FINAL

Sidmouth & East Beach Management Plan: Options Appraisal Report

Prepared for

East Devon District Council

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Executive Summary

This report presents the full appraisal of potential future coastal flood and erosion risk management options for the Sidmouth and East Beach Management Plan frontage, from long-list to short-list and selection of preferred option.

The options appraisal is underpinned by a series of baseline assessments covering:

- Coastal processes understanding.
- Defence condition and performance assessment.
- Environmental setting and features.
- Economics.

These baselines are provided in **Appendices A, B C and D** respectively.

Consultation with key stakeholders represented on the project steering group has occurred during the development of the options appraisal at both long-list and short-list stage. In addition, public consultation on the short-list options was conducted in June 2016. All comments made have informed refinement of the options appraisal.

Having considered the technical, environmental and economic appraisal for each short-listed option, the various sensitivity tests and the feedback from public consultation, on the face of it the technically preferred option that best achieves the project objectives is Option S4 and its variants. However, this is also the most expensive option with the worst economic case. Even under the 'best case' scenario (Sensitivity Test 8), more than £11m of funding contributions would be needed to unlock the government grant-in-aid funding accessed through the Environment Agency.

In order to progress Option S4 as the preferred option through to more detailed investigation, design and ultimately implementation, at this stage the Environment Agency's National Project Assurance Service (NPAS) will need to be assured that there is a high likelihood that this level of funding contribution can be secured; if it is not assured, it is unlikely to approve any spend to take this option forward.

Discussions with East Devon District Council have indicated that this level of funding contribution is not affordable to the council at this time. As such, the likely assurance required for NPAS cannot be given.

It may be possible to spend more time and effort seeking to identify and secure multiple sources of funding to provide the level of contribution Option S4 requires, but experience of such efforts in other parts of the UK indicate that this typically takes between two and six years, and is not always successful. If this route were taken, it would (a) not lead to any scheme development and implementation for several years when there is a need to take action as soon as possible, and (b) poses a risk of delaying 'doing something' whilst seeking to secure the required funding contributions and ending up not being able to secure that funding and so having wasted time when something could already have been done. Any delay in this regards obviously increases the likelihood that further erosion at East Cliff will accelerate any upgrade required along the western wall.

Given the above, the actual preferred option recommended to be progressed is Option S1, as this option is the one that gives the best balance between technical viability, environmental acceptability and economic case. Importantly, discussions with East Devon District Council have indicated the level of funding contribution required (c.£2.3m under the 'best case' scenario (Sensitivity Test 8)) is at a level that is more realistic with partners/beneficiaries contributing. This therefore provides a greater chance of project assurance in the shortest amount of time, thus enabling the necessary investigations and detailed design work to implement a scheme to be carried out as soon as possible.

Further work is still needed in the immediate future (within the next 6 months) to fully confirm the level of funding contribution that can be delivered to robustly evidence this in the business case when it is eventually submitted to the Environment Agency's NPAS. If as a result of that further work it is shown

that a greater level of funding contribution can be confirmed as being deliverable, then it may be possible to re-consider taking forward option S4 as the preferred option instead of Option S1, depending on what the final confirmed level of funding contribution is.

This funding work in the immediate future would be needed for either Option S1 or S4 and can be progressed alongside initial work to develop the detailed appraisal of the preferred Option S1, with the scope able to be changed if the additional partnership funding is made available.

1 Introduction

This report presents the full appraisal of potential future coastal flood and erosion risk management options for the Sidmouth and East Beach Management Plan frontage, from long-list to short-list and selection of preferred option.

The study frontage extends from Jacob's Ladder Beach in the west, to approximately 200m east of the River Sid, as well as upstream along the River Sid western wall to Ham Weir (see **Figure 1-1** and **Figure 1-2**).

The options appraisal is underpinned by a series of baseline assessments covering:

- Coastal processes understanding.
- Defence condition and performance assessment.
- Environmental setting and features.
- Economics.

These baselines are provided in **Appendices A, B C and D** respectively.

Consultation with key stakeholders represented on the project steering group has occurred during the development of the options appraisal. In addition, public consultation on the short-list options was conducted in June 2016. All comments made have informed refinement of the options appraisal.

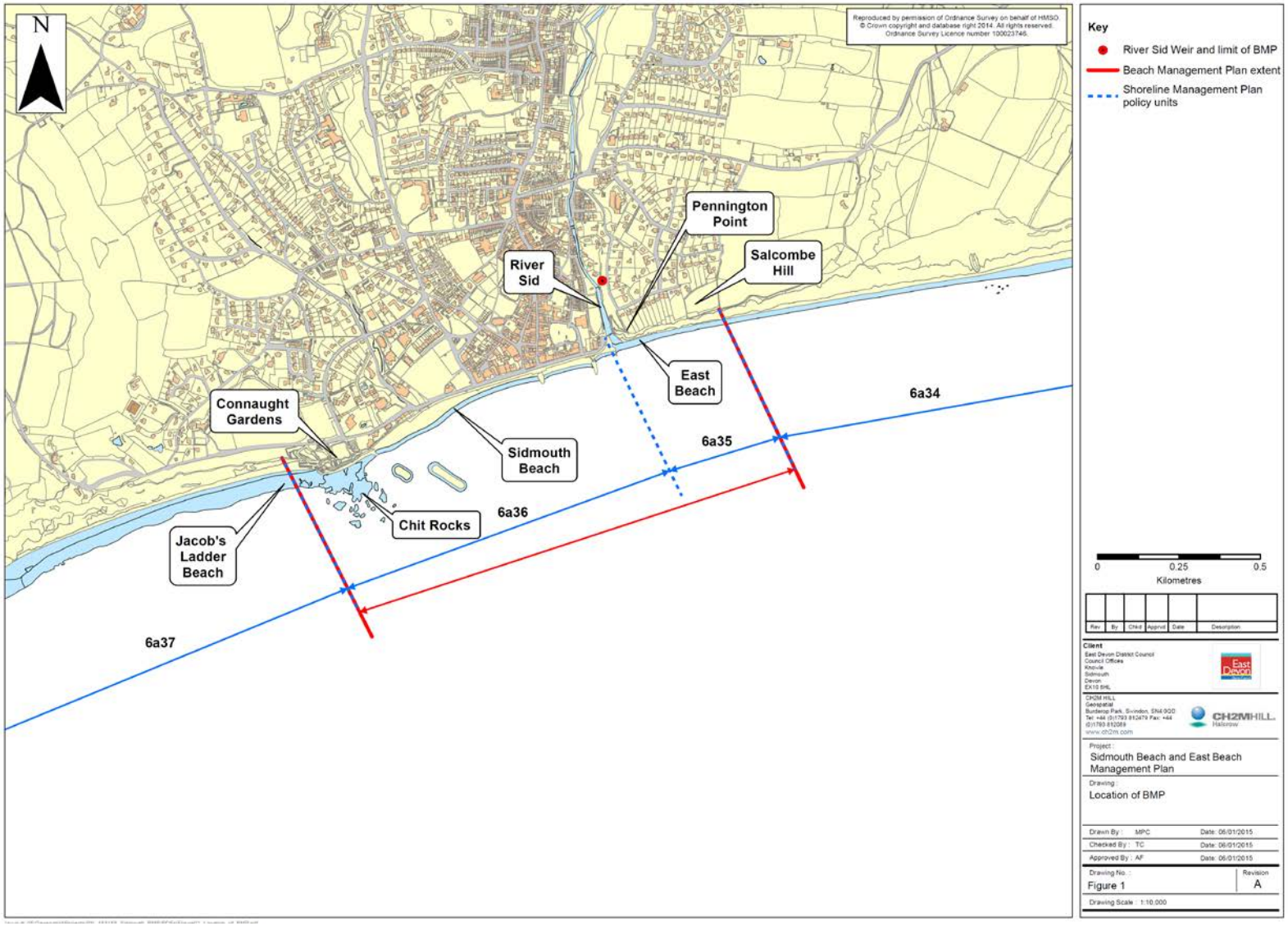

FIGURE 1-1
Sidmouth BMP extent

FIGURE 2-2
Key Features along BMP extent

1.1 Aims & objectives

The purpose of the project is to develop a Beach Management Plan (BMP) that defines how monitoring and maintenance works along the frontage are to be carried out for the purpose of Flood and Coastal Erosion Risk Management (FCERM) over the next five years, whilst also setting out measures aligned to longer-term management of the frontage, having appraised the longer term viability of options over a 100 year planning horizon as part of developing the BMP. The overall project aim is to develop one single integrated scheme for the seafront from Jacob's Ladder to East Beach, and to inform a separate scheme for the River Sid that will be led by the Environment Agency (EA) at a later date.

This will define how the beach management activities will contribute to the implementation of Shoreline Management Plan 2 (SMP2) policies of 'Hold the Line' and 'Managed Realignment' along the frontage in the short to long term in order to achieve the overall SMP2 policy objective to continue to provide FCERM to Sidmouth (Halcrow, 2011). The BMP will define management activities in relation to the monitoring and maintenance of the beach and associated control structures, and in doing so consider the inter-relationships between the beach and hard defence structures. It will also consider implications of future coastal erosion along East Beach for the River Sid defences, the Alma Bridge and cliff top properties along this part of the frontage.

The specific aims and objectives of the project are therefore as follows:

- **Project Aims:**
    1. Maintain the 1990's Sidmouth Coastal Defence Scheme Standard of Service.
    2. Reduce the rate of beach and cliff erosion to the east of the River Sid (East Beach).
    3. Carry out (1) and (2) in an integrated, justifiable and sustainable way.
- **Project Objectives:**
    a) Review, update and develop the existing Sidmouth BMP to include both Sidmouth seafront (SMP2 PU6a36) and East Beach (SMP2 PU6a35), in line with the methods and format consistent with the CIRIA Beach Management Manual (BMM) (second edition) guidance (Rogers et al., 2010), to ensure that there is a robust plan for managing the beaches and associated beach management structures (i.e. existing structures and any new ones which may be required and recommended) in a sustainable way.

    b) Undertake research to verify whether the rates of beach and cliff erosion to the east of the River Sid have increased when compared to historical (pre-Sidmouth sea defences) rates and determine an understanding of the relationship between coastal processes, beach volumes, cliff recession and coastal engineering over time. To include review and update (if necessary) of the SMP2 predicted erosion zones.

    c) Determine the risks associated with beach and cliff erosion along East Beach on the effectiveness of the River Sid defences, the Alma Bridge and cliff top properties.

    d) Determine if the Standard of Service provided by the Sidmouth seafront coastal defences constructed in the 1990's is being met and ensure that these are maintained in a sustainable way.

    e) Carry out a detailed inspection and engineering assessment to determine residual life and the current and future standard of protection of defences along the River Sid western wall given the risks posed by beach and cliff erosion to the east of the River Sid.

    f) Determine the preferred integrated, justifiable and sustainable coastal defence management options that:

        i. Maintains the Standard of Service for Sidmouth seafront defences;

        ii. Defines the requirements of engineering assessment to determine works appropriate to upgrade the River Sid western wall;

iii. **Reduce the rate of beach and cliff erosion for East Beach (that threatens the River Sid defences, Alma Bridge and cliff-top properties at Pennington Point);**

iv. **Does not compromise or adversely impact the integrity of the environmental features of the Dorset and East Devon UNESCO World Heritage Site, Sidmouth to West Bay Special Area of Conservation or the Sidmouth to Beer Coast Site of Special Scientific Interest; and**

v. **Ensures that monitoring undertaken as part of the South West Coastal Monitoring Programme is aligned to the requirements of the preferred option.**

If required, investigate available sources and suitability of material both within the study area (for recycling) or from distant sources (for recharge) as part of option appraisal.

In relation to the objectives stated above, (a) will be delivered as the final output from this project. Objectives (b), (c), (d) and (e) have been met through delivery of the baseline assessments of coastal processes, coastal defences, environment and economics developed as part of this project. Those baseline assessments have been used to inform identification of a long-list of potential future management options to address the project aims and objectives stated above (refer to **Section 2.1**), and underpin the technical, economic and environmental appraisal of each option at both long-list and short-list stages (refer also to **Section 1.3**).

Therefore**, in relation to the options appraisal presented in this document, it is objective (f) above that is relevant to consider**. Achievement (or otherwise) of the project aims and objective (f) items for each option is provided in the analysis of long-list and short-list options (refer to **Section 2** and **Section 3** respectively).

1.2 Issues identified from baseline assessments

In addition to achieving the project aims and objectives described above in **Section 1.1**, from the baseline assessments undertaken as part of this project, a number of additional issues were identified that could be considered as part of the options appraisal process. These issues, along with identification of the current management practice (where it currently occurs in some form to partly or fully address the issue identified) are summarised in **Tables 1-1 to 1-4**. These tables also include comment on how each issue is to be taken forward as part of the BMP development and option appraisal process. In viewing these tables, the following should be noted:

- **Table 1-1** summarises the issues identified from the environmental baseline (**Appendix C**). The environment baseline provides the key environmental baseline features within the BMP area and identifies some preliminary environmental issues/constraints that will require further consideration as the project develops and future management options are appraised.
- **Table 1-2** summarises the issues identified from the defence assessment report (**Appendix B**), which provides a baseline assessment of the coastal defences located along the BMP frontage. The purpose of the assessment was to provide information to inform the development of future coastal flood and erosion risk management measures for the frontage.
- **Table 1-3** summarises the issues identified from the coastal process baseline assessment (**Appendix A**). This baseline also provides the basis for technical appraisal of options in this document.
- **Table 1-4** summarises the issues identified from the economics baseline, (**Appendix D**). This economics baseline provides details of the economic basis (i.e. the economic benefits) for both ongoing and future beach management and coastal flood and erosion risk management activities along the Sidmouth frontage, within the extent of the Sidmouth and East BMP. The economic basis is developed from new assessment of flood and erosion risk, but set in context by comparing the findings of the new analysis with previous economic assessments used to

provide the business case for past coastal protection and flood defence schemes along the BMP frontage.

TABLE 1-1

Issues identified from the Environmental Baseline (Appendix C)

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
1.1	Impact of beach management activities on internationally, nationally and locally designated features needs to be considered, including on: o Dorset and East Devon UNESCO World Heritage Site o East Devon AONB o Water Framework Directive waterbodies o Bathing Water Directive bathing beach water quality o Sidmouth to West Bay SAC o Lyme Bay to Tor Bay SAC o Sidmouth to Beer Coast SSSI o Ladram Bay to Sidmouth SSSI o UK BAP Priority Habitats o Various historic environment features including listed buildings and conservation area.	UNESCO WHS and AONB both have management plans and policies guiding acceptable management in relation to these features. These are also reflected in Local Plan policies. Environment Agency monitors bathing water quality between May and September each year. No regular monitoring in relation to natural environment designations is believed to occur.	Implications of range of future management options upon each of the identified environmental features to be assessed as part of options appraisal.
1.2	Impact of noise/visual disturbance of beach management activities on residents, visitors and local businesses needs to be considered.		Implications of range of future management options upon these aspects to be assessed as part of options appraisal.
1.3	Provision of safe access to beach for Sidmouth Lifeboat and beach users both during beach management activities and at all other times (i.e. public safety measures as part of scheme design) is required.	East Devon District Council / Environment Agency responsible for undertaking public safety risk assessments and ensuring maintenance occurs to address any public safety issues for coastal defence assets they are responsible for (e.g. provision of safety railings where fall from height risk is present; repair of trip hazards etc. on access steps/ramps). Given the risks of cliff falls along East Beach, East Devon District Council do not promote access to East Beach and actively discourage it through signage provided at access points in this area, though they do recognise the need to	Consideration of how to incorporate safe access to the sea will be given as part of appraisal of a range of future management options in options appraisal.

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
		provide access is essential for safe egress for walkers from further east and the coastguard.	
1.4	Impact of coastal erosion to east of the River Sid on sustainability of Alma Bridge (and coastal path) in its current position.	Devon County Council already planning for future with replacement of current Alma Bridge proposed, in discussion with East Devon District Council, Environment Agency and Natural England alongside development of the BMP.	Implications of range of future management options upon Alma Bridge to be assessed as part of options appraisal.
1.5	Ensure future coastal defence solutions do not adversely impact water quality, including South West Water outfalls in the BMP area.	South West Water operate a sewage pumping station and long-sea outfall at the eastern end of the Sidmouth Town frontage.	Implications of range of future management options upon each of the identified environmental features to be assessed as part of options appraisal.
1.6	Need to work in partnership with other asset/land owners to provide FCERM measures in a sustainable, integrated way. In particular, East Devon District Council, Environment Agency, South West Water and Devon County Council (Highways) are major asset owners.	Primary asset owners being engaged in process of developing the BMP.	Consider in options appraisal and emphasise in final BMP to be produced as part of final project outputs.

TABLE 1-2
Issues identified from the Coastal Defence Assessment Baseline (Appendix B)

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
2.1	Need to monitor all defence assets regularly and consistently (including the offshore breakwaters and mobile beaches – which needs a baseline condition survey and profiles to be established as a minimum) to guide future maintenance works and thus ensure the condition and residual life assessed as part of the BMP is maintained and provided.	The Environment Agency undertake at least an annual visual inspection of their coastal defence assets; though no regular monitoring of the offshore breakwaters occurs. Post-storm inspections also occur. East Devon District Council undertake similar inspections of the coastal defences to the Environment Agency, though on a less frequent basis. South West Water and Devon County Council also undertake regular inspection of their assets along the Sidmouth frontage (i.e. outfall pipe and Alma Bridge/highways respectively).	This is a minimum requirement for future management of the BMP area and so will be directly reflected in the final BMP to be produced in Stage 6. It does not need to form part of the options appraisal.

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
2.2	Ensure that maintenance works, when undertaken, utilise appropriate methods and materials in order to maximise effectiveness and extend structure life as long as possible into the future.	Appears that repairs to expansion joints along seawall and promenade slabs has taken place using mortar. This is not appropriate and needs to be rectified.	Maintenance requirements will be considered as part of the range of future management options to be assessed as part of options appraisal.
2.3	Exposed reinforcement along access ramp at Jacobs Ladder Beach needs to be addressed in near future to prevent risk of failure if structure is to be maintained to maximise its predicted residual life.		Future management options to be assessed as part of options appraisal.
2.4	River Sid Training Wall requires immediate action to stabilise it. As a minimum it requires concrete patching of cracks and holes, addressing corrosion and abrasion in the steel sheet pile toe, and construction of scour protection along the toe. Also needs to address risk of instability from wave loading on western side of training wall where there is no material on eastern side. Measures to reduce wave reflection off both sides of the training wall would also be beneficial to reduce wave scour.		Future management options to be assessed as part of options appraisal.
2.5	As the cliffs to the east of the River Sid continue to erode, the River Training Wall (refer also to issue 2.4) and River Sid Western Wall (refer also to issue 2.11) will become increasingly exposed to full coastal conditions and so will require upgrading to full coastal standards. Based on the baseline assessments, this will be required within the next 10 to 20 years (i.e. by 2035 at the latest) in order to continue to reduce coastal flood risk to the low-lying Sidmouth town centre. Although the wall itself is of sufficient height to not be exceeded by extreme still water levels in the next 100 years, it is unlikely to be sufficient to be able to		Future management options to be assessed as part of options appraisal.

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
	withstand additional wave loading during storm events.		
2.6	The Standard of Protection against wave overtopping is low for pedestrian safety during storm events and so measures to deter pedestrians accessing the promenade along the BMP frontage during storms would be appropriate.		Consideration of measures to reduce level of wave overtopping to be considered as part assessment of a range of future management options in options appraisal.
2.7	There are a number of areas where there are significant 'fall from height' risks from access ramps from promenade to beach along the frontage (particularly between the groyne bays) and the training wall.	Responsibility of East Devon District Council to undertake public safety risk assessments and take appropriate actions.	Public safety issues associated with structures to be considered as part of options appraisal assessments of a range of future management options.
2.8	The risk of wave overtopping leading to structural damage of the seawall and promenade, and so increased risk of structural failure, is greatest at the eastern end of the Sidmouth town frontage (i.e. towards the River Sid) due to low beach levels.		Future management options to be assessed as part of options appraisal.
2.9	The slipway at the eastern end of the frontage promotes wave run-up which poses additional risk of coastal flooding in this area.		Future management options to be assessed as part of options appraisal.
2.10	The Standard of Protection against wave overtopping resulting in extensive flood risk will reduce to below the design standard of the 1990s scheme (assumed to be 1:200 year SoP against flood risk and 1:50 against erosion risk) in the future (particularly between the Bedford Groyne and the River Sid) as sea levels rise unless the 1990s design beach levels are provided and/or the height of the seawall is increased.	Periodic beach recharge (import of sediment to site) was assumed in the scheme design. Reviews post-scheme concluded additional recharge was not needed. Beach recycling occurred in January 2015, moving sediment from the western end of Sidmouth Town Beach (from behind the reefs) to the two groyne bays along the eastern part of the Sidmouth Town beach (between Bedford Groyne and the River Sid Training Wall).	Future management options to be assessed as part of options appraisal.
2.11	The River Sid Western Wall (upstream of Alma Bridge) is in generally fair condition. However, along the toe of the structure severe scour has developed and, due to lack of available design	Wall is inspected and maintained by the Environment Agency.	Future management options to be assessed as part of options appraisal.

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
	drawings for this wall, it is uncertain exactly what the level of risk associated with this is.		
2.12	The existing low-level flood gates along the landward edge of the promenade do not provide an entirely closed off barrier to the passage of water (there are gaps in the barrier even with flood gates closed). The flood gates themselves are also damaged and in need of repair.		Future management options to be assessed as part of options appraisal.

TABLE 1-3

Issues identified from the Coastal Processes Baseline (Appendix A)

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
3.1	There remains uncertainty about the coastal process interactions in this area, and detailed investigation supported by a thorough modelling programme is warranted. However, based on available data current understanding is that under normal conditions, Chit Rocks to the west and the River Sid training wall to the east inhibit sediment movement in and out of the Sidmouth town frontage, effectively making it a closed-system (which it was designed to be) except under storm conditions when some leakage around the training wall may possibly occur. The training wall (likely in combination with reduced sediment supply as recharge material is retained to the west by East Pier groyne) thus acts as a key control point along the entire frontage. The South West Water outfall may also be having some impact on the movement		Ensuring future monitoring is appropriate and aimed at overcoming some of the uncertainties in coastal processes understanding is a minimum requirement for future management of the BMP area and so will be directly reflected in the final BMP to be produced as an output of this project. It does not need to form part of the options appraisal.

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
	of sediment across the mouth of the River Sid. As a result, East Beach must rely on sediment supply from the east and this is interrupted by periodic landslides further east of East Beach.		
3.2	Cliff failure in cliffs along East Beach is dominated by discrete cliff recession events, driven by combination of groundwater (and thus rainfall) from the top and wave erosion at the toe (and thus beach level). Geological faults, rock material and the presence of the railway tunnel (where it remains) are also factors. The impact is particularly notable at Pennington Point due to the specific localised geology in this area which means very erodible material is present in this specific area which is not present along the adjacent coast. Frequency of cliff recession events is expected to increase in the future in response to predicted increases in rainfall and sea level rise.	Historically there was cliff top drainage to reduce groundwater issues, but no longer in place.	To be considered when assessing future management options to reduce rate of cliff recession as part of options appraisal.
3.3	There is very little natural supply of sediment to the coast suitable for beach-building from cliff erosion and/or the River Sid.	Shingle trapped by weirs on the River Sid is removed and sold-off, so not reaching the mouth of the River Sid. Volumes involved are relatively small. The Sidmouth Coastal Protection Scheme was designed on the assumption of regular beach recharge occurring to add sediment to the system that would otherwise not occur at the coast. This has not happened. Very infrequent beach recycling has occurred along the Sidmouth beach frontage.	Future management options to be assessed as part of options appraisal to consider future sources of sediment supply to the BMP area (e.g. recharge from external sites).
3.4	The BMP frontage is subject to bi-directional wave conditions, with periods of east-west and west-east transport depending on prevailing wave climate.		To be considered when assessing future management options as part of options appraisal.

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
	Along East Beach, seasonal variations in beach levels depend on seasonal storm activity (and its direction), but over a longer period, it is thought that a cycle of stability, depletion and recovery on a 20-40 year time-scale may occur.		
3.5	Sediment is moved from east to west to behind the two offshore breakwaters by east-south-east storms where it becomes mostly trapped as the breakwaters prevent movement from west to east under south-westerly conditions.		Future management options to be assessed as part of options appraisal to consider future sources of sediment supply to the BMP area (e.g. beach recycling operations).
3.6	Sediment along the Sidmouth town frontage tends remain within each groyne bay, being moved from one end of each groyne bay to the other, depending on prevailing wave direction and only moves out of the groyne bays when it is drawn-down the beach during storms.		Future management options to be assessed as part of options appraisal to consider future sources of sediment supply to the BMP area (e.g. beach recycling operations).
3.7	Current location of regularly monitored beach profiles is not sufficient to provide a good basis upon which to assess beach volume changes. Additional beach survey profile locations both within the groyne bays and along East Beach and the coast further east towards Beer Head, would be preferable.	Although ongoing monitoring as part of the South West Regional Coastal Monitoring Programme is building up a longer-term dataset to inform understanding of coastal processes, there have been changes over the period of the programme with regards which profile locations are surveyed regularly, meaning there is still some way to go to get a good dataset.	As per comment against issue 3.1.
3.8	Post-storm beach profile surveys need to be captured along the same profiles each time, and broadly to the same extent (i.e. to MLW position ideally).	Plymouth Coastal Observatory do post-storm surveys when requested by East Devon District Council as part of the South West Regional Coastal Monitoring Programme. However, to date the locations and extent of post-storm profile surveys have varied.	As per comment against issue 3.1.
3.9	The sediment pathway between the beaches and the nearshore to offshore remains uncertain and more regular bathymetry surveys of the area, supported by sediment sampling of the seabed, would help to enhance understanding.	Bathymetry surveys undertaken about every 5 years as part of the South West Regional Coastal Monitoring Programme.	As per comment against issue 3.1.

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
3.10	High quality aerial photography should be flown every 2-4 years. This is particularly needed along the cliffs of East Beach and further east. Along Cliff Road atop East Beach, this should also be supported by 6-monthly cliff top monitoring of distance to cliff edge from a defined datum.	Aerial photography is flown every 2-4 years as part of the South West Regional Coastal Monitoring Programme. It should be noted, however, that the coastal monitoring budget has been reduced and the frequency of all surveys is likely to be under pressure to be reduced in the future.	As per comment against issue 3.1.
3.11	Any future beach recharge/recycling operations along the frontage need to be supported by in- and out- beach profile surveys to enable improved calculation of beach volume changes over time and performance of recharge/recycling.		As per comment against issue 3.1.

TABLE 1-4
Issues identified from the Economics Baseline (Appendix D)

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
4.1	Coastal flood risk to low-lying Sidmouth town centre area is significant, with Present Value damages (PVd) estimated at £85,384k over 100 years.	Flood risk managed by coastal defences along open coast (operated by East Devon District Council) and along western side of River Sid (operated by the Environment Agency).	Forms part of the 'benefits' in assessing benefit cost of a range of future management options as part of options appraisal.
4.2	Significant additional benefits to Sidmouth town frontage from amenity benefit of continuing to provide coastal defences that include a beach (estimated to be PVd = £31,431k over 100 years). This means significant partnership funding is likely to be required to ensure beach can continue to be provided as part of future FCERM measures.		As per comment against issue 4.1.
4.3	Economic case for FCERM measures to reduce coastal erosion risk along Cliff Road (atop East Beach) is very weak at present time given projections for when property will be impacted by erosion (i.e. lost). If works were to occur	Emerging East Devon Local Plan includes commitment to identify Coastal Change Management Areas. This area at Sidmouth (i.e. Cliff Road etc.) should be included in a Coastal Change Management Area.	Economic case for Cliff Road forms part of the 'benefits' in assessing benefit cost of a range of future management options as part of options appraisal.

FCERM Issue		Current Management Practice (where applicable)	How issue is to be taken forward in subsequent stages of BMP development
	along East Beach, it is very likely that the majority of funding would need to come from third-party contributions, including infrastructure asset owners/operators if measures protect such features (e.g. sewage pumping station) that would otherwise be at risk from erosion of the cliffs along East Beach. As aim of BMP is to reduce rate of erosion and not prevent it in any case, there is a need to plan for adaptation in this area in the face of future coastal change such that a plan is in place for when the time comes to implement it in the future.		The residual risks of future coastal change depending upon eventual preferred option(s) identified for this area to be included in final BMP to be produced as output from this project, to guide East Devon District Council in establishing any future Coastal Change Management Area.
4.4	There is limited economic case for works at Jacob Ladder Beach and Connaught Gardens (Chit Rocks), save for ongoing maintenance of existing defences (wall and rock revetment) to maximise the existing life of the structure, and this future maintenance (and/or works (a) replace the structures if desired at a point in the future, and (b) to recycle beach sediment from the promenade area at Jacob's Ladder Beach back westwards when it causes an amenity use issue) will likely need to be fully-funded by third-party contributions.		Future management options to be assessed as part of options appraisal.

1.3 Basis for appraisal of options

This section provides details of how the appraisal of options has been undertaken at both long-list and short-list.

1.3.1 Technical appraisal

Each long-list and short-list option has been appraised for how well it would be anticipated to perform and achieve the aims and objectives of this project (refer to **Section 1.1**). This appraisal has been based upon the evidence and understanding of the coastal defences (**Appendix B**) and coastal processes (**Appendix A**) developed as part of this project.

1.3.2 Environmental appraisal

The environmental implications of each long-list and short-list option have been appraised against the understanding of the environmental characteristics of the area developed as part of this project (**Appendix C**). The appraisal identifies where possible, the positive and negative impacts on different environmental features of different options. It also attempts to indicate relative differences in environmental impacts between options, however this is not always possible at the high-level of appraisal that this work is undertaken at, and some aspects would only be discernible if more detailed appraisal were undertaken to develop a particular option or options if selected as the preferred option to take forward to such detailed appraisal.

1.3.3 Economic appraisal

The economic appraisal is based on assessment of the costs and benefits of each option. This is expressed as the benefit:cost ratio (BCR) for each option. The BCR then forms part of the Partnership Funding calculation to determine how much of the required costs can be claimed from central Government via the FCERM-GIA, and how much of the costs will have to be found from other sources of funding (refer to **BOX 1** below). This partnership funding calculation also takes into account the numbers of properties protected against the risk of flooding and erosion, the level of social deprivation of the areas at risk, and legal environmental requirements.

The benefits part of the BCR is based upon the do nothing scenario damages calculated in the economics baseline (**Appendix D**). In summary, this calculated that there are up to 108 residential and 80 commercial properties at risk of coastal flooding, with Present Value damages (PVd) calculated over a 100 year appraisal period to be £66,005k based on a lowest beach profile scenario. No account of any additional flood risk from fluvial flooding has been made as part of this project. There are also potentially up to 5 properties at risk of coastal erosion along Frontage C during the 100 year appraisal period, with a PVd of £9k. In addition, there are calculated to be £31,431k of amenity benefits over the appraisal period (from a combination of amenity losses avoided and amenity gains). In total therefore, the do nothing scenario damages for the BMP frontage could be up to £97,445k if amenity is included. For the short-list appraisal however, only the property damages have been used, giving do nothing damages of £66,014k; this represents a 'worst case' economics scenario. Sensitivity testing of the economic case, and associated partnership funding scores, using the amenity damages has been undertaken (refer to **Section 3.2.3** and **Section 3.2.8**).

Given that the flood modelling work completed as part of this project (refer to **Appendix D**) shows that for a scenario where the 1990's design beach level can be maintained over 100 years there are no damages calculated, it is assumed in the appraisal that each option will avoid all of these damages, in line with the aims and objectives of the project.

To provide the costs part of the BCR, for each option appraised broad costs have been developed based on industry standard rates and recent CH2M experience of similar types of works. In accordance with national guidance, a 60% optimism bias is then applied to total calculated costs.

BOX 1: Future funding of coastal defences

The way in which flood and coastal erosion risk management schemes are funded in England changed in April 2012. The previous system of funding, whereby only the highest priority schemes received 100% grant-in-aid (GIA) from central government was replaced by a new funding system.

Whilst some schemes will still be eligible for the full 100% grant-in-aid from central government, the new approach allows more schemes to be delivered with a lower percentage GIA contribution from central government, with the shortfall in funding to be made up from other funding sources – this is referred to as 'Partnership Funding' (Defra, 2011(a); Defra, 2011(b); and EA, 2012).

This Partnership Funding approach will allow schemes that would have historically been deferred, due to failure to meet the 100% GIA qualifying criteria, to proceed earlier than would be expected if they were solely dependent on receiving central government funding.

This change in approach reflects the fact that flood and coastal erosion risk management schemes provide multiple benefits to communities, not just protection against flood and erosion risks. For example, a defence may reduce risks to transport and services infrastructure that is critical to an area's economy and development potential. A defence may also provide public space or, where a beach is recharged, an important tourism and recreational resource.

The different, multiple beneficiaries from FCERM funded schemes presents the potential to access the various funding sources that are used by those beneficiaries, and this may be one way of achieving Partnership Funding. Given this possibility, the following are potential Partnership Funding routes that could be explored to deliver future FCERM activities along the coast (from McNally, Johns and Pygott, (2012)).

- Private investment (e.g. developer/landowner pays);
- Water company investment;
- Community Infrastructure Levy;
- Section 106 Agreements (Town & Country Planning Act, 1990);
- Council Tax;
- Public Works Loan Board;
- Business Rate Supplements;
- Business Improvement Districts;
- Asset Backed Securities;
- General Drainage Charge/Special Drainage Charge;
- Local Authority fees and charges;
- Trusts;
- Regional Growth Fund;
- Business Rate Retention;
- Tax Increment Finance;
- Local Government Bonds;
- Coastal Communities Fund.

2 Long-List Options Appraisal

2.1 Defining the long-list

The long-list of options to appraise was identified following a workshop held at CH2M's Exeter office on Tuesday 14th July 2015. The workshop involved members of CH2M's project team along with representatives of East Devon District Council and the Dorset and East Devon UNESCO World Heritage Site. In identifying these options, consideration has been given to both:

a) The project aims and objectives (**Section 1.1**); and

b) The issues identified from the baseline assessment understanding of the coastal processes, environmental features, coastal defences and potential economic viability (**Section 1.2**).

This is to ensure that the options to be appraised as part of this project are realistic and appropriate to potentially achieve the project aims and objectives and address the various issues identified.

In addition, consideration was also given to the following potential opportunities/additional benefits beyond flood and coastal erosion risk management that may be achievable with different long-list options:

1. EDDC's future intentions to redevelop Port Royal (lifeboat station, sailing club, drill hall, and toilets).
2. There has been talk in the past of a modest harbour which might be possible off of a Port Royal redevelopment.
3. Respecting and protecting the small fishing industry that exists in the Port Royal area.
4. Need emphasis on the importance of Alma Bridge and links to eastern Sidmouth.
5. The amenity and tourism value of the beach to the town is important, so options that maximise beach would be preferable.
6. If the existing rock groynes were to be modified, could they be modified in a way that would enable them to be used as a passenger dock for the Heritage Coast ferry?
7. Possibility of providing summer sheltered moorings/anchorage behind reef structures.
8. Potential to provide safe/quick access to the sea at the eastern end of the Sidmouth Town frontage for the lifeboat (and sailing club) and at the western end (Clifton Beach) for the lifeboat.
9. Potential for increasing beach hut provision along Sidmouth Town frontage.
10. Potential for development of the 'beach garden' located in the area behind the reefs.

In identifying the long-list of options, the BMP frontage was sub-divided into four frontage units (see also **Figure 2-1**):

A. Jacob's Ladder Beach and Connaught Gardens (Chit Rocks).

B. Sidmouth Town (Chit Rocks to the River Sid, including the training wall seawards of Alma Bridge).

C. East Beach (River Sid eastwards to BMP boundary).

D. River Sid Western Wall (upstream of the training wall / Alma Bridge).

FIGURE 2-1
BMP Frontage sub-units used for long-list options appraisal

Each frontage above has distinct existing physical characteristics and hence these constraints result in different viable options that could be considered for these lengths when taking into account the project aims and objectives. Options that may suit one frontage may therefore not be pertinent to others.

In general the following options and/or a combination of these were considered:

- Do nothing (to provide the baseline case against which to appraise do something options).
- Maintenance of the existing structures/continuation of the existing regime.
- Improvements and/or modifications to the existing defences, i.e. wall raising or changes in structure size or shape.
- Additional works, i.e. beach recharge or new offshore breakwater(s).
- Replacement of the existing structures, i.e. new groynes, revetments or walls.

It is important to note that whilst the BMP frontage has been split into four separate lengths for ease of undertaking the long-list options assessment, the overall purpose of the BMP is to develop one scheme for the seafront and all four frontages need to be considered in combination. This interaction between frontages is considered at a high-level during the appraisal of long-list options to select the short-list. The short-list appraisal (refer to Section 4) then appraises in further detail the in-combination options for each frontage for combinations of options along each frontage that will work together.

It should also be noted at this point, that the options for the River Sid (Frontage D) will help to inform a separate scheme for the River Sid which will be developed by the Environment Agency at a later date; likely after any scheme along the open-coast to address beach management along Frontages A, B and C.

In appraising each “do something” option, comparison is made to a baseline scenario of “do nothing”. This is required to demonstrate the case for doing something (e.g. what damages from flooding and erosion will be reduced or avoided by spending money on different options?). It does not assume do nothing is a valid option being considered.

2.1.1 Discounted options

As part of the long-list appraisal workshop, in addition to identifying potentially viable options to appraise, other options were discussed and discounted. For completeness, the following briefly discusses those options that were not considered appropriate or potentially viable for the long-list.

2.1.1.1 Frontage A

Frontage A is fronted by Chit Rocks and is formed by the Clifton Walkway and the cliffs above. Any option for this length would need to account for the existing natural features and the limited public usage on the foreshore at this location. It should be noted that this frontage provides only amenity value (Clifton walkway) rather than residential or commercial benefits.

The following options were not considered viable and were therefore not included within the long list of options:

- Wall raising – no requirement to raise existing structure heights to prevent overtopping.
- Beach recharge – Beach is separate from rest of BMP frontage and tends to accrete in this area, with sediment moving within this sediment sub-cell between Jacob’s Ladder and further west; as such there is no need to add new material from external sources to this area. Beach recharge may also necessitate the need for control structures such as groynes.
- Offshore breakwaters – Chit Rocks forms a natural rock outcrop. Creation of a public amenity beach was deemed inappropriate at this location as to do so would require control structures that would impact designated features and be hard to justify economically.

2.1.1.2 Frontage B

Sidmouth town frontage comprises a number of man-made coastal defence structures which protect the residential and business properties along Sidmouth seafront. This length is characterised by a public/amenity beach which is a key feature of this area.

Due to the mix of existing structures and the public use of the beach, a range of options were taken forward. Modifications to the existing structures were considered in combination with other options where appropriate. The removal of the existing breakwaters alone was not considered as this would impact on the existing beaches, which would then require significant ongoing beach recharge to try and maintain any beach.

2.1.1.3 Frontage C

The East Beach frontage is within a number of designations including UNESCO World Heritage Site and nationally designated geological sites; any works within this length has to address and/or work with these constraints.

Erosion at the toe of the cliff is the main driver, with cliff top erosion being a secondary mode of failure. Any solutions to prevent/reduce the toe erosion would therefore preferably be supported by cliff top erosion prevention (e.g. drainage supported by netting and/or pinning) as suitable.

As no existing structures currently exist along this frontage, options such as improvements or modifications to, or replacement of, existing structures are therefore not considered.

Recycling of beach material from East Beach or east thereof, or utilising any cliff fall materials, to increase the beach size immediately east of the River Sid is not possible due to access restrictions and environmental designations, and was therefore not considered. Beach recharge along Frontage C in isolation was not considered as it would require some form of control structure(s) to help retain it in the areas where it is desired.

2.1.1.4 Frontage D

The River Sid Western Wall, upstream of Alma Bridge, protects inland/upstream properties and infrastructure. The River Sid is mainly affected by reflected waves from the existing vertical walls within the channel and although doesn't form part of the overall beach frontage, any works within the local area may impact on the river walls and is therefore considered as part of the overall options selection.

Beach recharge, revetments or groynes are not applicable to this section as it is within the River Sid and not on the open coast, and were therefore not considered as part of the long listed options.

2.1.2 Options taken forward to long-list appraisal

The long-list of options to appraise for each frontage unit A, B, C and D, is summarised in **Tables 2-1 to 2-4** respectively. Figures to illustrate each of these options are provided in Appendix B (Note, these are for illustration only and do not represent a final scheme design; such details would not be developed fully until a definite scheme is being progressed).

TABLE 2-1
Summary of long-list options for frontage A: Jacob 's Ladder Beach and Connaught Gardens (Chit Rocks)

Option ID#	Option Description
A.0	Do Nothing
A.1	Maintenance of Jacob's Ladder Wall and Promenade (including repairs where reinforcement is exposed) for as long as economically viable to maximise assessed residual life, then withdraw maintenance once it is uneconomical to continue this practice. Undertake in combination with Option A.5.
A.2	Maintenance of Jacob's Ladder Wall and Promenade (including repairs where reinforcement is exposed) for as long as economically viable to maximise assessed residual life, then replace structure with new structure along same alignments once it is uneconomical to continue to maintain the existing structure. Maintenance of the remaining length (i.e. rock revetment) for the whole of the scheme life. Undertake in combination with Option A.5.

Option ID#	Option Description
A.3	Maintenance of rock revetment around Chit Rocks, including re-packing of rock at eastern end where it adjoins Jacob's Ladder Beach. Maintenance of Jacob's Ladder seawall and promenade for the whole of the scheme life. Undertake in combination with Option A.5.
A.4	Maintenance of rock revetment around Chit Rocks, including re-packing of rock at western end where it adjoins Jacob's Ladder Beach and extension of rock armour along toe of Jacob's Ladder Seawall (approx. 10-20m extension envisaged) in support of Option A.1/A.2 by contributing to efforts to extend the residual life of that wall. Maintenance of Jacob's Ladder seawall and promenade for the whole of the scheme life. Undertake in combination with Option A.5.
A.5	Periodic removal of shingle from Jacob's Ladder Beach promenade area, with sediment placed to the west of the wall within this sediment cell (not to be removed to east of Chit Rocks or elsewhere under any circumstances). Undertake in combination with Option A.1/A.2/A.3/A.4. Maintenance of Jacob's Ladder seawall and promenade for the whole of the scheme life.

TABLE 2-2

Summary of long-list options for frontage B: Sidmouth Town (Chit Rocks to the River Sid, including the training wall seawards of Alma Bridge)

Option ID#	Option Description
B.0	Do Nothing
B.1a	Maintain existing defence configuration. Repair/replace training wall along same alignment. Undertake periodic beach recycling only with available sediment. Raise height of seawall along front (seaward) edge of promenade to reduce volume of wave overtopping at some point in the future.
B.1b	As Option B.1a, but raise height of seawall along back (landward) edge of promenade to reduce risk of propagation of wave overtopping at some point in the future (i.e. replace existing low-level flood barrier/flood gate system with a higher, more robust structure and flood gate system).
B.2a	Maintain existing defence configuration and design (i.e. seawall, offshore reefs, 3 rock groynes). Repair/replace training wall along same alignment. Undertake periodic beach recharge to maintain volume to level of design beach, supported by ongoing beach recycling.
B.2b	As Option B.2a, except repair and shorten length of both the current freestanding section of training wall and East Pier.
B.3a	Remove breakwaters and groynes and training wall and replace with large-scale rock revetment along frontage. Raise height of seawall along back (landward) edge of promenade to reduce risk of propagation of wave overtopping seaward edge at some point in the future (i.e. replace existing low-level flood barrier/flood gate system with a higher, more robust structure and flood gate system). Also consider in combination with Option C.1.
B.3b	As Option B.3a but replace with concrete stepped revetment.
B.4a	Modify existing Bedford Steps, York Steps and East Pier rock groynes (from existing length) to make 'T-head' type groynes to retain sediment in small stable bays between each groyne bay. Support with periodic beach recycling and/or recharge to retain volume to give required design beach. Repair/replace training wall along same alignment.
B.4b	As Option #B.4a but shortening length of East Pier groyne in the process. Repair/replace training wall and shorten length of the current freestanding section.
B.4c	As option #B.4a, but remove training wall and place rock-armour around seawall where it curves into the River Sid. Also consider in combination with Option C.1.
B.4d	As Option #B.4a, but remove East Pier rock groyne and training wall and place rock-armour around seawall where it curves into the River Sid. Also consider in combination with Option C.1.
B.5a	Remove the three rock groynes and training wall. Construct additional offshore rock breakwaters (number to be determined at later date) to implement broadly the technically preferred solution identified by HR Wallingford in the 1990s. Reefs would be structures of similar size/scale as the two existing breakwaters, tapering in (and so being gradually smaller potentially) to minimise diffraction impacts on down-drift coast. Support with periodic beach recharge and recycling. Note 1, option has potential to be extended along East Beach – see Option C.7a – so also consider in-combination with that option. Note 2, reefs could incorporate biological units to encourage flora and fauna development.

Option ID#	Option Description
B.5b	As Option B.5a except that reefs would be structures of lower height (so more inter-tidal; not exposed above sea level all the time) compared to the two existing breakwaters, tapering in to minimise diffraction impacts on down drift coast. Note 1, option has potential to be extended along East Beach – see Option C.7b – so also consider in-combination with that option. Note 2, reefs could incorporate biological units to encourage flora and fauna development.
B.6	Maintain/repair training wall to reduce imminent risk of failure in short term in advance of undertaking any of the Options B.1 to B.5 above.

TABLE 2-3

Summary of long-list options for frontage C: East Beach (River Sid eastwards to BMP boundary)

Option ID#	Option Description
C.0	Do Nothing
C.1a	For options where training wall shortening or removal is considered (Options B.2b, B.3a, B.3b, B.4c and B.4d), construct one or two short/low-level rock groynes about 150-200m east of the River Sid to aid beach levels control as scheme transitions eastwards from hold the line at Sidmouth to no active intervention to the east.
C.1b	As Option C.1a, supported by periodic beach recycling.
C.2a	Construct 210m rock revetment along base of cliff. i.e. previously proposed 2004 option IV A
C.2b	As Option C.2a, supported by cliff top drainage measures (to be determined following investigation of groundwater flows) and/or cliff top slope regrading and pinning (e.g. soil nailing and netting).
C.3a	Construct 210m rock revetment along frontage, offset 5-10m from the base of cliff.
C.3b	As Option C.3a, supported by cliff top drainage measures (to be determined following investigation of groundwater flows) and/or cliff top slope regrading and pinning (e.g. soil nailing and netting).
C.4a	Construct 3 low-level rock groynes along base of cliff over a length of approximately 210m east of the River Sid. i.e. previously proposed 2004 option IV C
C.4b	As Option C.4a, supported by cliff top drainage measures (to be determined following investigation of groundwater flows) and/or cliff top slope regrading and pinning (e.g. soil nailing and netting).
C.5a	Construct 50m rock revetment along base of cliff immediately east of the River Sid (i.e. around Pennington Point). i.e. previously proposed 2004 option III
C.5b	As Option C5.a, supported by cliff top drainage measures (to be determined following investigation of groundwater flows) and/or cliff top slope regrading and pinning (e.g. soil nailing and netting).
C.6a	Construct a 35m 'T-head' type rock groyne along base of cliff immediately east of the River Sid (i.e. around Pennington Point). i.e. previously proposed 2004 option II
C.6b	As Option C.6a, supported by cliff top drainage measures (to be determined following investigation of groundwater flows) and/or cliff top slope regrading and pinning (e.g. soil nailing and netting).
C.7a	Extend Option B.5a further east, with offshore breakwaters (at similar height to existing two Sidmouth breakwaters) tapering towards the eastern end of the BMP area. Beach recharge would not occur along East Beach, only along Sidmouth Town frontage, but removal of groynes/training wall would enable transport along the shoreline of the recharge material placed along Sidmouth Town frontage.
C.7b	Extend Option B.5b further east, with offshore breakwaters/reefs (at lower height than the two existing Sidmouth breakwaters) tapering towards the eastern end of the BMP area. Beach recharge would not occur along East Beach, only along Sidmouth Town frontage, but removal of groynes/training wall would enable transport along the shoreline.

TABLE 2-4
Summary of long-list options for frontage D: River Sid Western Wall (upstream of the training wall / Alma Bridge)

Option ID#	Option Description
D.0	Do Nothing
D.1	Maintenance of existing western wall, which is in fair condition, to maximise its residual life for as long as possible. Repair scour in immediate future to support this. As and when wall becomes exposed to full coastal conditions (if/when cliff to the east retreats sufficiently far to cause this), replace wall with a coastal-standard vertical seawall. NB: need for this (and timing) depends on Options for East Beach, so consider this option in combination with each of Options C.1 to C.7.

2.2 Summary of long-list options appraisal

As described in **Section 1.3**, each of the long-list of options has been appraised as follows:

- Technically in terms of expected performance in achieving the objectives (specifically objectives (f)i, (f)ii and (f)iii – refer to **Section 1.1**) ; longevity (sustainability); and coastal process implications). This draws upon the understanding developed in the coastal processes and defence assessment baselines.
- Economically in terms of indicative benefit:cost ratio (BCR) and partnership funding score.
- Environmentally in terms of likely implications for a range of environmental receptors as defined in the environmental baseline assessment, and particularly with regards to objective (f)iv – refer to **Section 1.1**.

The appraisal has considered options in each frontage unit A, B, C and D both in isolation and, where appropriate, in combination with options in other frontage units. Illustrations of most options are provided in **Appendix E**, whilst the full appraisals are provided in **Appendix F**. However, for ease of understanding, the appraisals are summarised in **Sections 2.2.1 to 2.2.4**.

2.2.1 Frontage A: Jacob's Ladder Beach and Connaught Gardens (Chit Rocks)

Within this frontage six potential options are identified (including do-nothing). These options are described in **Table 2-1** above.

2.2.1.1 Technical & Economic Assessment Summary

The SMP policy for this frontage is to hold the line. The do-nothing option (Option A.0) would not comply with this and is therefore not considered further.

Options A.1 to A.4 inclusive all comply with this policy. However, Option A.1 (maintenance for as long as viable then withdraw maintenance) would only provide a short term – approximately 15 year solution – before reverting to do-nothing and hence is not considered further. Option A.5 (periodic removal of shingle from Jacob's Ladder Beach promenade) is included as part of the overall works for Options A.1, A.2, A.3 and A.4.

Very limited technical differences exist between the main options of A.2 to A.4. Option A.2 comprises of maintenance followed by replacement of the structures, whereas Options A.3 and A.4 rely on minor initial costs and long term maintenance requirements over the scheme life.

No residential or commercial properties are at risk within this frontage within the next 100 years. However, Options A.2 to A.4 would protect amenity and tourism aspects including the South West Coastal Path, beach huts and Connaught Gardens.

As the frontage has no FCERM benefits, an economic analysis is therefore not applicable. All funding for any option within this length will require 100% funding from non Grant-in Aid sources. Indicative costs for Options A.2 to A.4 are £2,627k (Option A.2), £737k (Option A.3) and £2,215k for Option A.4.

The recommended technical and economic option to take forward to the short-list appraisal is Option A.3 (maintenance of rock revetment around Chit Rocks including repacking of rock and maintenance of the seawall and promenade) as it meets the SMP objective and has the lowest costs of the viable options. This is to be supported by Option A.5 (periodic clearing of shingle from the promenade area).

2.2.1.2 Environmental Assessment Summary

Environmentally, the majority of the six potential options have very similar impacts to the current situation and limited, if any change, is predicted.

Option A.2 (due to its short term protection only) and Option A.4 (due to increased extent of rock revetment), are most likely to have in the main a number of negative benefits as the coastline reverts to a do-nothing scenario.

2.2.1.3 Conclusion

The combined environmental, technical and economic appraisal of long-list options for Frontage A identifies Option A.3 (maintenance of rock revetment around Chit Rocks including repacking of rock and maintenance of the seawall and promenade) to take forward to the short-list appraisal. This is to be supported by Option A.5 (periodic clearing of shingle from the promenade area).

2.2.2 Frontage B: Sidmouth Town (Chit Rocks to the River Sid, including the training wall seawards of Alma Bridge)

The potential options for Frontage B: Sidmouth Town, are listed in **Table 2-2** above.

2.2.2.1 Technical & Economic Assessment Summary

Over the Sidmouth main coastal frontage the SMP policy is to hold the line. The primary objectives for this frontage is to ensure that the standard of service provided by the Sidmouth seafront coastal defences is being met and maintained in a sustainable way, and that the option does not compromise the adjacent East Beach objectives of reducing the rate of erosion and not compromising the integrity of the environmental features.

Option B.0 is the baseline option of do-nothing and as such would not meet the above objectives. It is therefore not suitable to be carried forward as a short listed option.

The standard of protection afforded by Options B.1a and B.1b (retain existing defences and raise the height of the seawall along the seaward and landward sides respectively) is dependent upon the new wall height that would have to be built. It is assumed in Option B.1a, where the new wall is constructed at the seaward edge of the existing defence, that the existing structure is suitable to allow this. Construction of the raised seawall on the seaward side would provide better pedestrian safety from overtopping than construction on the landward side. Option B.1a also has a lower cost and a greater benefit cost ratio than Option B.1b (cost of £5,663k with a benefit:cost ratio of 11.6 compared with a cost of £6,818k with a benefit:cost ratio of 9.7). However within both B.1 options there is both risk of increased scour and, as beach recycling is only undertaken within the frontage, beach material volumes are at risk of diminishing over time. Options B.1a and B.1b are therefore not taken forward to the short-list.

Options B.2a and B.2b (undertake periodic beach recharge together with repair/replace training wall or repair/shorten the training wall and East Pier groyne respectively) would ensure that the standard of protection is maintained and result in a more stable beach than existing due to the ongoing beach recharge. Option B.2a would re-create the original design from the 1990's Sidmouth Coastal Defence Scheme and maintain a public beach. Option B.2b also allows for a more gradual transition between the 'hold-the-line' policy for Frontage B and the 'managed realignment' policy of Frontage C. However, Option B.2b may require additional beach recharge compared to Option B.2a.

The construction of large scale revetment – either rock or stepped concrete – are very similar in benefit:cost ratios and are considered to improve the standard of protection from overtopping, together with improved standard of protection from defence erosion/failure. However, over time it is likely that the beach is likely to be lost. Option B.3a (rock revetment) would be more adaptable to

potential lowering of the foreshore than a concrete revetment (Option B.3b) in response to reduced beach levels.

A number of different options involving modifications to the existing rock groynes together with beach recharge are considered in Options B.4a to B.4d. These options provide the necessary standard of defence and also provide an improved beach.

To allow more gradual transitions in shoreline orientation between the Sidmouth frontage 'hold-the-line' policy and the River Sid and Sidmouth (East) policy of 'managed realignment' (i.e. East Beach frontage), Options B.4b and B.4d include for shortening or removing groynes as they near the River Sid. These are considered more appropriate solutions than Options B.4a and B.4c which retain the existing lengths of the groynes. However, the removal of both the training wall and East Pier rock groyne (Option B4.d) could result in a permanent loss of the beach at this location. Of the two remaining options, Option B.4d is marginally cheaper than Option B.4b and has a higher cost benefit ratio (£14,264k costs, benefit:cost ratio of 4.6 and partnership funding score of 27%, compared to £15,855k costs, benefit:cost ratio of 4.2 and partnership funding score of 25%).

The removal of the existing beach structures and replacement with additional offshore reefs and beach recharge are considered in Options B.5a and B.5b. Option B.5a allows for reefs similar in size to the two existing reefs, and Option B.5b with lower level reefs that would be exposed above sea level less often (i.e. at low-tide). The effectiveness of the lower level reefs would, however, be reduced particularly during storm events when beaches would become more mobile. As such Option B.5a is preferred over option B.5b. Option B.5a has a cost of £10,193k, a benefit:cost ratio of 6.5 and a partnership funding score of 38%.

Option B.6 is considered in combination with any of the main options noted above as an immediate option to ensure the continued effectiveness of the River Sid training wall, whilst other schemes are being implemented. The cost of this option is included within the values noted above.

The recommended technical and economic options to take forward to the short-list appraisal are Option B.2a (undertake periodic beach recharge), B.2b (shorten training wall and East Pier groyne and undertake periodic beach recharge), B.4b (modify existing groynes including shortening East Pier to make 'T-head' type groynes plus periodic beach recycling and/or recharge), B.4d (modify existing groynes to make 'T-head' type groynes, remove training wall and East Pier groyne and support with beach recycling and/or recharge) and B.5a (remove existing beach structures and construct new offshore breakwaters – similar in size to existing).

2.2.2.2 Environmental Assessment Summary

Environmental impacts from Options B.1a, B.1b and B.2a and B.2b are similar for each option. Option B.2a, however, may have some additional negative long term impacts on fish ecology due to the increase in sediment loads from the beach recharge. Landscape characteristics may be affected if the sea wall in Options B.1a and B.1b is constructed to a greater height than existing. Option B.2b may have positive geological impacts on the UNESCO designated site by increasing natural processes.

The Sidmouth frontage is designated as a bathing beach. Any long term loss of the beach (options B.3a and B.3b) would conflict with this designation and are therefore not taken forward to the short-list. Options B.1a and B.1b only allow for recycling of any beach material within the existing frontage – there is a risk that, with sea level rise there could be increased scour along the seawall and this together with recycling only from within the frontage, the volume of beach material may diminish.

There is minimal to no difference between the environmental impacts from Options B.4(a-d) to B.5(a-b). However, it should be noted that construction of offshore reefs would be to the detriment of loss of habitat to benthic species associated with soft sediment, although construction could be of benefit to epibenthos species including BAP species associated with rocky reef substrate. Comparing B.5a and B.5b, there would be lesser visual impact from B.5b as the structures would be lower and thus more submerged at high tide.

2.2.2.3 Conclusion

The combined environmental, technical and economic appraisal of long-list options that are identified to be taken forward to the short-list appraisal for Frontage B: Sidmouth Town, are as follows:

- Option B.2a – Maintain existing defence configuration. Repair/replace training wall along same alignment. Undertake periodic beach recharge to maintain volume to level of design beach, supported by ongoing beach recycling.
- Option B.2b - Maintain existing defence configuration. Repair and shorten length of both the current freestanding section of training wall and East Pier. Undertake periodic beach recharge to maintain volume to level of design beach, supported by ongoing beach recycling.
- Option B.4b - Modify existing Bedford Steps, York Steps and East Pier rock groynes to make 'T-head' type groynes to retain sediment in small stable bays between each groyne bay and shortening East Pier groyne in the process. Support with periodic beach recycling and/or recharge to retain volume to give required design beach. Repair/replace training wall and shorten its length.
- Option B.4d – Modify existing Bedford Steps and York Steps rock groynes to make 'T-head' type groynes to retain sediment in small stable bays between each groyne bay. Support with periodic beach recycling and/or recharge to retain volume to give required design beach. Remove East Pier rock groyne and training wall and place rock-armour around seawall where it curves into the River Sid.
- Option B.5 – remove existing beach structures and construct new offshore breakwaters, supported with periodic beach recycling and recharge. *Note: the number, position, size and height of structures to deliver Option B.5 would only be known after modelling of the structures were undertaken and hence both options (B.5a and B.5b) can be considered 'viable' at this stage.*

It is assumed that all of the above options include for immediate repair to the River Sid training wall (Option B.6) until the final option can be implemented.

2.2.3 Frontage C: East Beach (River Sid eastwards to BMP boundary)

The potential options for Frontage C: East Beach, are listed in **Table 2-3** above.

2.2.3.1 Technical & Economic Assessment Summary

The SMP policy for this frontage is managed realignment to control the rate of beach and cliff erosion along this frontage but not prevent it all together, and so minimise the risk to Sidmouth Town from exposure by outflanking and thus increased risk of coastal flooding via the River Sid. Cliff failure along this frontage is dominated by discrete cliff recession events, driven predominantly from wave erosion at the toe and exacerbated by cliff top erosion from groundwater.

The frontage has a number of designations including UNESCO World Heritage Site and nationally designated geological sites due to outcrops at the base of the cliffs. Any options should not compromise or adversely impact the integrity of the environmental features and would need agreement from a number of statutory bodies, including Natural England.

The most viable options for this area include rock revetment, groynes and breakwaters or a combination thereof. In addition to these, consideration to include cliff top drainage/mitigation is included within some sub-options.

The construction of a number of small scale rock groynes along the frontage (Options C.1a and C.1b), would provide a transition between the hold the line policy of the adjacent Sidmouth Town (Frontage B) and the managed realignment policy for this East Beach frontage. However, without any recycling of beach material (excluded from option C1.a) any rock groynes are at risk of the loss of sediment and hence usefulness.

Option C.1 is utilised in combination with Options B.2b, B.3a, B.3b, B.4c and B.4d only.

Options C.2a and C.5a allow for the construction of 210m or 50m length rock revetment respectively to the toe of the existing cliffs, with Options C.2b and C.5b additionally including cliff top drainage thereby reducing the rate of cliff top erosion. The shorter revetment would need to consider potential outflanking to the east and increased erosion to parts of the East Cliff, therefore Option C.5(a-b) is less technically favoured than Option C.2.

Options C.3a and C.3b are similar to options C.2a and C.2b (210m revetment) except that the rock revetment is constructed several metres out from the toe of the cliffs. Options C.3(a-b) thereby enables reduced wave erosion of the cliff whilst permitting access to the designated areas at the cliff toe. There is, however, the risk that these options could become outflanked and beach material washed out from between the structure and the cliffs. Option C.3 is preferred over Options C.2 and C.5, with Option C.3b the most technically viable of all these options.

The options of constructing rock groynes along the base of the cliffs are considered in Options C.4 and C.6 (3 low level rock groynes, and a 35m T-head groyne respectively). In both cases each option allows for works with and without cliff top drainage which is considered necessary to alleviate the cliff top recession. Outflanking of the groynes would need to be considered as this could accelerate the cliff erosion along parts of East Beach. Options C.4b and C.6b are considered the most technically viable from Options C.4 and C.6.

It should be noted that the construction of any groyne or revetment along the immediate frontage may not be considered as 'managed realignment' and hence may not meet the SMP2 policy requirements for this frontage.

Options C.7a and C.7b would only be implemented in combination with equivalent options along Frontage B (i.e. Options B.5a and B.5b) to construct offshore breakwaters tapering towards the end of the study area, which would allow the formation of salients/tombolos providing a beach in front of the existing cliffs thereby helping to reduce toe erosion rates. It is assumed in both cases that if the existing groynes and training wall are removed (refer to Frontage B options above), this should enable beach material to be transported along the shoreline. The effectiveness of Option C.7b (low level breakwaters) would be reduced during storm events when beaches become more mobile compared with similar height breakwaters that would be provided in option C.7a, however the final height of the breakwater would only be determined via modelling and to ensure that any wave induced current or other additional marine safety issues are resolved.

Technically, the preferred options for this frontage are therefore Options C.1b, C.3b, C.4b, C.6b and C.7a.

Within this frontage there are very little direct benefits, albeit indirect benefits include extending the western wall life of the River Sid and providing additional protection to Alma Bridge and in turn, critical infrastructure such as the South West Water pumping station locations behind the western wall immediately upstream of the Alma Bridge. As such, benefit:cost ratios are zero with no partnership funding score for this frontage. The costs of the preferred technical options are: £1,105k, £5,588k, £2,048, £3,834k and £3,453k for Options C.1b, C.3b, C.4b, C.6b and C.7a respectively. However, options along this frontage would support achievement of the economic benefits defined for Frontage B, and so at short-list stage the combined benefits and costs for Frontages B and C will be considered as part of considering a single integrated scheme for the open-coast frontage at that stage of the options appraisal process.

2.2.3.2 Environmental Assessment Summary

As the frontage is designated for geological interest which includes the rock outcrops at the toe of the cliffs any structure that impacts upon this is considered unsuitable or should be minimised as much as possible. Any short-listed option would need agreement from Natural England. On this basis Options C.1a and C.1b are most appropriate as they consist of one or two short/low level groynes, or Options C.5a and C.5b as they consist of a short length (50m) of revetment immediately along the toe. Options C.7a and C.7b that include offshore breakwaters are also appropriate for the same reasons. Options C.7a and C.7b also have a lesser impact upon natural processes than Options C.1 to C.6, with Option C.7b having the lesser impact than C.7a. Natural England have noted that they

would not support the rock revetment options of C2, C3 and C5, and that the scale/number of groynes in Option C1 would be preferable to Option C4. Natural England have also stated that cliff top drainage, netting and pinning, would be detrimental to both designated features of the SAC and the World Heritage Site; as such any option proposing such measures are not supported.

The preferred environmental options for Frontage C are therefore Options C.1a, C.1b and C.7b.

2.2.3.3 Conclusion

The combined environmental, technical and economic appraisal of long-list options that are identified to be taken forward to the short-list appraisal for Frontage C: East Beach, are as follows:

- Option C1.b – Construct 1 or 2 short/low level rock groynes about 150-200m east of the River Sid to aid beach levels controls as it transitions eastwards, supported by periodic beach recycling within Frontage B. *Note: Option C.1 is utilised in combination with Options B.2b, B.3a, B.3b, B.4c and B.4d only*.
- Option C.7 – Construction of offshore breakwaters (tapering towards the eastern end of the study areas. *Note: the number, position, size and height of structures to deliver Option C.7 would only be known after modelling of the structures were undertaken and hence both options (C.7a and C.7b) can be considered 'viable' at this stage.*

2.2.4 Frontage D: River Sid Western Wall (upstream of the training wall / Alma Bridge)

2.2.4.1 Technical & Economic Assessment Summary

Within the River Sid only two viable options exist for the western wall – do nothing, and maintenance of the wall until uneconomically viable then replace (refer to **Table 2-4** above). It is considered that complete performance failure of the existing River Sid western wall will occur within the next 15 years due to is poor condition.

Not undertaking any works is not considered to comply with the SMP policy for this unit of hold the line and as such the option of do nothing (Option D.0) is considered inappropriate. In addition without constraint the river may attempt to meander and potentially impact upon the eastern bank.

The timing of Option D.1 (maintenance for as long as is economically viable then replace with a coastal standard wall) is dependent upon which option is considered for Frontage C: East Beach and hence, how soon coastal influences affect the River Sid western wall. It is assumed that the upstream Ham Weir is sufficient and no additional works are required to the weir, although this would need to be confirmed by further investigations at the time of any design of an upgrade to the western wall, which would also need to consider potential for wave propagation up the River Sid and wave reflection from the western wall on the opposite undefended eastern bank of the River Sid. Continued protection of the western wall will ensure that the Port Royal and small fishing industry which are located at this point are protected. The cost of Option D.1 is included within Options B.1 to B.5.

2.2.4.2 Environmental Assessment Summary

Do nothing (Option D.0) is likely to have an impact upon a number of criteria compared with the existing conditions. Option D.1 is likely to have a number of temporary impacts during construction and is therefore the environmentally preferred option.

2.2.4.3 Conclusion

The preferred technical and environmental option for Frontage D: River Sid western wall, is Option D.1 (maintenance for as long as is economically viable then replace with a coastal standard wall). This is to be considered in combination with options for Frontages B and C as part of the short-list options appraisal.

2.3 Proposed short-list options

The proposed short listed options for Sidmouth and East Beach BMP are summarised in the following.

2.3.1 Frontage A: Jacob's Ladder Beach and Connaught Gardens (Chit Rocks)

Due to the limited nature of the options very little technical and environmental differences exist between the options for this frontage. Option A.3 (maintenance of seawall, promenade and rock revetment including re-packing of rock) meets the required SMP policy of hold the line and has the lowest costs compared to the other viable options. This is to be supported by Option A.5 (periodic clearing of shingle from the promenade area).

2.3.2 Frontage B: Sidmouth Town (Chit Rocks to the River Sid, including the training wall seawards of Alma Bridge)

The following options are recommended to be taken forward to short-list appraisal for Frontage B:

- Option B.2a – Maintain existing defence configuration. Repair/replace training wall along same alignment. Undertake periodic beach recharge to maintain volume to level of design beach, supported by ongoing beach recycling.
- Option B.2b - Maintain existing defence configuration. Repair and shorten length of both the current freestanding section of training wall and East Pier. Undertake periodic beach recharge to maintain volume to level of design beach, supported by ongoing beach recycling.
- Option B.4b - Modify existing Bedford Steps, York Steps and East Pier rock groynes to make 'T-head' type groynes to retain sediment in small stable bays between each groyne bay and shortening East Pier groyne in the process. Support with periodic beach recycling and/or recharge to retain volume to give required design beach. Repair/replace training wall and shorten its length.
- Option B.4d – Modify existing Bedford Steps and York Steps rock groynes to make 'T-head' type groynes to retain sediment in small stable bays between each groyne bay. Support with periodic beach recycling and/or recharge to retain volume to give required design beach. Remove East Pier rock groyne and training wall and place rock-armour around seawall where it curves into the River Sid.
- Option B.5 – remove existing beach structures and construct new offshore breakwaters, supported with periodic beach recycling and recharge. *Note: the number, position, size and height of structures to deliver Option B.5 would only be known after modelling of the structures were undertaken and hence both options (B.5a and B.5b) can be considered 'viable' at this stage.*

It is assumed that all of the above options include for immediate repair to the River Sid training wall (Option B.6) until the final option can be implemented.

Options B.2a and B.2b meet the required SMP policy objective and also ensures that the standard of service provided by the Sidmouth seafront coastal defences is met. By providing beach nourishment and or recycling on a regular basis this also ensures a beach is maintained providing a public amenity.

Options B.4b and B.4d enable a beach to be maintained more easily than at present and together with beach recharge also provides a public amenity along the frontage. The shortening or removal of the East Pier and training walls allows for a transition between the Frontage B SMP policy of hold-the-line and the SMP policy of managed realignment along Frontage C: East Beach.

The provision of reefs (similar in size to those existing) under Option B.5a also meets the above criteria and enables tombolos/salients to be created forming a beach along the frontage together with beach recharge/recycling to support as necessary. However, as noted above, detailed investigation will be required if taken forward to determine their height and to ensure wave induced current or other additional marine safety issues are resolved. Such investigations are beyond the scope of this current project.

With reference to **Section 2.1**, each of these options support most, if not all, of the potential opportunities/additional benefits beyond flood and coastal erosion risk management and this will be considered in further in the short-list appraisal (refer to **Section 3**).

2.3.3 Frontage C: East Beach (River Sid eastwards to BMP boundary)

To reduce the effects of the cliff erosion, whilst minimising the impacts upon the important environmental designations within this frontage, the recommended short-listed options for East Beach are:

- Option C.1b – Construct 1 or 2 short/low level rock groynes about 150-200m east of the River Sid to aid beach levels controls as it transitions eastwards, supported by periodic beach recycling within Frontage B. *Note: option is used where training wall is removal is considered i.e. Option B.2b, B.3a, B.3b, B.4c and B.4d.*
- Option C.7 – Construction of offshore breakwaters (tapering towards the eastern end of the study areas. *Note 1: the number, position, size and height of structures to deliver Option C.7 would only be known after modelling of the structures were undertaken and hence both options (C.7a and C.7b) can be considered 'viable' at this stage. Note 2: Option C.7 is only considered in combination with Option B.5a or B.5b.*

2.3.4 Frontage D: River Sid Western Wall (upstream of the training wall / Alma Bridge)

Within the River Sid, to ensure the continued effectiveness of the defences within this frontage the only viable option proposed is Option D.1 (maintenance for as long as is economically viable then replace with a coastal standard wall).

2.3.5 In-combination options taken forward to short-list

Based on the preferred options that are proposed to be taken forward to the short list, **Table 2-5** below provides a summary of the possible in-combination options that could form the basis of the short-list options appraisal, in keeping with the aim of the project to develop a single, integrated project for the open coast.

Upon further review of the possible in-combination options, it is evident that some options are only viable in combination with certain other options. As such, Option B.2a therefore has no corresponding option for Frontage C and so this option is not considered appropriate to take forward to the short-list. This then leaves the final in-combination options to be taken forward to the short-list, as shown in **Table 2-6**.

TABLE 2-5

Possible In-combination Options

A: Jacob's Ladder Beach and Connaught Gardens	B: Sidmouth Town	C: East Beach	D: River Sid Western Wall
Option #A.3 (maintenance of seawall, promenade and rock revetment including re-packing of rock). Supported by Option #A.5 (Periodic removal of shingle from Jacob's Ladder Beach promenade area, with sediment placed to the west of the wall within this sediment cell).	Option #B.2a – Maintain existing defence configuration. Repair/replace training wall along same alignment. Undertake periodic beach recharge to maintain volume to level of design beach, supported by ongoing beach recycling. Supported by Option #B.6 (immediate repair to the River Sid training wall downstream of Alma Bridge) until the final option can be implemented).	No matching option for frontage C is preferred.	Option #D.1 (maintenance for as long as is economically viable then replace with a coastal standard wall).
	Option #B.2b - Maintain existing defence configuration. Repair and shorten length of both the current freestanding section of training wall and East Pier. Undertake periodic beach recharge to maintain volume to level of design beach, supported by ongoing beach recycling. Supported by Option #B.6 (immediate repair to the River Sid training wall downstream of Alma Bridge) until the final option can be implemented).	Option #C1.b – Construct 1 or 2 short/low level rock groynes about 150-200m east of the River Sid to aid beach levels controls as it transitions eastwards, supported by periodic beach recycling within Frontage B.	
	Option #B.4b - Modify existing Bedford Steps, York Steps and East Pier rock groynes to make 'T-head' type groynes to retain sediment in small stable bays between each groyne bay and shortening East Pier groyne in the process. Support with periodic beach recycling and/or recharge to retain volume to give	Option #C1.b – Construct 1 or 2 short/low level rock groynes about 150-200m east of the River Sid to aid beach levels controls as it transitions eastwards, supported by periodic beach recycling within Frontage B.	

A: Jacob's Ladder Beach and Connaught Gardens	B: Sidmouth Town	C: East Beach	D: River Sid Western Wall
	required design beach. Repair/replace training wall and shorten its length. Supported by Option #B.6 (immediate repair to the River Sid training wall downstream of Alma Bridge) until the final option can be implemented).		
	Option #B.4d – Modify existing Bedford Steps and York Steps rock groynes to make 'T-head' type groynes to retain sediment in small stable bays between each groyne bay. Support with periodic beach recycling and/or recharge to retain volume to give required design beach. Remove East Pier rock groyne and training wall and place rock-armour around seawall where it curves into the River Sid. Supported by Option #B.6 (immediate repair to the River Sid training wall downstream of Alma Bridge) until the final option can be implemented).	Option #C1.b – Construct 1 or 2 short/low level rock groynes about 150-200m east of the River Sid to aid beach levels controls as it transitions eastwards, supported by periodic beach recycling within Frontage B.	
	Option #B.5 – Remove existing beach structures and construct new offshore breakwaters. *The number, position, size and height of structures to deliver option would only be known after modelling of the structures was undertaken as part of detailed design.* Supported by Option #B.6 (immediate repair to the River Sid training wall downstream of Alma Bridge) until the final option can be implemented).	Option #C.7 – Construction offshore breakwaters tapering towards the eastern end of the study areas. *The number, position, size and height of structures to deliver option would only be known after modelling of the structures was undertaken as part of detailed design.*	

TABLE 2-6

Final In-combination Options taken forward to Short-list

Option ID	A: Jacob's Ladder Beach and Connaught Gardens	B: Sidmouth Town	C: East Beach	D: River Sid Western Wall
S1	Option A.3 (maintenance of seawall, promenade and rock revetment including re-packing of rock). Supported by Option A.5 (Periodic removal of shingle from Jacob's Ladder Beach promenade area, with sediment placed to the west of the wall within this sediment cell).	Option B.2b - Maintain existing defence configuration. Repair and shorten length of both the current freestanding section of training wall and East Pier. Undertake periodic beach recharge to maintain volume to level of design beach, supported by ongoing beach recycling. Supported by Option B.6 (immediate repair to the River Sid training wall downstream of Alma Bridge) until the final option can be implemented).	Option C1.b – Construct 1 or 2 short/low level rock groynes about 150-200m east of the River Sid to aid beach levels controls as it transitions eastwards, supported by periodic beach recycling within Frontage B. *NB: the core appraisal assumes 1 groyne; sensitivity testing assesses 2 groynes.*	Option D.1 (maintenance for as long as is economically viable then replace with a coastal standard wall).
S2	Option A.3 (maintenance of seawall, promenade and rock revetment including re-packing of rock). Supported by Option A.5 (Periodic removal of shingle from Jacob's Ladder Beach promenade area, with sediment placed to the west of the wall within this sediment cell).	Option B.4b - Modify existing Bedford Steps, York Steps and East Pier rock groynes to make 'T-head' type groynes to retain sediment in small stable bays between each groyne bay and shortening East Pier groyne in the process. Support with periodic beach recycling and/or recharge to retain volume to give required design beach. Repair/replace training wall and shorten its length. Supported by Option B.6 (immediate repair to the River Sid training wall downstream of Alma Bridge) until the final option can be implemented).	Option C1.b – Construct 1 or 2 short/low level rock groynes about 150-200m east of the River Sid to aid beach levels controls as it transitions eastwards, supported by periodic beach recycling within Frontage B. *NB: the core appraisal assumes 1 groyne; sensitivity testing assesses 2 groynes.*	Option D.1 (maintenance for as long as is economically viable then replace with a coastal standard wall).

Option ID	A: Jacob's Ladder Beach and Connaught Gardens	B: Sidmouth Town	C: East Beach	D: River Sid Western Wall
S3	Option A.3 (maintenance of seawall, promenade and rock revetment including re-packing of rock). Supported by Option A.5 (Periodic removal of shingle from Jacob's Ladder Beach promenade area, with sediment placed to the west of the wall within this sediment cell).	Option B.4d – Modify existing Bedford Steps and York Steps rock groynes to make 'T-head' type groynes to retain sediment in small stable bays between each groyne bay. Support with periodic beach recycling and/or recharge to retain volume to give required design beach. Remove East Pier rock groyne and training wall and place rock-armour around seawall where it curves into the River Sid. Supported by Option B.6 (immediate repair to the River Sid training wall downstream of Alma Bridge) until the final option can be implemented).	Option C1.b – Construct 1 or 2 short/low level rock groynes about 150-200m east of the River Sid to aid beach levels controls as it transitions eastwards, supported by periodic beach recycling within Frontage B. *NB: the core appraisal assumes 1 groyne; sensitivity testing assesses 2 groynes.*	Option D.1 (maintenance for as long as is economically viable then replace with a coastal standard wall).
S4	Option A.3 (maintenance of seawall, promenade and rock revetment including re-packing of rock). Supported by Option A.5 (Periodic removal of shingle from Jacob's Ladder Beach promenade area, with sediment placed to the west of the wall within this sediment cell).	Option B.5 – Remove existing beach structures and construct new offshore breakwaters. ***The number, position, size and height of structures to deliver option would only be known after modelling of the structures was undertaken as part of detailed design if this option was taken forward as the preferred option.*** Supported by Option B.6 (immediate repair to the River Sid training wall downstream of Alma Bridge) until the final option can be implemented).	Option C.7 – Construction of new offshore breakwaters tapering towards the eastern end of the study areas. ***The number, position, size and height of structures to deliver option would only be known after modelling of the structures was undertaken as part of detailed design if this option was taken forward as the preferred option.***	Option D.1 (maintenance for as long as is economically viable then replace with a coastal standard wall).

3 Short-List Options Appraisal

3.1 Summary of short-list options appraisal

Each of the short-list of options identified in **Table 2-6** above has been appraised in technical, economic and environmental terms as described in **Sections 1.3 and 2.2**.

The appraisal has considered options in for each frontage unit A, B, C and D in combination as set out in **Table 2-6**. Illustrations of each option (and sensitivity tests – refer also to **Section 3.2**) are provided in **Appendix G**. Full appraisals of each option are provided in **Appendix H**, but for ease of understanding, are summarised here in **Table 3-1**. The final selection of a preferred option (refer to **Section 5**) will need to take a balanced view of the technical viability, environmental impacts, and economic case (including affordability).

TABLE 3-1
Summary of short-list options appraisal

	Option S1	Option S2	Option S3	Option S4
Economic appraisal				
Benefits	£66,014k	£66,014k	£66,014k	£66,014k
Costs *Ratio of capital to maintenance costs excluding discount factors*[1]	£11,004k including 60% optimism bias *77% : 23%*	£16,410k including 60% optimism bias *85% : 15%*	£14,566k including 60% optimism bias *83% : 17%*	£19,894k including 60% optimism bias (*NOTE: re-use of existing rock groynes into new breakwaters may provide capital cost saving of approximately £0.5m)* *90% : 10%*
Benefit:Cost Ratio	6.0	4.0	4.5	3.3
Partnership Funding Score	36%	24%	27%	20%
Partnership Funding Requirement	£7,073k	£12,479k	£10,635k	£15,963k
Properties	Hinterland would be protected. No residential or commercial properties would be lost to erosion within 100 years.			
Infrastructure	Option protects tourism and amenity interests including SW Coast Path National Trail, beach huts and Connaught Gardens from erosion; and may help delay and reduce impact on Alma Bridge and River Sid western wall from erosion of East Cliff. No other infrastructure would be lost.			Much as Options S1, S2 and S3, but much more likely to reduce impacts on Alma Bridge and River Sid western wall.
Transport	No transport links would be lost.			
Development	Increased standard of flood risk protection increases potential for future development within the Sidmouth frontage although predicted long term loss of beach may influence development types if beach recharge and recycling does not occur as assumed.			
Technical appraisal				
Technical Issues	Short term maintenance/repair of training wall undertaken until long term solution implemented when training wall changes will be designed to suit; at this time access for beach maintenance at East Beach will be improved by reducing the length of the training wall. Standard of protection from overtopping and defence erosion/failure improved to original design level along Sidmouth frontage as currently no beach recharge undertaken. Creation of beach along toe of cliff aided by rock groynes and beach recycling reducing rates of cliff toe erosion. Rock groynes along East Beach could become disconnected from the cliff face as erosion (albeit retarded) continues, and then outflanked, so periodic works would be needed to manage this. River Sid western wall defence failure prevented through ongoing maintenance extending the lifespan of the wall beyond its residual life of 15-30 years until unviable and economic to continue, or when cliffs erode such that the wall becomes	Short term maintenance/repair of training wall undertaken until long term solution implemented when training wall changes will be designed to suit; at this time access for beach maintenance at East Beach will be improved by reducing the length of the training wall. Standard of protection improved to original design level along Sidmouth frontage due to improved beach levels providing reduced overtopping and protection from scour/erosion. Creation of beach along toe of cliff aided by rock groynes and beach recycling reducing rates of cliff toe erosion. Rock groynes along East Beach could become disconnected from the cliff face as erosion (albeit retarded) continues, and then outflanked, so periodic works would be needed to manage this. River Sid western wall defence failure prevented through ongoing maintenance extending the lifespan of the wall beyond its residual life of 15-30 years until unviable and economic to continue, or when cliffs erode such that the wall becomes	Short term maintenance/repair of training wall undertaken until long term solution implemented when training wall will be removed and replaced by rock armour protection which helps to dissipate wave energy at River Sid entrance and reduces wave reflection onto promenade. This will provide greater access to East Beach for beach maintenance works compared to Options S1 and S2. Standard of protection to Sidmouth frontage improved to original design level due to improved beach levels providing reduced overtopping and protection from scour/erosion. Creation of beach along toe of cliff aided by rock groynes and beach recycling reducing rates of cliff toe erosion. Rock groynes along East Beach could become disconnected from the cliff face as erosion (albeit retarded) continues, and then outflanked, so periodic works would be needed to manage this. River Sid western wall defence failure prevented through ongoing maintenance extending the lifespan of the wall beyond its residual life of 15-30	Short term maintenance/repair of training wall undertaken until longer term scheme implemented. **The number, position, size and height of offshore breakwater structures to deliver this option would only be known after modelling of the structures was undertaken as part of detailed design if this option was taken forward as the preferred option.** Offshore reefs will create salient/tombolos providing a more stable beach in front of the existing structures and in front of the existing cliffs which will reduce cliff toe erosion rates. Guidance states that the lower the reef crest height the lower the beach level achievable along the shoreline and the smaller the salient (tombolo) that develops will be. HR Wallingford physical modelling also showed that the more angled the reefs, then the more recycling will be required as sediment is driven westwards behind reefs during south-easterly storms. Both factors would need to be considered carefully, and in particular future relationship between design reef crest height versus future sea level (which could swamp the reefs making them

[1] In the cost estimates, the initial scheme construction for each option and subsequent beach recharge campaigns are considered to be capital expenditure items; ongoing beach recycling and structure maintenance activities are considered maintenance.

	Option S1	Option S2	Option S3	Option S4
	exposed to full coastal conditions and a new coastal standard wall is constructed.	exposed to full coastal conditions and a new coastal standard wall is constructed.	years until unviable and economic to continue, or when cliffs erode such that the wall becomes exposed to full coastal conditions and a new coastal standard wall is constructed.	less effective if not designed to sufficient height form the outset). Standard of protection likely to be improved from existing levels to original design levels due to improved beach levels providing reduced overtopping and protection from scour/erosion. River Sid western wall defence failure prevented through ongoing maintenance extending lifespan of wall beyond its residual life of 15-30 years until unviable and economic to continue, or when cliffs erode such that the wall becomes exposed to full coastal conditions and a new coastal standard wall is constructed. Risk of exposure by cliff erosion, and so need to upgrade western wall to full coastal standard, considered to be lower compared to Options S1, S2 and S3.
Coastal Processes Assessment	The short 'I' shaped groynes will stabilise the sediment in the bay while still allowing sediment transfer between frontage B and C – direction of transport and volumes will obviously depend upon prevailing conditions. Although this may have benefits with respect to frontage C, it may not fully address the issue of variable beach levels at the eastern end of the Sidmouth frontage, which will need to be addressed through regular beach recycling/ recharge.	T-head extensions may reduce current-induced scour around the toe of the structure and thereby improve stability and may act to slow or stop the movement of beach sediment on/offshore. This will likely improve the stability of the beach (compared to Option S1) and thereby reduce the risk of beach levels reaching critical levels at one end of the bay under periods of prolonged uni-directional transport reducing the need for recycling of beach material on the frontage. Between East Pier Groyne and the training wall the shorter groyne lengths may mean that sediment bypassing would increase thereby creating a more mobile beach with greater interaction with East Beach. This will require regular beach recharge and recycling to maintain beach levels.	T-head groynes would stabilise much of the beach with the exception of the beach between York Groyne and the River Sid. Here the influence of the T-head extension at York Steps groyne would only have a limited influence, and therefore the shape of the beach would change significantly. Without additional stabilizing structures, compared to Option S2 the beach would move to a more linear form, with a shingle upper beach and sandy lower beach. With no structure at the end of the Sidmouth frontage, and limited interaction with the beaches to the west of York Steps, there is a risk that the beach could disappear altogether, either periodically or permanently, without regular beach recharge and recycling. Without the training wall, the river mouth will be more dynamic with greater sediment interaction between the beach at the eastern end of Sidmouth and East Beach.	The beach is likely to widen behind the reefs with the formation of a series of tombolos in the lee of each breakwater. It is possible that a narrower beach would develop towards the east as the size of the rock reefs taper. Tombolos have previously formed on the landward side of the existing offshore breakwaters but in the future it would be necessary to undertake regular beach recycling and recharge in order to prevent the beach becoming too narrow between the breakwaters, although the frequency of such operations will likely be lower than for the other options. Without the training wall, the river mouth will be more dynamic with greater interaction between the beach at the eastern end of Sidmouth and East Beach. Removal of groynes along the shoreline, access for beach maintenance is much improved compared to other options which will have to access individual groyne bays.
Environmental appraisal				
Geology Geomorphology	No in-combination effects are likely. Changes to coastal processes by the implementation of the scheme within all but East Beach sections will promote natural coastal processes rather than inhibit. No in-combination effects to UNESCO World Heritage Site and nationally designated geological are envisaged.	In-combination effects are likely. Changes to coastal processes by the implementation of the scheme are likely. In operation Sidmouth and East Beach sections combined will likely further inhibit natural coastal processes rather than promote. In-combination effects to UNESCO World Heritage Site and nationally designated geological sites by a reduction of natural processes of erosion is envisaged. Impacts likely to be similar to Option S1.	In-combination effects are likely. Changes to coastal processes by the implementation of the scheme are likely. In operation Sidmouth and East Beach sections combined will likely further inhibit natural coastal processes rather than promote. In-combination effects to UNESCO World Heritage Site and nationally designated geological sites by a further increase in the reduction of natural processes of erosion is envisaged. Impacts likely to be less than other options.	In-combination effects are likely. Changes to coastal processes by the implementation of the scheme are likely. In operation Sidmouth and East Beach sections combined will likely further inhibit natural coastal processes rather than promote. In-combination effects to UNESCO World Heritage Site and nationally designated geological sites by a further increase in the reduction of natural processes of erosion is envisaged. Impacts likely to be greater than other options.
Water quality	In-combination effects pose potential impact with these combined options • Predicted in-combination effects from works at Sidmouth Town and River Sid Western Wall. Increased threat of greater chemical pollution (chemical composition unknown) by increased volume of sediment.			

	Option S1	Option S2	Option S3	Option S4
	• Greater volume of sediment may cause increased temporary sedimentation impacts. Timing may be key to reducing impacts.			
Ecology	In-combination effects pose potential increased impact to: • SAC features, Cliff: vegetated sea cliff of Atlantic and Baltic Coasts, Tilio-Acerion forest. Beach/inshore: Annual vegetation of drift lines • Potential BAP Habitats present, Cliff: maritime cliff and slopes. Beach/inshore: Coastal vegetated shingle, *Sabellaria alveolata* reefs, Sub-littoral sands and gravels • Species associated with the structures being modified Possible long term changes to cliff SAC designated features and BAP Habitat from changes in erosion rates from the modification and construction of structures. Sedimentation from works at Sidmouth Town may impact neighbouring frontages (if works below MHWS), except River Sid Western Wall. BAP habitats above MHWS maybe be impacted by plant access to/from neighbouring frontages.	In-combination effects pose potential increased impact to: • SAC features, Cliff: vegetated sea cliff of Atlantic and Baltic Coasts, Tilio-Acerion forest. Beach/inshore: Annual vegetation of drift lines • Potential BAP Habitats present, Cliff: maritime cliff and slopes. Beach/inshore: Coastal vegetated shingle, *Sabellaria alveolata* reefs, Sub-littoral sands and gravels • Nursery and spawning grounds of fish species associated with the structures being modified, removed and constructed Possible long term changes to cliff SAC designated features and BAP Habitat from changes in erosion rates from the modification and construction of structures. Greater disturbance/ increased sedimentation in the water column from combined works at Sidmouth Town and East Beach may impact each (except River Sid Western Wall) and neighbouring frontages (if works below MHWS). Timing is key to reduce impact on fish spawning/nursery grounds. BAP habitats above MHWS maybe be impacted by plant access to/from neighbouring works frontages.	In-combination effects pose potential increased impact to: • SAC features, Cliff: vegetated sea cliff of Atlantic and Baltic Coasts, Tilio-Acerion forest. Beach/inshore: Annual vegetation of drift lines • Potential BAP Habitats present, Cliff: maritime cliff and slopes. Beach/inshore: Coastal vegetated shingle, *Sabellaria alveolata* reefs, Sub-littoral sands and gravels • Nursery and spawning grounds of fish species associated with the structures being modified, removed and constructed Possible long term changes to cliff SAC designated features and BAP Habitat from changes in erosion rates from the modification and construction of structures. Greater disturbance/ and increased sedimentation in the water column from works at Sidmouth Town and East Beach combined may impact each (except River Sid Western Wall) and neighbouring frontages (if works below MHWS) dependant on the tidal direction during works. Timing is key to reduce impact on fish spawning/nursery grounds. BAP habitats above MHWS maybe be impacted by plant access to/from neighbouring works frontages.	In-combination effects pose potential increased impact to: • SAC features, Cliff: vegetated sea cliff of Atlantic and Baltic Coasts, Tilio-Acerion forest. Beach/inshore: Annual vegetation of drift lines • Potential BAP Habitats present, Cliff: maritime cliff and slopes. Beach/inshore: Coastal vegetated shingle, *Sabellaria alveolata* reefs, Sub-littoral sands and gravels • Nursery and spawning grounds of fish species associated with the structures being modified, removed and constructed Possible long term changes to cliff SAC designated features and BAP Habitat from changes in erosion rates from the modification and construction of structures. Combined offshore breakwater construction at Sidmouth Town and East Beach would create an increased impact. Breakwater construction would be at the detriment of loss of habitat to benthic species associated with soft sediment however construction could be of benefit to epibenthos species including BAP and species associated with rocky reef substrate for example *Sabellaria alveolata* reefs. Other species may also benefit if rock-pool type features are included in the reef construction. Long term altered changes to ecology. Greater disturbance/ and increased sedimentation in the water column from works at Sidmouth Town and East Beach combined may impact each (except River Sid Western Wall) and neighbouring frontages (if works below MHWS) dependant on the tidal direction during works. Timing is key to reduce impact on fish spawning/nursery grounds. BAP habitats above MHWS maybe be impacted by plant access to/from neighbouring works frontages.
Fisheries	Temporary in-combination effects to launch/landing access from construction and maintenance works if undertaken across all four frontage sections at a similar time for commercial fishing boats and recreational beach fishing. Impacts can be reduced by either timing the implementation of individual construction/ maintenance actions within each frontage or reducing the length of time of impact by implementing actions together to ensure launch access is maximised.			Temporary in-combination effects as per Options S1, S2 and S3. Possible long term changes to access may be seen at East Beach. The offshore breakwater has the potential to create a hazard to vessels, and recreational fishers who may try and access it (see navigation). The structure itself may provide increased fishing ground (reef) for pelagic species, however breakwater construction may impact

	Option S1	Option S2	Option S3	Option S4
				benthic species (loss of sediment habitat) changing fishing potential.
Navigation	Temporary in-combination effects to launch/landing access from construction and maintenance works if undertaken across all four frontage sections at a similar time for commercial and recreational boats. Impacts can be reduced by either timing the implementation of individual construction/maintenance actions within each frontage or reducing the length of time of impact by implementing actions together to ensure launch access is maximised.			The dangers to safe navigation of structures lying just below the water surface would be significant, both to local vessels (particularly in unfavourable sea conditions) and to visitors. Wave induced currents may develop – to be investigated at next stage of works if carried forward. Long term impacts/ navigational changes will be seen with greater impact in- combination with new breakwaters at Sidmouth Town and East Beach, although these will be charted. An increased combined temporary impact may be seen during construction and maintenance actions for boat landing/launch access and recreational beach fishing across all four frontage sections. Key is either reduce impacts by timing construction/ maintenance actions in stages or by reducing the length of time of impact by implementing actions together to ensure launch access is maximised.
Landscape	There will be a greater combined short term visual impact during construction. Long term, a greater combined visual impact from changes at Sidmouth Town and East Beach on setting of designated and non-designated features and include Sidmouth Town Centre Conservation Area, listed buildings, WHS, East Devon AONB, East Devon Heritage Coast and the Blackdowns NCA. The construction of new rock groynes to the east of the mouth of the River Sid would introduce a man-made structure into what is a prominent view of the natural coast.			Impacts much the same as for Options S1, S2 and S3, though potentially greater negative impact on landscape features depending upon scale, height and number of reefs, which would need to be considered in more detailed design appraisal if selected as preferred option. The new structures would potentially have a significant landscape and seascape visual impact on the setting of WHS and AONB.
Archaeology and Cultural Heritage	Potential long term, in-combination effect on the setting of cultural heritage asset.			
Air quality	Any in-combination effects are considered negligible.			
Noise	The combination of works undertaken at each frontage together will increase noise and vibration impacts. The application of mitigation – acoustic barriers, monitoring etc. may be required. Impacts can be further reduced by either timing the implementation of individual construction/maintenance actions within each frontage or reducing the length of time of impact by implementing actions together to ensure noise and vibration is impacts are minimised.			
Amenity value	Potential temporary, negative in-combination effect on amenity value during construction periods. Impacts can be reduced by either timing the implementation of individual construction/ maintenance actions within each frontage or reducing the length of time of impact by implementing actions together to ensure access is maximised. Positive impact of ensuring beach is provided for amenity benefit through ongoing regular beach recharge and recycling.			Impacts much as for Options S1, S2 and S3. Potential long term, in-combination effect on safety from the construction of offshore breakwaters at Sidmouth Town and East Beach, may encourage swimming between them, pose vessel safety issues and reduce surfability of area.

3.2 Sensitivity testing

The following sensitivity test scenarios were investigated for the in-combination short-list options:

1. What are the implications of do-nothing along frontage C (East Beach) in each of the in-combination options (S1, S2, S3 and S4)?
2. What is the economic impact if Frontage D (River Sid) is implemented 5 or 10 years earlier?
3. What is the economic impact for each option if amenity benefits were included?
4. What are the impacts if two groynes were constructed along Frontage C (East Beach) rather than one groyne on options S1, S2 and S3?
5. For Option S4, the core appraisal is based on a technical solution that assumes four shore parallel offshore breakwaters would be a technically appropriate solution, but noting that further investigation may result in a different arrangement of additional offshore breakwaters. To illustrate this further during the short-list appraisal, this sensitivity test appraises the implications if an alternative layout with breakwaters angled similar to the two existing breakwaters is constructed.
6. What is the economic impact if the frequency of beach recycling and recharge is greater than assumed in the cost appraisal for each of the in-combination options (S1, S2, S3 and S4)?
7. What is the economic impact if the River Sid western wall maintenance and upgrade works were taken out of the business case for Sidmouth beach management work for each of the in-combination options (S1, S2, S3 and S4)?
8. What is the economic case of combining Sensitivity Test 3 and Sensitivity Test 7, both of which in isolation improve the economic case?

The findings of these sensitivity tests are summarised in **Sections 3.2.1 to 3.2.8.**

3.2.1 Scenario 1 – Implications of do-nothing along frontage C (East Beach)

3.2.1.1 Coastal processes

The cliffed frontage of East Beach has been subject to erosion in recent years. The period since 2000 has been characterised by several very wet years and a sustained period of low beach levels. If the cliff remains undefended it is likely to continue to erode but there is some limitations on how long for.

The historical data (quantitative analysis of aerial photos and OS maps and qualitative assessment of anecdotal records) suggests that East Beach grows and declines over a period of roughly around 20 to 40 years and that low beaches are associated with accelerated erosion. Recent research by Gerd Masselink at Plymouth University presented at the 10th anniversary meeting of the South West Regional Coastal Monitoring Programme suggests beach behaviour is caused by storm directionality and specifically variability in periods of south-westerly and easterly waves in southwest England. Whilst this research is still being developed, these initial findings show a roughly 20-30 year cycle between periods when easterlies dominate. The most recent period when easterlies dominated was c.1940s to mid-1980s (coinciding with when East Beach was healthy) and since the mid- to late 1980s to present south-westerlies have been dominant (coinciding with when East Beach was depleted).

As a result it is considered that if there are no defences at East Beach there are two possible scenarios. Firstly, the cliff continue to erode until it forms a bay at East Beach in response to the erosion. It is considered likely that at this point the erosion would slow down because the coast would have reached an equilibrium form. The second scenario is that the beach, which has been moved east by south-westerlies in recent years, would be returned by a series of south-easterlies. The beach level would be reasonably high and the erosion of the cliffs would slow down. It would be

very difficult to assess which scenario would be more likely to happen in the future. However, in either case it is likely that the risk of cliff erosion along East Beach leading to exposure of the western wall of the River Sid, and thus the need to upgrade this to a full coastal standard wall, will occur sooner than compared to Options S1 to S4. This would increase the risk of loss to coastal erosion of a number of properties along Cliff Road within the 100 year appraisal period compared to Options S1 to S4.

3.2.1.2 Environmental Impacts

Should no works be undertaken along East Beach, the main impacts are presumed similar for each option. The impacts are shown in **Table 3-2** below.

TABLE 3-2
Sensitivity test - environmental Impacts (if Do-Nothing along Frontage C (East Beach))

Description	Negative or Positive Impact
Positive impact on the UNESCO World Heritage Site and nationally designated geological sites by allowing natural processes of erosion to enhance features.	Positive
Long term, erosion debris present could be at the detriment of loss of habitat for benthic species.	Negative
Long term, erosion debris may block the River Sid, which may create flooding issues from blockages.	Negative
Impact for launch/landing access for recreational boats.	Negative
Changes in landscape character and there will be impact to the setting of the designated features including AONB and setting of the WHS from all frontages.	Negative
Likely permanent direct impacts, and on setting of designated and non-designated Archaeology and Cultural Heritage features.	Negative
Total impact to access/and on beach amenities from property erosion debris including direct impact and access to SW Coast Path National Trail.	Negative
Erosion debris may end up placed along neighbouring frontages with the tide, and additionally get trapped by other beach structures at Sidmouth Town creating larger structures and further constraining natural processes.	Negative
Erosion debris would cause a health and safety issue. Measures to prevent public access directly from neighbouring frontages Sidmouth Town and River Sid western wall would need to be addressed.	Negative

3.2.1.3 Economic Impacts

Table 3-3 summaries the economic impacts occur if no works were implemented along frontage C (East Beach).

TABLE 3-3
Sensitivity test - economic impacts if Do-Nothing along Frontage C (East Beach) (values in [ ] show variation compared to Options S1 to S4 as shown in Table 3-1)

	Option S1	Option S2	Option S3	Option S4
Benefits (£k)	66,005 [-9]	66,005 [-9]	66,005 [-9]	66,005 [-9]
Costs (£k) (including 60% optimism bias)	12,262 [+1,258]	17,668 [+1,258]	15,823 [+1,257]	18,112 [-1,782]
Benefit cost ratio	5.4 [-0.6]	3.7 [-0.3]	4.2 [-0.3]	3.6 [+0.3]
PF Score	32% [-4%]	22% [-2%]	25% [-2%]	22% [+2%]
Contribution Required (£k)	8,357 [+1,314]	13,763 [+1,284]	11,918 [+1,283]	14,207 [-1,756]

The impact of do nothing along East Beach is to increase the costs and so funding contribution required for Options S1, S2 and S3. This is because compared to the assessment of these three

options in Table 5-1, do nothing along East Beach means that cliff erosion will continue at a higher rate and so lead to the need to upgrade the River Sid western wall earlier than in those core appraisals. This is also the case for Option S4, however, the increased cost of constructing the western wall earlier is more than offset by the reduced cost of constructing an offshore reef along East Beach; hence the economic impact of do nothing on East Beach improves the economic metrics.

3.2.2 Scenario 2 – What is the economic impact if Frontage D (River Sid) is implemented 5 or 10 years earlier?

Table 3-4 below summarises the key economic metrics should the River Sid western wall works be brought forward by 5 or 10 years. This reflects the uncertainty about how future rates of recession will be impacted by each option.

TABLE 3-4
Sensitivity test – economic impact if Frontage D needs to be implemented earlier (values in [ ] show variation compared to Options S1 to S4 as shown in Table 3-1)

	5 years earlier	**10 years earlier**	**5 years earlier**	**10 years earlier**	**5 years earlier**	**10 years earlier**	**5 years earlier**	**10 years earlier**
	Option S1		**Option S2**		**Option S3**		**Option S4**	
Benefits (£k)	66,014 [0]	66,014 [0]	66,014 [0]	66,014 [0]	66,014 [0]	66,014 [0]	66,014 [0]	66,014 [0]
Costs (£k) (including 60% optimism bias)	11,301 [+297]	11,645 [+641]	16,707 [+297]	17,051 [+641]	14,862 [+296]	15,206 [+640]	20,190 [+296]	20,534 [+640]
Benefit cost ratio	5.8 [-0.2]	5.7 [-0.3]	4.0 [0]	3.9 [-0.1]	4.4 [-0.1]	4.3 [-0.2]	3.3 [0]	3.2 [-0.1]
PF Score	35% [-1%]	34% [-2%]	24% [0]	23% [-1%]	26% [-1%]	26% [-1%]	19% [-1%]	19% [-1%]
Contribution Required (£k)	7,370 [+297]	7,714 [+641]	12,776 [+297]	13,120 [+641]	10,931 [+296]	11,275 [+640]	16,259 [+296]	16,603 [+640]

In all instances the impacts are similar with increased costs and lower benefit cost ratios due to the earlier implementation of the works along the River Sid western wall.

3.2.3 Scenario 3 – Economic impact for each option if amenity benefits are included

Table 3-5 shows the impact upon the economics of including an additional £31,431k of amenity benefit (refer to **Section 1.3.3**). In all cases, it increases the benefit:cost ratios and reduces the amount of funding contribution required.

TABLE 3-5
Sensitivity test – economic impact if amenity benefits included (values in [ ] show variation compared to Options S1 to S4 as shown in Table 3-1)

	Option S1	Option S2	Option S3	Option S4
Benefits (£k)	97,445 [+31,431]	97,445 [+31,431]	97,445 [+31,431]	97,445 [+31,431]
Costs (£k) (including 60% optimism bias)	11,004 [0]	16,410 [0]	14,566 [0]	19,894 [0]
Benefit cost ratio	8.9 [+2.9]	5.9 [+1.9]	6.7 [+2.2]	4.9 [+1.6]
PF Score	52% [+16%]	35% [+11%]	39% [+12%]	29% [+9%]
Contribution Required (£k)	5,327 [-1,746]	10,733 [-1,746]	8,888 [-1,746]	14,216 [-1,746]

It should be noted that this amenity benefit is comprised of (a) amenity damages avoided (i.e. avoiding loss of amenity value by doing something rather than doing nothing), and (b) additional amenity gain of providing a scheme that seeks to retain beach levels that are of benefit for amenity use. This amenity gain component is based on data from previous work at Sidmouth and is more pertinent to Options S1, S2 and S3 as it was derived based on scheme options involving groynes and beach management. Whilst the amenity benefits are applied uniformly across all four options in this appraisal, with further investigation (i.e. undertaking a contingent valuation survey), it may be possible to determine more distinct variation of the amenity gain aspect in particular for each of the four options; however, given the lower payment rates for amenity benefit in terms of the partnership funding calculation, it is considered unlikely that this would influence the option selection.

3.2.4 Scenario 4 – Impacts if two groynes are constructed along Frontage C (East Beach) rather than one groyne on options S1, S2 and S3

3.2.4.1 Coastal Processes

The impact upon the wider coastal processes of constructing two groynes along East Beach will be very similar to the impacts of the one groyne scenario considered in Options S1 to S3. The addition of a second groyne will, however, likely provide a more stable beach along East Beach compared to the one groyne option. Access to the eastern most groyne bay may also prove more challenging than for the one groyne scenario. This must be balanced with the fact that if only one groyne is used to stabilise the frontage, it may be too far from the rest of the Sidmouth frontage to reduce erosion of the coast between those two points significantly. Two groynes may therefore be the best solution for stabilising the beach while ensuring in the longer term that the natural beach can return to this frontage. Numerical modelling will be required to make a full assessment on the optimum groyne field layout.

Any groyne construction would also need to be coupled with regular beach recharge and recycling (in combination with that along the Sidmouth Town frontage) to ensure that there was a healthy beach in front of the cliff.

It should be noted that even if the cliff is defended it will continue to erode, especially in the short term while the over-steepening and weakening of the cliff still has an effect even if the erosion of the toe is slowed down. There will always be large storm waves which impact the toe or heavy rainfall which affects the stability of the cliff face.

3.2.4.2 Economics

If two groynes were constructed instead of one along frontage C (East Beach) in all cases the costs increase marginally, with a lower benefit:cost ratio. Partnership funding scores also reduce with

greater contributions being required. A summary of the economic implications are shown below in **Table 3-6**.

TABLE 3-6
Sensitivity test – economic impact if 2 groynes (rather than 1 groyne) is constructed on Frontage C (East Beach) (values in [ ] show variation compared to Options S1 to S4 as shown in Table 3-1)

	Option S1	Option S2	Option S3
Benefits (£k)	66,014 [0]	66,014 [0]	66,014 [0]
Costs (£k) (including 60% optimism bias)	11,428 [+424]	16,833 [+423]	14,989 [+423]
Benefit cost ratio	5.8 [-0.2]	3.9[-0.1]	4.4 [-0.1]
PF Score	34% [-2%]	23% [-1%]	26% [-1%]
Contribution Required (£k)	7,497 [+424]	12,902 [+423]	11,058 [+423]

3.2.4.3 Environmental Impacts

The main impacts are presumed similar for each option and are summarised in **Table 3-7** below.

TABLE 3-7
Sensitivity test – environmental impact if 2 groynes (rather than 1 groyne) is constructed on Frontage C (East Beach)

Description	Negative or Positive Impact
Changes in landscape character and there will be impact to the setting of the designated features including AONB and setting of the WHS. Two groynes will create a larger footprint and will cause a greater impact on the landscape than one groyne. A landscape assessment may confirm this.	Negative
Two groynes are likely to be a greater constraint on natural processes than one groyne causing likely greater long term impacts to UNESCO World Heritage Site and nationally designated geological site features.	Negative

3.2.5 Scenario 5 – Impacts of an offshore breakwaters layout with the structures angled similar to the two existing breakwaters

3.2.5.1 Coastal Processes

The impact of constructing the offshore breakwaters at a more oblique angle (consulted on as Option 4B – refer to **Section 4**) in the way assumed in this sensitivity test (see **Figure G-8 in Appendix G**) compared to the shore-parallel arrangement assumed in the core appraisal of Option S4 (see **Figure G-7 in Appendix G**) will be a more mobile beach, with much less stable salients behind the structures and the development of deeper troughs during southerly and south easterly storms than compared to more shore-parallel structures. This greater beach volatility is due to the minimal protection that the oblique structures provide against waves from those directions. In such events, beach sediment will be moved much more readily towards the west along the shoreline, potentially denuding the beach in places against the seawall to the extent that there will be a greater risk of wave overtopping compared to the shore-parallel structures. At East Beach, this could also pose a greater risk of a storm event lowering beach levels and exposing the toe of the cliffs to wave attack compared to the shore-parallel structures and this promoting coastal erosion.

A direct comparison with the performance of the current structures is not entirely appropriate, as the beach shape there is the result of both the longer and shorter breakwaters being in close proximity and have an 'in-combination' effect. Although two distinct tombolos are evident at low water, they combine to provide only one salient on the upper beach, with the inshore breakwater exerting a strong influence on protecting and stabilising that feature. Along the remainder of the

frontage, with the oblique layout, secondary wave diffraction around the subsequent offshore breakwaters will help to move beach material towards the east and develop salients during south-westerlies, but south-easterlies will see the beaches orienting shore-normal to the uninterrupted wave fronts, which will drive beach material westward.

In addition, the greater mobility of the beach behind the structures will also lead to potentially higher ongoing beach maintenance requirements to recycle and/or recharge sediment along the frontage (compared to the shore-parallel structures) if there are prolonged periods of south-easterlies. This is also something that was predicted in the HR Wallingford physical modelling when developing the current scheme, whereby the more angled the reefs, the greater the movement of the beach behind (HR Wallingford, 1993).

As already noted in Option S4, the relative difference in beach stability behind different offshore breakwater layouts is very much dependent upon the position, orientation, height, length and spacing of the structures, relative to the shoreline, and this would require further detailed investigation should offshore breakwaters (Option S4) be selected as the preferred option over the other Options S1, S2 and S3.

3.2.5.2 Economics

With the oblique offshore breakwater layout assumed in this sensitivity test, there is potential that the total construction length of these structures could be about 50m less than the shore-parallel layout. In terms of the economics calculated as part of the short-list, which is based in part on cost per unit length of asset type, this would equate to this oblique breakwater option being marginally lower cost than the shore-parallel layout in Option S4, by £324k. This equates to an increase in benefit cost ratio of 0.1 (to 3.4) and partnership funding score of 1% (to 21%); meaning a funding contribution of £15,640k would still be required (£323k less than Option S4).

However, the oblique structures as envisaged in this scenario are located in deeper water than the shore-parallel layout, particularly at the seaward ends, but will still need to have crests at similar elevation to have a similar influence, so will be of greater total construction height. Because these are structures trapezoidal in shape, this has a considerable bearing on costs. For example, if structures such as these have a height of 5 to 6 metres (bed to crest), a 1m lower bed level will result in the cost of those structures being over 20% greater. If this is the case, then it is likely that the potential small cost saving in construction costs suggested above will not actually be realised, and actually the total costs will be even greater than the shore-parallel layout, making the economic case worse, not better. The cost of constructing reefs in deeper water was a limiting factor in the development of options for the current scheme by HR Wallingford's physical modelling work in 1992/3.

It is also important to note that this oblique layout is also likely to require a greater level of ongoing beach maintenance activity than the shore-parallel breakwater layout in Option S4. This might take the form of more regular recharging, to address greater volatility and potential losses, or require more beach recycling and re-distribution operations to achieve the minimum profiles required to reduce wave overtopping or erosion. In addition, due to the potential for greater erosion at East Beach with oblique breakwaters compared to shore-parallel breakwaters, there is also a risk that this layout would result in the need to implement the upgrade to the River Sid Western Wall earlier, which as shown in Sensitivity Test 2 above (**Section 3.2.2**) results in a reduced economic case.

Given the very small different in economic case that can be discerned at this strategic level of appraisal, only if this option is selected as the preferred option would it be possible to determine more specific differentiation as part of further detailed investigations into final breakwater layout options.

3.2.5.3 Environmental Impacts

The impacts of offshore breakwaters in any arrangement will be highly dependent upon the final configuration including number, alignment, length, spacing and height of the structures. As such, the main impacts are presumed to be similar as for Option S4 in terms of the various environmental receptors appraised, as it is not possible to discern any significant difference at this strategic level of

assessment. It would only be possible to discern clear differences between options through more detailed investigation that would be needed to develop an offshore breakwaters option if taken forward as the preferred option.

3.2.6 Scenario 6 – Increase in frequency of beach recycling and recharge

Table 3-8 shows the impact upon the economics of increasing the frequency of the beach recharge and recycling.

The baseline economics assume beach recycling activities take place every 5 years and beach recharge every 20 years. In this sensitivity test these timings have been reduced to every 2 years and 10 years respectively.

In all cases, as would be expected the costs increase and benefit cost ratios drop. However, as Option S4 has the least proportionate increase in cost the change in benefit:cost ratio and PF score is less marked.

TABLE 3-8
Sensitivity test – economic impact if beach recycling and recharge frequency is increased (values in [ ] show variation compared to Options S1 to S4 as shown in Table 3-1)

	Option S1	Option S2	Option S3	Option S4
Benefits (£k)	66,014 [0]	66,014 [0]	66,014 [0]	66,014 [0]
Costs (£k) (including 60% optimism bias)	15,550 [+4,546]	19,682 [+3,272]	17,937 [+3,371]	22,947 [+3,053]
Benefit cost ratio	4.3 [-1.7]	3.4 [-0.6]	3.7 [-0.8]	2.9 [-0.4]
PF Score	25% [-11%]	20% [-4%]	22% [-5%]	17% [-3%]
Contribution Required (£k)	11,619 [+4,546]	15,751 [+3,272]	14,006 [+3,371]	19,015 [+3,052]

3.2.7 Scenario 7 – Assume River Sid western wall upgrade and maintenance does not form part of the Sidmouth beach management business case

Table 3-9 shows the impact upon the economics of removing the costs for maintaining and upgrading the western wall of the River Sid from the business case for beach management along the Sidmouth open coast. This assumes that as and when such works are required, this will obtain the necessary funding from the Environment Agency as a separately justifiable scheme.

In all cases, as would be expected the costs decreases and benefit cost ratios rise. This most improves the economic case for Option S1 as the western wall upgrade and maintenance costs comprise a large proportion of the total costs compared to the other options.

TABLE 3-9

Sensitivity test – economic impact if assume River Sid western wall upgrade and maintenance does not form part of the Sidmouth beach management business case (values in [ ] show variation compared to Options S1 to S4 as shown in Table 3-1)

	Option S1	Option S2	Option S3	Option S4
Benefits (£k)	66,014 [0]	66,014 [0]	66,014 [0]	66,014 [0]
Costs (£k) (including 60% optimism bias)	9,033 [-1,971]	14,439 [-1,971]	12,594 [-1,971]	17,922 [-1,971]
Benefit cost ratio	7.3 [+1.3]	4.6 [+0.6]	5.2 [+0.7]	3.7 [+0.4]
PF Score	44% [+8%]	27% [+3%]	31% [+4%]	22% [+2%]
Contribution Required (£k)	5,102 [-1,971]	10,508 [-1,971]	8,663 [-1,971]	13,991 [-1,971]

3.2.8 Scenario 8 – Combine Sensitivity Tests 3 and 7

Table 3-10 shows the impact upon the economics of combining Sensitivity Tests 3 and 7, both of which in isolation improve the economic case of each option.

In all cases, as would be expected, the economic case of including amenity benefits and removing he costs of maintaining and upgrading the River Sid western wall is greater than either Sensitivity Tests 3 and 7 in isolation. The total improvement in terms of reduced contribution required is the combined reduction from Sensitivity Tests 3 and 7, and most improves the economic case for Option S1.

TABLE 3-10

Sensitivity test – economic impact if include amenity benefits and assume River Sid western wall upgrade and maintenance does not form part of the Sidmouth beach management business case (values in [ ] show variation compared to Options S1 to S4 as shown in Table 3-1)

	Option S1	Option S2	Option S3	Option S4
Benefits (£k)	97,445 [+31,431]	97,445 [+31,431]	97,445 [+31,431]	97,445 [+31,431]
Costs (£k) (including 60% optimism bias)	9,033 [-1,971]	14,439 [-1,971]	12,594 [-1,971]	17,922 [-1,971]
Benefit cost ratio	10.8 [+4.8]	6.8 [+2.8]	7.7 [+3.2]	5.4 [+2.1]
PF Score	63% [+27%]	39% [+15%]	45% [+18%]	32% [+12%]
Contribution Required (£k)	3,356 [-3,717]	8,762 [-3,717]	6,917 [-3,718]	12,245 [-3,718]

4 Summary of Consultation

Public consultation on the short-list options appraisal summarised in **Section 3** ran from 15th June 2016 (when a public exhibition was held) to 5th July 2016. As part of the consultation, feedback was requested from consultees as to which was their preferred option and for what reasons. Over 150 people at risk of flooding or erosion were written to and the event publicised through the local press, social media and the community groups who are part of the steering group, and around 100 members of the local community attended the public exhibition, with consultation material also available at East Devon District Council's Sidmouth office and website for those unable to attend on the day. In total, 60 people provided feedback either on the day of the public exhibition or afterwards, with feedback being received from a broad range of people across Sidmouth and the surrounding area, not just those residents and businesses affected directly by flooding and erosion.

Figure 4-1 summarises the responses received from those 68 respondents in relation to preferred options. **Figure 4-2** summarises the reasons those 68 respondents cited for selecting that preferred option.

In summary, around a third of those who responded were in favour of Option 4 in some form (shore parallel or more angled reefs). Responses indicate that people primarily liked this option because they felt the breakwaters offered the best defence from flooding and coastal erosion. The visual impact was clearly also important to the local community, and often cited in the responses received as the reason for a preference for one option over another.

Option 1 was the second preferred option, only just ahead of Option 2. Option 3 is clearly the least favoured, whilst a number felt some other option should be considered.

Additional comments made by respondents can be broadly summarised as follows:

- A number of concerns were expressed over the visual impacts, with a number of people commenting that additional breakwaters would be a real eyesore and put off tourists.
- Some people highlighted the need to protect the town from south easterly storms, as well as south westerly ones.
- Concern was raised about removing some of the existing shoreline structures which have provided excellent defence to Sidmouth for the last 20 years.
- There was general concern about the timescale and a consensus that work needs carrying out as soon as possible.
- There were also comments about the inclusion of a jetty or harbour, which people are keen to see in place and this can be given further consideration as part of the outline design for the preferred option.
- A number of respondents felt that the best protection against flooding and coastal erosion would come at a higher cost and that realistically it would be difficult to achieve.
- Beach users felt that additional breakwaters would detract from the visual amenity of the beach, and could create a hazard.

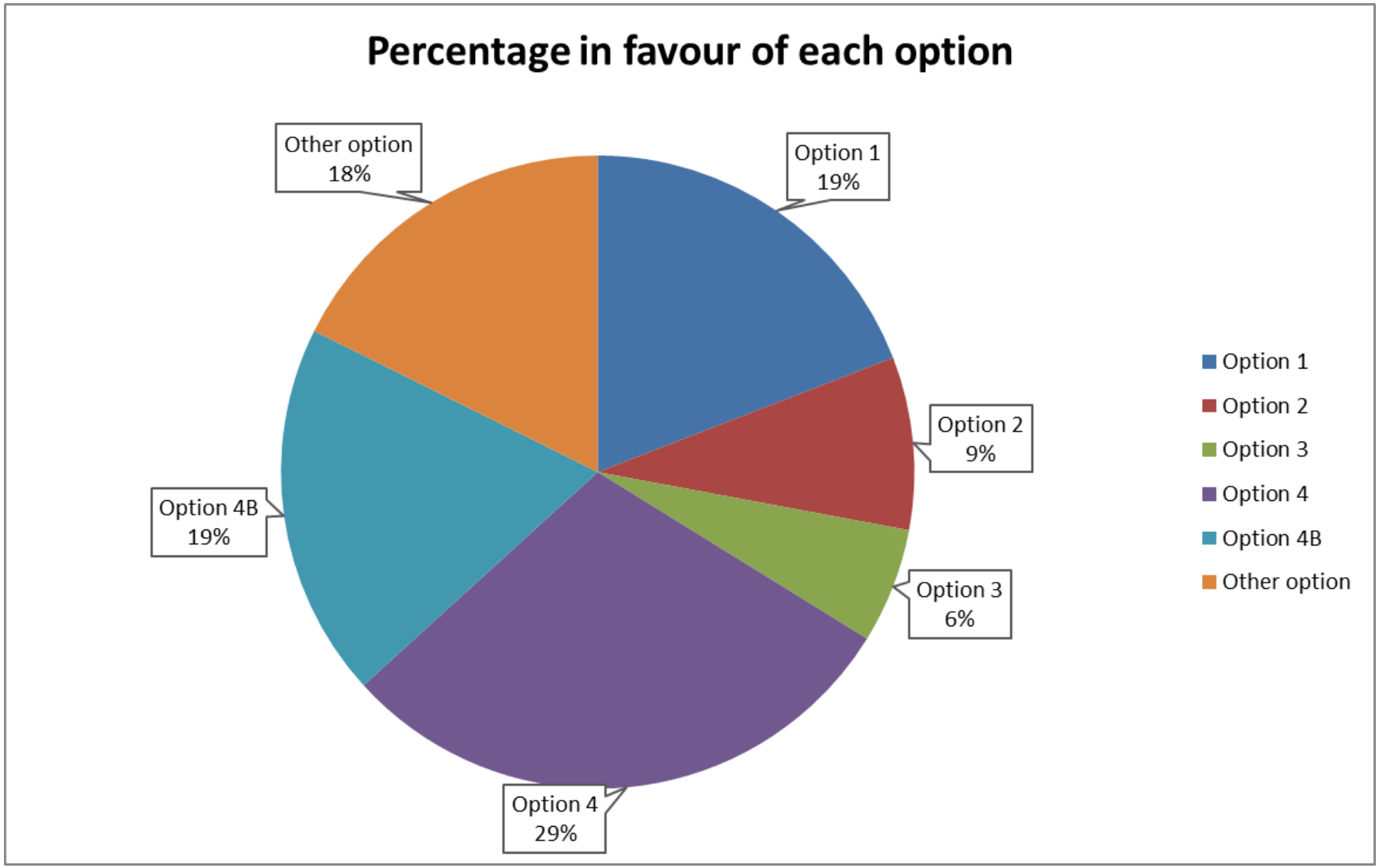

FIGURE 4-1
Summary of public consultation responses on preferred option.

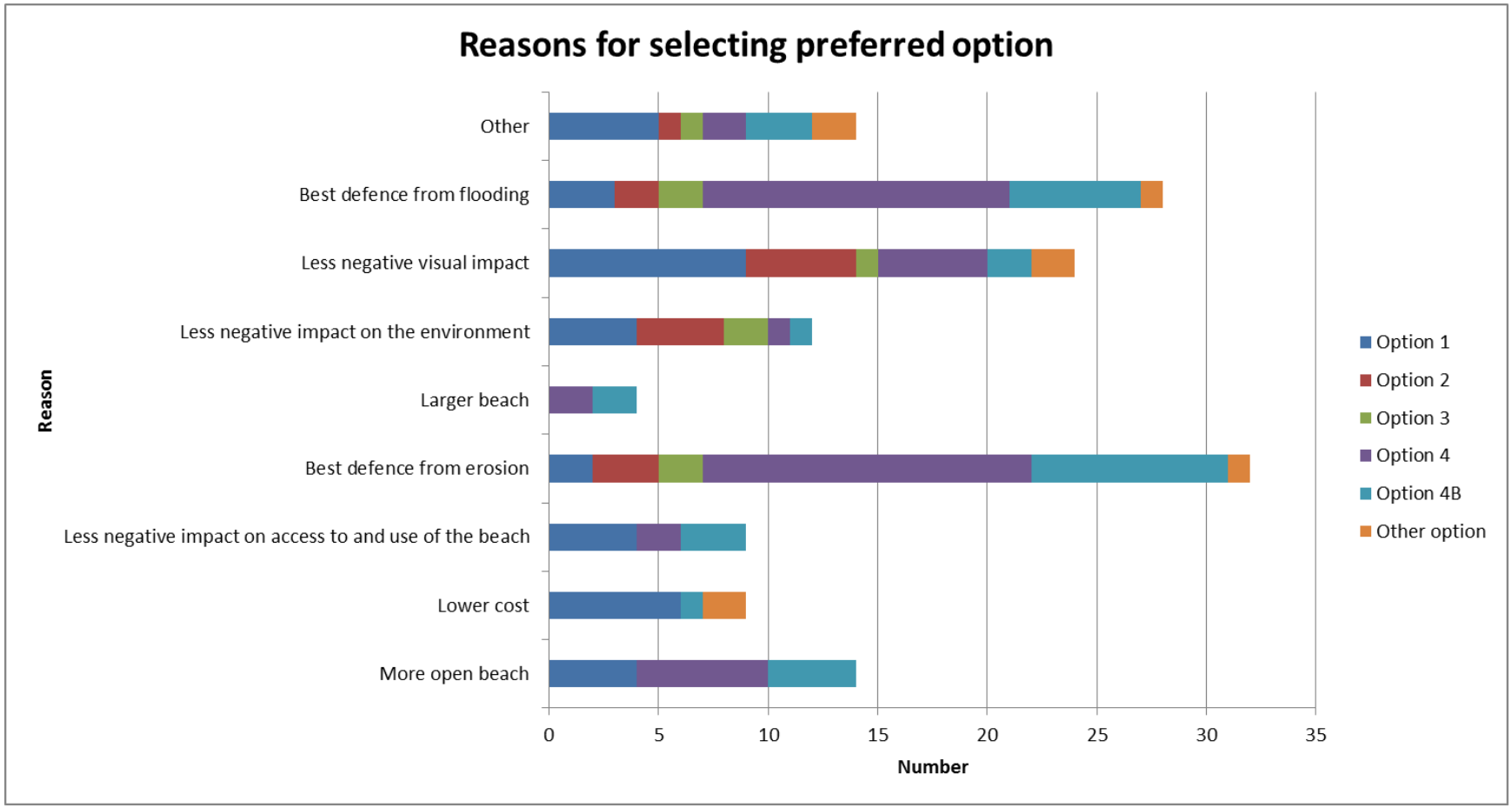

FIGURE 4-2
Summary of public consultation responses on reasons for selecting preferred option.

5 Preferred Option Selection

Having considered the technical, environmental and economic appraisal for each option, the various sensitivity tests and the feedback from public consultation, on the face of it the technically preferred option that best achieves the project objectives is Option S4 and its variants. However, this is also the most expensive option with the worst economic case. Even under the 'best case' scenario (Sensitivity Test 8), more than £12m of funding contributions would be needed to unlock the government grant-in-aid funding accessed through the Environment Agency.

In order to progress Option S4 as the preferred option through to more detailed investigation, design and ultimately implementation, at this stage the Environment Agency's National Project Assurance Service (NPAS) will need to be assured that there is a high likelihood that this level of funding contribution can be secured; if it is not assured, it is unlikely to approve any spend to take this option forward.

Discussions with East Devon District Council have indicated that this level of funding contribution is not affordable to the council at this time. As such, the likely assurance required for NPAS cannot be given.

It may be possible to spend more time and effort seeking to identify and secure multiple sources of funding to provide the level of contribution Option S4 requires, but experience of such efforts in other parts of the UK indicate that this typically takes between two and six years, and is not always successful. If this route were taken, it would (a) not lead to any scheme development and implementation for several years when there is a need to take action as soon as possible, and (b) poses a risk of delaying 'doing something' whilst seeking to secure the required funding contributions and ending up not being able to secure that funding and so having wasted time when something could already have been done. Any delay in this regards obviously increases the likelihood that further erosion at East Cliff will accelerate any upgrade required along the western wall.

Given the above, the actual preferred option recommended to be progressed is Option S1, as this option is the one that gives the best balance between technical viability, environmental acceptability and economic case. Importantly, discussions with East Devon District Council have indicated the level of funding contribution required (c.£3.3m under the 'best case' scenario (Sensitivity Test 8)) is at a level that is more realistic with partners/beneficiaries contributing. This therefore provides a greater chance of project assurance in the shortest amount of time, thus enabling the necessary investigations and detailed design work to implement a scheme to be carried out as soon as possible.

Further work is still needed in the immediate future (within the next 6 months) to fully confirm the level of funding contribution that can be delivered to robustly evidence this in the business case when it is eventually submitted to the Environment Agency's NPAS. If as a result of that further work it is shown that a greater level of funding contribution can be confirmed as being deliverable, then it may be possible to re-consider taking forward option S4 as the preferred option instead of Option S1, depending on what the final confirmed level of funding contribution is.

This funding work in the immediate future would be needed for either Option S1 or S4 and can be progressed alongside initial work to develop the detailed appraisal of the preferred Option S1, with the scope able to be changed if the additional partnership funding is made available. As such, this is the basis of the forward plan presented in Table 5-1 for progressing the development of a project to secure the longer-term management of coastal flood and erosion risk along the BMP whilst ensuring ongoing monitoring and maintenance occurs whilst that project is developed.

TABLE 5-1

Forward Plan for taking forward project to develop long-term scheme for the BMP frontage, alongside ongoing monitoring and maintenance works in the immediate future.

Activity	2016	2017				2018				2019				2020				2021			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
A. Funding Investigations																					
A1. Undertake further work to fully confirm the level of funding contribution that can be delivered to robustly evidence this in the business case when it is eventually submitted to the Environment Agency's NPAS. If as a result of that further work it is shown that a greater level of funding contribution can be confirmed as being deliverable, then it may be possible to re-consider taking forward Option S4 as the preferred option instead of Option S1, depending on what the final confirmed level of funding contribution is.																					
B. Scheme Development																					
B1. Appoint consultant to undertake scheme development work.																					
B2. Numerical modelling planning to define specification for field data collection.																					
B3. Procure and undertake field data collection (bathymetry survey, wave and current monitoring, sea bed sediment sampling).																					
B4. Develop, calibrate and validate numerical spectral-wave model.																					
B5. Develop, calibrate and validate numerical hydrodynamic (tide) model.																					
B6. Develop, calibrate and validate numerical wave and tide model / sediment transport model.																					
B7. Derive updated nearshore extreme wave and water levels (joint extreme probability) along the BMP frontage; to include assessment of wave and water level climate that could be expected along the River Sid western wall under a scenario of further East Beach erosion.																					
B8. Use updated nearshore extreme wave and water levels (joint extreme probability) to drive updated overtopping analysis; to include assessment of overtopping potential that could be expected along the River Sid western wall under a scenario of further East Beach erosion.																					
B9. Review and refine National Receptor Database (NRD) data to ensure as many properties as possible are accurately defined in the NRD to inform updated economic damages assessment.																					
B10. Use updated overtopping analysis to drive updated flood modelling to determine updated economic damages assessment (also using refined NRD data).																					
B11. If budgets allow, it would be beneficial to undertake contingent valuation survey to inform refinement of amenity benefits assessment to make this aspect of the economics appraisal more robust.																					
B12. Use wave model to drive shoreline evolution model (to be developed, calibrated and validated) in order to assess potential alongshore sediment transport rates.																					
B13. Use updated nearshore extreme wave and water levels (joint extreme probability) to undertake beach profile cross-shore response modelling (to be developed, calibrated and validated) to assess mobility of beach under storm conditions.																					

Activity	2016	2017				2018				2019				2020				2021			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
B14. Use validated models to assess scheme options to develop Option S1 or S4 (depending on funding investigation outcomes). This work is to include assessment of: • Size, length, spacing, placement (including leaving gap between groyne head and cliff toe), orientation and number of groynes required on East Beach to achieve maintenance of beach levels. • Impacts of shortening existing structures, including training wall, and adding new structures upon flood and erosion risk and sediment transport (shoreline and nearshore), including impacts under prolonged periods of south-easterly and south-westerly conditions compared to typical conditions. • Role of SWW outfall upon sediment transport patterns with new scheme layout. • Volume and placement of initial beach recharge as part of scheme construction. • Potential volume and frequency of future maintenance beach recharge and recycling.																					
B15. Use modelling results to develop outline scheme design (including costs using early contractor involvement) and inform accompanying Environmental Impact Assessment (to include Landscape/Seascape Visual Impact Assessment, Water Framework Directive Assessment and Habitats Regulation Assessment (Appropriate Assessment)).																					
B16. Undertake public consultation.																					
B17. Prepare Outline Business Case, including refinement of economic case and confirmation of funding contributions.																					
B18. Gain approval of Outline Business Case from Environment Agency.																					
B19. Based on outline design, specify, procure and undertake geotechnical investigations to inform final design.																					
B20. Procure contractor to deliver scheme as D&B contract.																					
B21. Contractor to undertake final design work, including final costings and development of final business case.																					
B22. Undertake public consultation.																					
B23. Gain approval of Outline Business Case from Environment Agency.																					
B24. Gain all required consents (including planning and marine licence).																					
B25. Scheme construction (to include in- and out-surveys before and after construction works).																					
B26. Undertake ongoing public engagement during construction works.																					
B27. Review and update BMP to reflect newly constructed scheme details and more recent monitoring data.																					
B28. Post-scheme monitoring.																					
C. Ongoing Monitoring																					
C1. Ensuring work of the SWRCMP continues as a minimum to provide ongoing capture of data to inform future management decisions at Sidmouth.																					

Activity	2016	2017				2018				2019				2020				2021			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
C2. Current location of regularly monitored beach profiles is not sufficient to provide a good basis upon which to assess beach volume changes. Additional beach survey profile locations both within the groyne bays and along East Beach and the coast further east towards Beer Head, would be preferable, and there should be no further changes to the regularly surveyed profile positions in the future such that a long-term dataset is developed to inform future management. EDDC to work with PCO/SWRCMP to achieve this.																					
C3. Post-storm beach profile surveys need to be captured along the same profiles each time, and broadly to the same extent (i.e. to MLW position ideally).																					
C4. The sediment pathway between the beaches and the nearshore to offshore remains uncertain and more regular (annual) bathymetry surveys of the nearshore area particularly between the existing reefs and the beach, supported by sediment sampling of the seabed, would help to enhance understanding. *This annual surveying is in addition to bathymetry surveys undertaken about every 5 years as part of the SWRCMP.*																					
C5. High quality aerial photography should be flown every 2-4 years. This is particularly needed along the cliffs of East Beach and further east. Along Cliff Road atop East Beach, this should also be supported by 6-monthly cliff top monitoring of distance to cliff edge from a defined datum. *This monitoring is in addition to aerial photography flown every 2-4 years as part of the SWRCMP should also continue.*																					
C6. Undertake regular monitoring of all defence assets in a consistent way (including the offshore breakwaters – which needs a baseline condition survey and profiles to be established as a minimum in the near future) to guide future maintenance works and thus ensure the condition and residual life assessed as part of the BMP is maintained and provided. This should be annual visual inspections each spring and post-storm inspections as required.																					
D. Ongoing Maintenance																					
D1. The River Sid Western Wall (upstream of Alma Bridge) is in generally fair condition. However, along the toe of the structure severe scour has developed and, due to lack of available design drawings for this wall, it is uncertain exactly what the level of risk associated with this is. As such, investigations should be undertaken in the near future to inform future management decisions.																					
D2. River Sid Training Wall (downstream of Alma Bridge) requires immediate action to stabilise it. As a minimum it requires concrete patching of cracks and holes, addressing corrosion and abrasion in the steel sheet pile toe, and construction of scour protection along the toe. Also needs to address risk of instability from wave loading on western side of training wall where there is no material on eastern side. Measures to reduce wave reflection off both sides of the training wall would also be beneficial to reduce wave scour.																					
D3. Exposed reinforcement along access ramp at Jacobs Ladder Beach needs to be addressed in near future to prevent risk of failure if structure is to be maintained to maximise its predicted residual life.																					

Activity	2016	2017				2018				2019				2020				2021			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
D4. There are a number of areas where there are significant 'fall from height' risks from access ramps from promenade to beach along the frontage (particularly between the groyne bays) and the training wall. East Devon District Council to undertake public safety risk assessments and take appropriate actions on an ongoing basis. To be guided by annual visual inspections of defence assets (refer to "C6" above).																					
D5. Ensure that maintenance works, when undertaken, utilise appropriate methods and materials in order to maximise effectiveness and extend structure life as long as possible into the future.																					
E. Other																					
E1. As the aim of the BMP is to reduce rate of erosion and not prevent it along East Cliff/East Beach, there is a need to plan for adaptation in this area in the face of future coastal change such that a plan is in place for when the time comes to implement it in the future. The emerging East Devon Local Plan includes commitment to identify Coastal Change Management Areas. This area at Sidmouth (i.e. Cliff Road etc.) should be included in a Coastal Change Management Area as soon as possible.																					
E2. The Standard of Protection against wave overtopping is low for pedestrian safety during storm events and so measures to deter pedestrians accessing the promenade along the BMP frontage during storms would be appropriate. EDDC to work with EA to manage risk appropriately in future.																					
E3. Work in partnership with other asset/land owners to provide FCERM measures in a sustainable, integrated way. In particular, East Devon District Council, Environment Agency, South West Water and Devon County Council (Highways).																					

6 References

- Defra (2011a). *Partnership Pays: An introduction to the future funding and management of flood and coastal erosion management projects for Local Authorities and Internal Drainage Boards.*
- Defra (2011b). *Flood and Coastal Resilience Partnership Funding: Defra policy statement on an outcome-focused, partnership approach to funding flood and coastal erosion risk management.* May 2011.
- Environment Agency (2012). *Principles for implementing flood and coastal resilience funding partnerships*.
- Environment Agency (2010). *Guidance for outline design of nearshore detached breakwaters on sandy macro-tidal coasts*. Defra and Environment Agency FCERM R&D Programme. February, 2010.
- Halcrow (2011). *South Devon and Dorset (Durlston Head to Rame Head) Shoreline Management Plan Review (SMP2).* South Devon and Dorset Coastal Authorities Group, June 2011.
- HR Wallingford (1993). *Sidmouth, Devon: Mobile Bed Physical Model Study. Report EX2607*. January, 1993.
- McNally, C., Johns, D. and Pygott, K., (2012). *Partnership Funding for Flood Risk Management*. Environment Agency Toolbox Talk, 19th January 2012.

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Appendix A
Coastal Processes Understanding Baseline

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Appendix B
Defence Assessment Baseline

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Appendix C
Environmental Baseline

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Appendix D
Economic Baseline

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Appendix E
Illustrations of Long-list Options

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Appendix F
Long-list Option Appraisal Tables

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Appendix G
Illustrations of Short-list Options

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Appendix H
Short-list Option Appraisal Tables

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