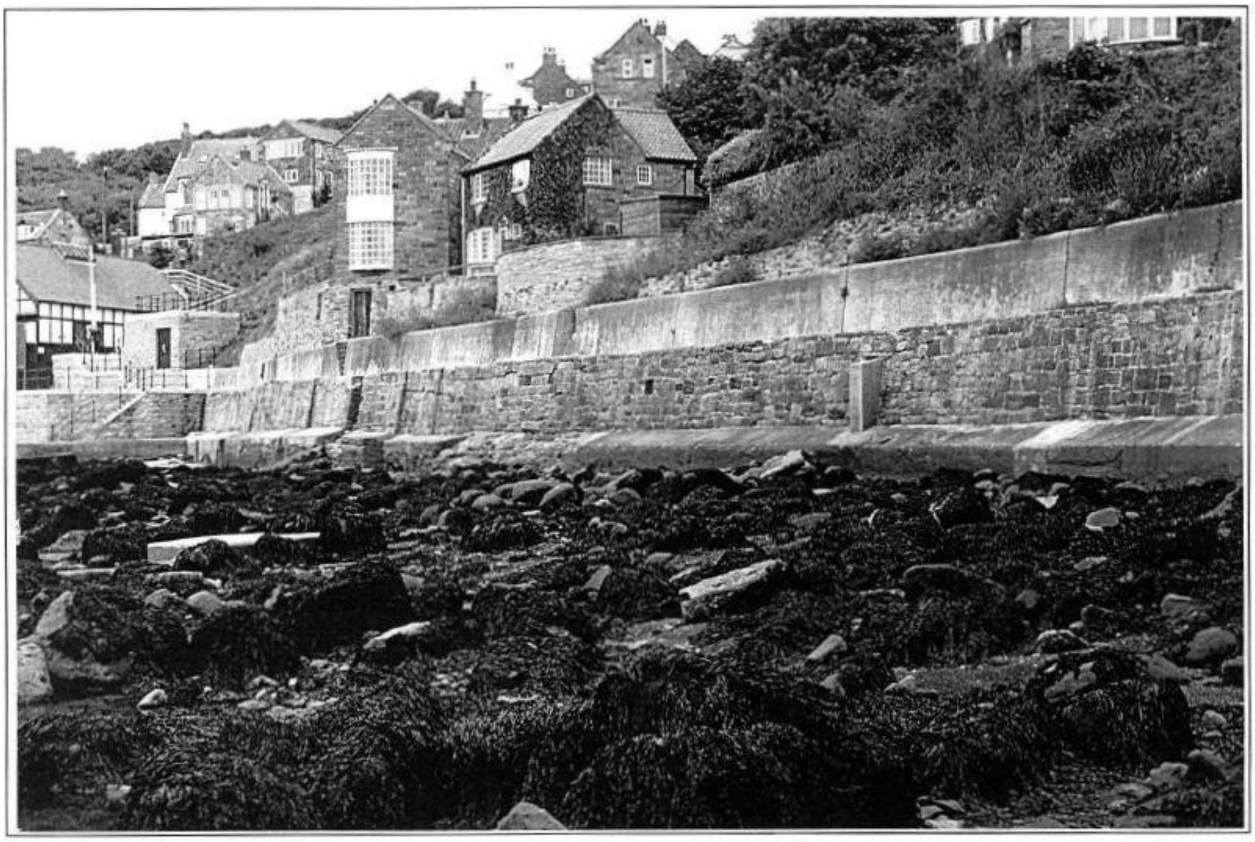
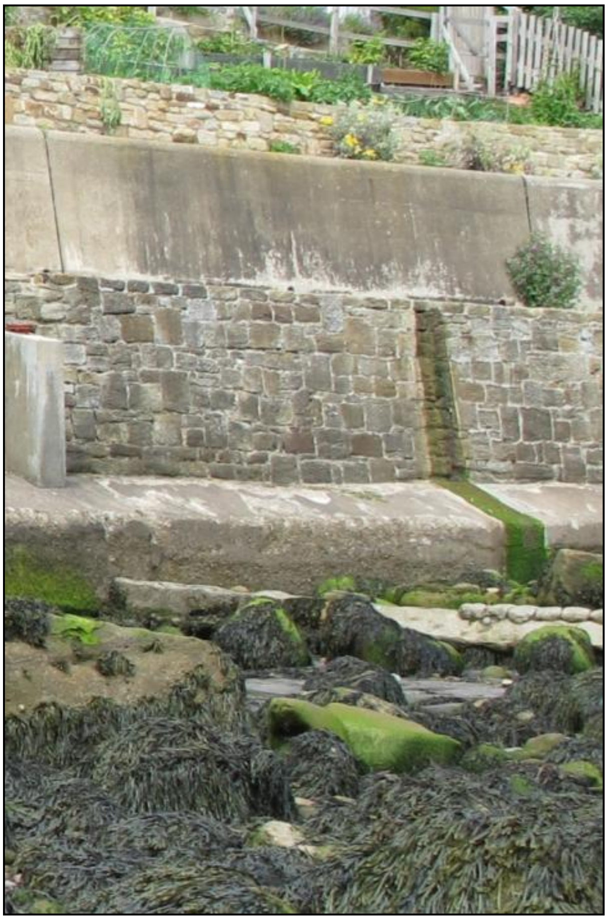


PLATE 18 DEFENCE ELEMENT 240/6508 LOOKING FROM THE NORTHEAST, AUGUST 2002.

PRESENT DAY – PLATE 18 Defence element from the east, July 2013

PLATE 21 LOW BEACH LEVELS EXPOSE UNDERCUTTING OF FOUNDATION WITHIN DEFENCE ELEMENT 240/6508, AUGUST 2002.



PRESENT DAY – PLATE 21 defence element, July 2013

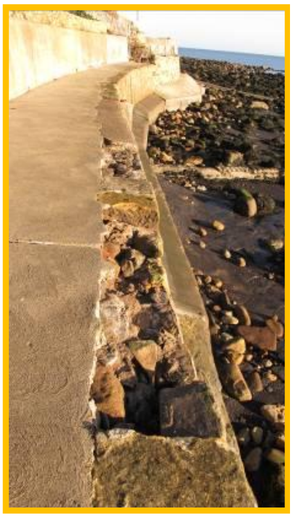
PLATE 19 SEVERE CRACKING WITHIN LOWER AND MIDDLE WALLS OF DEFENCE ELEMENT 240/6508, AUGUST 2002.

PLATE 20 UNDERMINING OF SEAWALL AND COLLAPSE OF STEPS WITHIN DEFENCE ELEMENT 240/6508, AUGUST 2002

PRESENT DAY – PLATES 19 & 20 defence element, July 2013

PRESENT DAY – PLATES 19 & 20 defence element close-up, July 2013


17th December 2013 Damage to wall blocks




(Asset Ref. 1221D901D0601C03)

Same area as above with diagonal cracks and coping damage in wall, 17th December 2013.
(Asset Ref. 1221D901D0601C03)

Gaps at joints and more missing blocks, 17th December 2013.
(Asset Ref. 1221D901D0601C03)

Cliff adjacent to north end of seawall from the top promenade, 10th July 2013.
(Asset Ref. 1221D901D0601C01)

Further erosion of cliff adjacent to north end of seawall, and seawall damage since July 2013, from the top promenade, 17th December 2013. Old concrete wall/cliff abutment now missing.
(Asset Ref. 1221D901D0601C01)

Storm Damage post 5th December 2013 – Village seawall and Upgarth Hill defence element, 17th December 2013

PLATE 23 SEAWALL DAMAGE WITHIN DEFENSE ELEMENT 240/6507, UNDERCUTTING IS HIDDEN BY MUDSTONE FRAGMENTS ERODED FROM ADJACENT CLIFFS, AUGUST 2002.

PLATE 23 – Upgarth Hill defence element, November 2009